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THE BABYLONIAN ASTRONOMICAL DIARIES: A CONTEXTUAL SURVEY AND GRAPHICAL ANALYSIS OF THEIR IMPLIED REFERENCE SYSTEM

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THE BABYLONIAN ASTRONOMICAL DIARIES: A CONTEXTUAL SURVEY AND GRAPHICAL ANALYSIS OF THEIR IMPLIED REFERENCE SYSTEM

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Abstract

Babylonian scribes nightly observed and recorded celestial events for over six centuries during the first millennium BC. A number of cuneiform tablets containing these astronomical diaries have been recovered and later were translated by Abraham Sachs and Hermann Hunger.

The majority of diary entries track the position of the moon with reference to 31 "normal stars," all within 10 degrees of the ecliptic. Entries specify the moon as being "above," "below," "in front of," or "behind" a second body by a specified distance in cubits. The scribes fail to define either the reference system used for these topographical relations or the dimensions of a cubit. Any instruments that may have been utilized in these observations have not survived.

Gerd Graßhoff posits that "topographical relations in the Babylonian Diaries are accurately measured ecliptic coordinates," and that a cubit represents 2.5 angular degrees. His findings have been questioned and I examine these issues through a new approach. In my research I perform a contextual study of factors leading to the diary observations. Additionally I conduct a graphical computer analysis that depicts actual positions of the bodies in question on specified dates.

Computer-generated star-charts and coordinates for the selected entries clearly show a direct interdependence between the topographical relations and the celestial course of the sun, moon, and planets. Virtually every relation that I

examined corresponds generally with celestial longitude and latitude. While my study produced certain cubit values not far from Graßhoff's, I found an inconsistency in these dimensions that casts great doubt as to the existence of a uniform system of measure. The computer-generated star-charts distinctly reflect correlation to the general path of ecliptic travel, but it is doubtful that the topographical relations of the *Astronomical Diaries* refer to any specific coordinate reference system.

Introduction

Near the end of the fourth millennium BC socioeconomic forces in the Mesopotamian valley gave rise to the first documented system of writing and a well-developed mathematics. Early Babylonians believed strongly that their gods signaled to them, by way of natural signs, warnings of imminent ill fortune. These portents were for the city-state and its king, not for the private individual. A common means of prognostication during the second millennium was the search for divine warnings given in the condition of livers of sheep. Later, as astronomical observations and predictions became more exact, celestial omens grew to become the primary source of divination for the welfare of the nation.[1]

Babylonian scribes recorded heavenly phenomena nightly for six centuries. No other scientific study throughout history has been conducted over such a great period of time. The compilation of these astronomical diaries commenced sometime after the reign of Nabonassar (747-733 BC), preserving data in cuneiform on clay tablets. Abraham Sachs and Hermann Hunger have published the Akkadian transliteration and English translation of these texts. The oldest

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[1] Daniel C. Snell, *Life in the Ancient Near East* (New Haven, CT: Yale Univ. Press, 1997), 17-18; Tamsyn Barton, *Ancient Astrology* (London: Routledge, 1994), 10-11; John Britton and Christopher Walker, "Astronomy and Astrology in Mesopotamia," in *Astronomy Before the Telescope*, ed. Christopher Walker (New York: St. Martin's Press, 1996), 42-44.

surviving diary entry is from 652 BC and the most recent from 61 BC. It is estimated that only about five percent of the diaries have been found.[2]

Astronomical scribes recorded lunar, planetary, meteorological, economic, and political events. The changing positions of the moon and planets were often described in reference to a set of "normal stars" lying near the ecliptic, the apparent path of the sun across the sky. The moon and planets also traverse nearly the same course. The diaries never mention the orientation to which these observations are referenced. Neither do they define the dimensions of a cubit nor do they specify the exact time of night that the recordings were made.[3]

In the chapters to follow I approach these questions with both contextual and graphical analyses. I will examine the possibility that the *Astronomical Diaries* recorded data in reference to the ecliptic path of the sun. I will also evaluate the dimensions of a cubit, and will attempt to explore the times that some of these observations may have been made. My research will compare ecliptic coordinates to ascertain if the topographical relations are relative to celestial longitude and latitude. It will also use them to determine angular distances between the bodies and isolate cubit distances in angular degrees. When practical I will use celestial

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[2] N. M. Swerdlow, *The Babylonian Theory of the Planets* (Princeton: Princeton Univ. Press, 1998), 16-17; Hermann Hunger, "Non-mathematical Astronomical Texts and Their Relationships," in *Ancient Astronomy and Celestial Divination*, ed. N. M. Swerdlow (Cambridge, MA: MIT Press, 1999), 82.

[3] Gerd Graßhoff, "Normal Star Observations in Late Babylonian Astronomical Diaries," in *Ancient Astronomy and Celestial Divination*, ed. N. M. Swerdlow (Cambridge, MA: MIT Press, 1999), 97-99.

clues and cubit size to estimate the time that a particular observation may have been made. The graphical star-charts are an integral part of my study and the positions that they depict will provide a fresh perspective on the questions at hand.

Chapters 1 through 7 trace the chronology and development of many factors affecting first millennium astronomy and astrology. Frequent changes of politics influenced the environment fostering scientific development. The inventions of writing and sexigesimal mathematics and their use by the scribes of Mesopotamia were elements essential to astrological and astronomical innovation. Temple scribes are of interest since they were charged to perform the bulk of the observations and record the results. Cosmological and religious beliefs form the frame of reference inspiring omens and divination. Astrology grew to be pre-eminent for prognostication and, in the quest for more accurate predictions, gave rise to mathematical astronomy. The zodiac was created to facilitate these studies and the course traveled by the sun, moon, and planets was closely monitored. Bodies lying near this path became the focus of celestial observations. The Babylonians utilized a luni-solar calendar, and an understanding of its elements and the nature of Babylonian timekeeping are essential in following the scribal entries.

Chapter 8 discusses the *Astronomical Diaries* and their translation by Sachs and Hunger.

The methodology used in my research is outlined in Chapter 9. In it I discuss such elements as the computer software used to generate star-charts, the spherical trigonometry used to convert celestial coordinates and the procedures followed to examine selected diary entries in the search for a frame of reference. Detailed explanations for the table columns are also included with Appendix 1.

Chapter 10 provides my analytical results for each selected day. Included are comments describing the bodies referenced in the entry, examination of the associated topographical relations, and individual angular dimensions of the cubit. Errors in observation or translation brought to light in the graphical analyses are discussed. While no effort has been made to isolate the exact time of each entry, certain observations gave significant astronomical clues as to when they might likely have been made. Whenever applicable I have included this information.

In the appendices are the data tables I prepared containing coordinates for the bodies in question, differences in celestial longitude and latitude, cubit distances in relation to these coordinates, and correlations with the topographical relations. Following the tables are the computer-generated star-charts corresponding with each selected diary entry. The charts depict the Babylonian skies in a perspective similar to that actually seen by the scribe recording the observation.

It is my intent to show through historical analysis that the Babylonians were very much aware of the course traveled by the planets across the sky and that they centered much of their astronomical thought around it. I will also explore further the reasons for their astronomy and how it evolved. The aim of my data collection and analysis, both quantitative and graphical, is to demonstrate the orientation of the topographical relations and to show the relative size of a cubit. The star charts were instrumental in providing visual clues as to the approximate time that certain observations were made and, most importantly, they clearly show that the topographical relations in the *Astronomical Diaries* were recorded in direct relation to the ecliptic path of travel.

Chapter 1

Historical Overview

Observation of the heavens is as old as human curiosity. Alexander Marshack claims that 30,000-year-old bone engravings from the Upper Paleolithic represent a rudimentary calendar tracing moon phases over two lunations. Evidence of celestial curiosity is found throughout the spectrum of ancient civilizations and it is of little wonder that we see extensive documentation of astronomical interest in Mesopotamia.[4]

During the Ubaid period (c. 5000–3500 BC), the peoples surrounding the Tigris and Euphrates began to coalesce into cities. As urban society developed with increasingly larger numbers of citizens, so did the requirements for its administration. Near the end of the Late Uruk period (c. 3500–3200 BC), we find the first pictograms depicting records for purposes of accounting. Clay tokens had been used for such since as early as 8000 BC. The Sumerian pictograms evolved into early cuneiform (c. 3200–2900 BC) and became the first fully developed system of writing known to us today.[5]

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[4] Alexander Marshack, *The Roots of Civilization: The Cognitive Beginnings of Man's First Art, Symbol and Notation* (New York: McGraw-Hill, 1972), 45-50. These bone engravings were found at the Abri Blanchard site in the Dordogne region of France.

[5] Snell, *Life in the Ancient Near East*, 14; Amélie Kuhrt, *The Ancient Near East c. 3000-330 BC*, 2 vols. (London: Routledge, 1995), I:23-25; Denise Schmandt-Besserat, "Record Keeping Before Writing," in *Civilizations of the Ancient Near East*, ed. Jack M. Sasson, 4 vols. (Peabody, MA: Hendrickson Publishers, 2000), IV:2097.

While writing was likely developed for purposes of accounting and bureaucratic records, it quickly was adapted for a wide variety of purposes, including the earliest written accounts relating to the heavens. Babylonian records of stars near the path of travel of the sun and the moon go back as far as writing itself, which is evidence of early conceptualization with an ecliptic orientation.[6]

The time of the Early Dynastic periods (c. 2900–2350 BC) was one of relative progress. Irrigational agriculture was refined, primitive democracy developed, and cities continued to grow. Kings ruled city-states and took on the role of protector of citizens. Perhaps the relative security of city walls caused further migrations until about 80% of the population lived in these communities of 15,000 – 30,000 inhabitants.[7]

In the Agade period (c. 2340–2159 BC), Akkadian came to flourish as a written language and dominated the region for most of the following two millennia. Sumerian, however, remained a language for scholarly and religious purposes. During this time we find records of the Agade Dynasty's omens and

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[6] E. G. Richards, *Mapping Time: The Calendar and its History* (New York: Oxford Univ. Press, 1999), 26. *Ecliptic* refers to the apparent path of the sun as it travels across the sky.
[7] Kuhrt, *The Ancient Near East*, I:26; Snell, *Life in the Ancient Near East*, 17-19.

the belief that the god of the sun signaled the future on the entrails of sheep, a process known as extispicy.[8]

Agricultural productivity thrived and trade flourished during the Third Dynasty of Ur, or the Ur III period (c. 2112–2004 BC). Further records of astronomical activity, however, are not found until the 18th century.[9]

In the Old Babylonian period (c. 2000–1600 BC) King Hammurapi (1792–1750) united Mesopotamia through a series of expansive efforts. During the reign of King Ammisaduqa (1702-1682) we find the earliest records of systematic observations of celestial objects in the recording of data regarding the first and last sightings of Venus, as well as documentation of eclipses.[10]

The Kassite period in Babylonia (1595-1155) was an era of building and cultural development. The epic poem, *Enūma Eliš*, emerged with references made of moon phases and also the stars used for timekeeping throughout the year. The belief in portents affecting the future of the King and country was well developed by this time, as evidenced by *Enūma Anu Enlil*, a vast listing of omens and required remedies to ward off the ill events foretold. *Enūma Anu Enlil*

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[8] Kuhrt, *The Ancient Near East,* I:46-48; John F. Robertson, "The Social and Economic Organization of Ancient Mesopotamian Temples," in *Civilizations of the Ancient Near East*, ed. Jack M. Sasson, 4 vols. (Peabody, MA: Hendrickson Publishers, 2000), I:447.

[9] Snell, *Life in the Ancient Near East*, 37,41; Britton, "Astronomy and Astrology," 42.

[10] Britton, "Astronomy and Astrology," 42; F. Richard Stephenson, "Modern Uses of Ancient Astronomy," in *Astronomy Before the Telescope*, ed. Christopher Walker (New York: St. Martin's Press, 1996), 331.

appears to incorporate data from the Old Babylonian period and King Ammisaduqa. An Elamite raid on Babylon ended the dynasty of the Kassites.[11]

The period known as the Neo-Babylonian lasted roughly between 1000 and 539 BC. Assyrian reconquest of Babylonia proceeded gradually (911-823) with its primary goal as securing control of trade routes. Shalmaneser III (858-823) took great interest in Babylon, which experienced a great renaissance of science and literature.[12]

The ninth century was an era of recovery and stability, but the eighth became a period of political disturbance with conquest by the Assyrian King, Tiglath-pileser III (744-727). Nabonassar (747-733) became the ruler of Babylonia and, during his reign, the quality and quantity of recorded astronomical observations improve dramatically. Scribes tabulated eclipse and other celestial data that would be referenced for centuries. Claudius Ptolemy used their records for his work in Alexandria in the second century AD. Increased interest in astronomical study was likely driven by needs to refine celestial divination and the calendar. MUL.APIN, an astronomical text listing many stars and constellations, dates from about 700 BC.[13]

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[11] James Evans, *The History and Practice of Ancient Astronomy* (New York: Oxford Univ. Press, 1998), 14-15; Dominique Charpin, "The History of Ancient Mesopotamia: An Overview," in *Civilizations of the Ancient Near East*, ed. Jack M. Sasson, 4 vols. (Peabody, MA: Hendrickson Publishers, 2000), II:821.

[12] Charpin, "History of Ancient Mesopotamia," 822-823.

[13] Snell, *Life in the Ancient Near East*, 79; Charpin, "History of Ancient Mesopotamia," 823; Evan Hadingham, *Early Man and the Cosmos* (Norman: Univ. of Oklahoma Press, 1984), 12; Britton, "Astronomy and Astrology," 42; Evans, *History and Practice*, 15.

The early seventh century finds another period of instability as the Assyrians and Chaldeans vie for control of Babylon. In 689 Senacherib (704-681) wielded near total destruction upon the city after a 15-month siege. His son, Esarhaddon (680-669), later began its rebuilding and instituted a period of great prosperity for the region. Esarhaddon received a significant amount of advice from astrologers and priests as to his health and how to avoid the intended outcome of ill omens.[14]

Babylon revolted between 652 and 648, but fell again after a two-year siege, beginning a period of great hardship and famine. The Assyrian king, Assurbanipal (669-627), installed Kandalanu (648-627) to govern Babylonia. Assurbanipal began a systematic collection of all written works for his library in Ninevah, including those describing astronomical events of the Old Babylonian period. Kandalanu's reign was relatively tranquil and peaceful. Significant records of Saturn observations have been recovered, the first extant detailed astronomical data since the time of Amissaduqa, over 1000 years before.[15]

During this same time, the scribes of *Enūma Anu Enlil* began a nightly systematic recording of celestial phenomena in what has become known to us as the *Astronomical Diaries*. The first extant entry is dated in 652 BC, but the

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[14] Wolfram von Soden, *The Ancient Orient: An Introduction to the Study of the Ancient Near East* (Grand Rapids, MI: William B. Eerdmans, 1994), 58; Charpin, "History of Ancient Mesopotamia," 824-825; Kuhrt, *The Ancient Near East*, II:615.

[15] C. B. F. Walker, "Babylonian Observations of Saturn During the Reign of Kandalanu" in *Ancient Astronomy and Celestial Divination*, ed. N. M. Swerdlow (Cambridge: MIT Press, 1999), 61-76; Kuhrt, *The Ancient Near East*, II:588-589.

practice likely began somewhat earlier. Diary recordings were made throughout most of the remainder of the millennium.[16]

In 625 BC Nabopolassar (625-605), a Chaldean, took control of Babylon. The Chaldeans were key in returning power and influence to Babylonia. This was also the beginning of a great era of renaissance in astronomy. Mesopotamian celestial influence in Egypt and Greece later grew so great that "Chaldean" became synonymous with Babylonian astronomy and astrology.[17]

Nebuchadnezzar II (604-562) succeeded his father, Nabopolassar, and during his 42-year reign instituted a great rebuilding program. Nebuchadnezzar conquered Jerusalem and deported many Jews to Babylon, where they adopted the Babylonian luni-solar calendar. He built the Hanging Gardens, one of the Seven Wonders of the World, and the high Temple, otherwise known as the "Tower of Babel." Babylon became synonymous with luxury and splendor.[18]

Nabonidus (555-539) came to power and sought to ward off a growing threat from the Persian king, Cyrus the Great. Nabonidus alienated the population and priesthood by attempting to change the god of Babylon from Marduk to Sin,

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[16] Abraham J. Sachs and Hermann Hunger, *Astronomical Diaries and Related Texts from Babylonia*, 3 vols. (Vienna: Österreichische Akademie der Wissenschaften, 1988), I:13; Evans, *History and Practice*, 16.
[17] A. Leo Oppenheim, *Ancient Mesopotamia* (Chicago: Univ. of Chicago Press, 1964), 160; von Soden, *The Ancient Orient*, 59; Evans, *History and Practice*, 16.
[18] Kuhrt, *The Ancient Near East*, 609; von Soden, *The Ancient Orient*, 60.

causing massive unrest. Cyrus entered Babylon almost unopposed and ended Babylonian autonomy forever.[19]

The period of Archaemenid rule lasted from 539-333 BC. There was little disruption to life in Babylon under Cyrus and astronomy continued to thrive. The scribes of *Enūma Anu Enlil* recorded their daily celestial entries, and there were rapid increases in the sophistication of astronomical knowledge. By the fifth century we see the introduction of the equal-sign zodiac and calendar intercalations were standardized on a nineteen-year cycle. Astronomical development continued to flourish after the conquest by Alexander the Great in 332. Personal horoscopes begin to be found in increasing numbers.[20]

Alexander intended to make Babylon his capital, but died there in 323 leaving his generals to vie for control. Ultimately, rule of the western portion of the empire rested with Ptolemy I Soter (lasting through Cleopatra VII), while Seleucus I Nicator seized power in the east, to include Babylonia. Henceforth, the *Diaries* are dated by years of the Seleucid Era. Civil institutions once again survived the political transition and mathematical astronomy reached full maturity during this period, including the introduction of the Babylonian theory of the

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[19] Snell, *Life in the Ancient Near East*, 117; von Soden, *The Ancient Orient*, 60; Kuhrt, *The Ancient Near East*, II:600.

[20] Evans, *History and Practice*, 15-17; Kuhrt, *The Ancient Near East*, 603; von Soden, *The Ancient Orient*, 61; F. Rochberg, "Babylonian Horoscopy: The Texts and their Relations," in *Ancient Astronomy and Celestial Divination*, ed. N. M. Swerdlow (Cambridge: MIT Press, 1999), 39-42.

planets. Horoscopes continued to thrive and Babylonian influence upon Greek astronomy and astrology was significant.[21]

The Parthians siezed control of Babylonia and governed during the remainder of its astronomy and diary observations. Their rule lasted from c. 140 BC to AD 224, at which time control passed to the Sassanians.[22] The *Diaries* become much more extensive during Parthian rule and are recorded until at least 61 BC.[23]

Early Hellenic astronomers also made use of Babylonian astronomical data. The Greeks found Babylonian planetary tropical and synodic periods to be very accurate and incorporated them into their geometric planetary theory.[24] They also made use of Babylonian lunar eclipse records dating back as far as 730 BC.[25]

In the second century AD, adding Babylonian data to his own, the Alexandrian Greek astronomer, Claudius Ptolemy, derived and published his astronomical theories as the *Syntaxis*. The geocentric *Syntaxis* remained the world standard for cosmology and astronomy for fourteen centuries. Upon the decline of the Roman Empire, the responsibility for the preservation of astronomical knowledge returned once again to Mesopotamia. Ptolemy's work was translated into Arabic

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[21] Kuhrt, *The Ancient Near East*, 611; Evans, *History and Practice*, 15, 17, 23, Rochberg, "Babylonian Horoscopy," 39-42; E. J. Bickerman, *Chronology of the Ancient World* (London: Thames and Hudson, 1968), 127-130.
[22] The Parthians and Sassanians were both from Iran.
[23] Evans, *History and Practice*, 17; von Soden, *The Ancient Orient*, 61.
[24] A body's tropical period is the interval between successive orbital passages through its equinox. A synodic period is the time required for a planet to return to the same position with respect to the sun as seen from the earth.
[25] Evans, *History and Practice*, 22-23.

and studied by men such as Naṣīr al-Dīn al-Ṭūsī, a Persian astronomer in the thirteenth century. The Muslims knew the *Syntaxis* as *al-megiste* and brought it to Europe where it was translated to Latin. The *Almagest*, as it came to be known, continued to dominate astronomical thought until challenged by the publication of the heliocentric theories of Nicolaus Copernicus in AD 1543, thus bringing to a close over 4500 years of Babylonian astronomical influence. Copernicus made significant use of the work of Ptolemy who, in turn, had relied greatly upon the astronomical data compiled by Babylonian scribes.[26] The legacy of Babylonian astronomy and mathematics remains with us today in such things as the constellations of the zodiac and the sexigesimal ordering of our clocks and compasses.

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[26] Evans, *History and Practice*, 15-17, 23; G. J. Toomer, *Ptolemy's Almagest* (Princeton: Princeton Univ. Press, 1998), 9-10; F. J. Ragep, *Naṣīr al-Dīn al-Ṭūsī's Memoir on Astronomy (al-Tadhkira fī ᶜilm al-hay'a)*, 2 vols. (New York: Springer-Verlag, 1993), I:24-25; Nicolaus Copernicus, *On the Revolution of Heavenly Spheres* (Amherst, NY: Prometheus, 1995), 8-9.

Chapter 2

Writing

The earliest written record in Mesopotamia is found in clay tokens dating to 8000 BC. This system was the precursor of later cuneiform script and mathematics. The tokens represented commodities on a one-for-one basis, with different tokens signifying different commodities. For the sake of convenience, these tokens eventually came to be stored in sealed clay envelopes. As the tokens were fully enclosed and not visible, the envelopes were marked with symbols representing the token types and quantities within. By the latter half of the fourth millennium, clay tablets with symbols and marks representing tokens and quantities replaced the actual envelopes and tokens. These innovations, necessitated by requirements to adequately administer a distributive economy, led to the invention of writing.[27]

Pictograms, such as those representing tokens, came to be applied to other things as well. As symbols were devised to represent various objects or ideas, Sumerian cuneiform was born. The history of writing corresponds with human development. The system of tokens became necessary in the eighth millennium for the distribution of agriculture. As tokens became numerous and cumbersome,

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[27] Schmandt-Besserat, "Record Keeping Before Writing," IV:2097-2106; Snell, *Life in the Ancient Near East*, 16.

a new method for their accounting was required. The symbology invented to represent the quantity of tokens in an envelope became the first known example of abstract numerals, an important concept in the development of Babylonian mathematics.[28]

The earliest cuneiform system of writing was found in Uruk, and was already highly developed, including hundreds of pictograms and numerical signs. Evidence of the earlier stages of writing has yet to be discovered. Cuneiform utilizes clay tablets with a reed stylus to impress symbols in soft, but slowly drying clay. The medium is inexpensive and, when fired, is very durable. Cuneiform is Latin for "nail shaped," from the pattern of the markings. The original tablets read from top to bottom, but by the 24th century they were being written from left to right. Over 600 signs were developed with multiple word and phonetic values.[29]

Sumerian is thought to be the world's oldest written language. Cuneiform first developed from the pictograms of the fourth millennium and was further refined during the third. Sumerian was displaced by Akkadian and disappeared as a spoken language sometime in the second millennium, but remained as a written language of the educated and bureaucratic elite. As written in cuneiform,

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[28] Schmandt-Besserat, "Record Keeping Before Writing," IV:2102-2104; Kuhrt, *The Ancient Near East*, I:26.
[29] von Soden, *The Ancient Orient*, 31-33; Oppenheim, *Ancient Mesopotamia*, 229; Snell, *Life in the Ancient Near East*, 16.

Sumerian is a mixture of word-signs and syllabograms. The great majority of Sumerian words have one or two syllables, easily depicted with cuneiform symbols.[30]

Sumerian cuneiform was adapted to Akkadian and the significant differences between the two languages made this system very complex to learn and use. The Babylonians utilized Sumerian word-signs to represent syllables of Akkadian words. The same Sumerian signs were thus used as phonograms as well as ideograms.[31]

Sachs and Hunger present the *Astronomical Diaries* with transliterations and translations of the Akkadian entries on opposing pages. Hunger states that, in many cases, the actual Akkadian equivalent of a symbol remains unknown, so he uses the Sumerian instead. Akkadian words are, by convention, written in italics, while Sumerian words are given in Roman type. Hyphens are used to join transliterations, while periods connect "normalizations" - the spelling of Sumerian words in Latin script without regard to the actual original spelling in cuneiform. Superscripts indicate words are members of particular classes, and subscripts or

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[30] D. O. Edzard, "The Sumerian Language," in *Civilizations of the Ancient Near East*, ed. Jack M. Sasson, 4 vols. (Peabody, MA: Hendrickson Publishers, 2000), IV:2107-2109; Kuhrt, *The Ancient Near East*, I:60.

[31] Evans, *History and Practice*, 12; von Soden, *The Ancient Orient*, 34. Phonograms represent a syllable's sound while ideograms represent a meaning.

accents identify various homophones of a cuneiform symbol. Indices are assigned according to the relative frequency that the homophone occurs and have nothing to do with the Sumerian pronunciation of the word. An example of such is "DUG," which as DUG means "pot," as DÙG means "good," and as DUG_4 means "to say." Numerical indices begin with $INDEX_4$, as the acute accent (´) is used in place of $INDEX_2$ and the grave accent (`) supplants $INDEX_3$. Entries in the *Diaries* normally are mixtures of Akkadian and Sumerian and contain many examples of these conventions, such as SAG GE_6 (beginning of the night), $MURUB_4$ (middle part of the night), and ZALÁG (last part of the night).[32]

[32] Sachs, *Astronomical Diaries*, I:36; D. O. Edzard, "The Sumerian Language," IV:2108.

Chapter 3

Scribes

Scribes (Akkadian *ṭupšarru* or Sumerian DUB.SAR – "tablet writer") were among the social elite of Mesopotamian society. They were masters of writing, science, literature, and religion in a culture that was largely illiterate. Those selected to be students in the scribal school were sons of wealthy merchants, priests, governors, and ambassadors. Mesopotamian kings often considered scribes to be among their most trusted advisors.[33]

The work of the scribe was done primarily with a clay tablet and reed stylus, materials readily available in Mesopotamia. Several other media were occasionally utilized, but the *Astronomical Diaries* were kept in clay. Smooth, wet clay was impressed with a stylus and became permanent when dry. Mistakes were corrected by rubbing the clay with a finger. Several weeks were generally required for the clay to harden and there are noticeable differences of impression in diary entries made early, versus late, in a month. Most tablets were rectangular and of various sizes, but the larger texts approached the dimensions of 45 by 30 cm. Columns were laid out carefully and information was recorded most often from left to right on the obverse and opposite on the reverse, and from top to

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[33] Laurie E. Pierce, "The Scribes and Scholars of Ancient Mesopotamia," in *Civilizations of the Ancient Near East*, ed. Jack M. Sasson, 4 vols. (Peabody, MA: Hendrickson Publishers, 2000), IV:2265-77.

bottom. Space was frequently left in the last column for a colophon listing the name of the scribe and/or the owner of the tablet. Scribes prepared the quality and layout of tablets according to their intended use. The largest texts were for literary, historical, and political records.[34]

Early Sumerian cuneiform consisted of logograms, or signs, for entire words. Later these same symbols were utilized instead for syllables, as phonograms. Both logograms and phonograms were used, sometimes in the same tablet, creating a complicated system requiring intensive study. These complexities were further exaggerated when the Sumerian system was adapted to create a written form of Akkadian, even though there were insufficient characters to properly service the new language. This led to many ambiguities as the same sign might have multiple values as a phonogram and still more as an ideogram representing meanings. Scribes could choose to record a word with a single symbol for a Sumerian ideogram that would require several symbols for the syllabic phonograms in Akkadian. This, in turn, complicated further the reading of the texts. Such difficulty in mastering cuneiform kept literacy rates low and eventually led to Babylonian adoption of the much simpler Aramaic alphabetic system.[35]

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[34] Pierce, "Scribes and Scholars," IV:2265-2277; Sachs, *Astronomical Diaries*, I:12; Oppenheim, *Ancient Mesopotamia*, 239-240.
[35] Oppenheim, *Ancient Mesopotamia*, 236; Evans, *History and Practice*, 12.

Mastering cuneiform required protracted study under an experienced scribe (Akkadian *ummānu* – "expert professor"). The scribal school, known as "the tablet house" (Sumerian É.DUB.BA.A, or Akkadian *bīt ṭuppi*), was a place for mastery of language, literature, mathematics, and music. Skill in cuneiform was developed through extensive copying of previous works that were often added to the personal collections of the masters. Such a school is evident in earlier periods, but later instruction appears to have been conducted in homes rather than at an academy.[36]

Scribes were ultimately groomed for specific duties; however the same scribe might be tasked with more than one. The recorders of the *Astronomical Diaries* were called *ṭupšar Enūma Anu Enlil*, or "scribes of *Enūma Anu Enlil*." Seventy percent of all scribes were involved in administrative pursuits such as recording transactions, contract work, serving as notaries, official record keeping, etc.; twenty percent performed similar work for private individuals; and the remaining ten percent were engaged in scientific pursuits. Palace scribes acted as secretaries to the king. Temple scribes were administrative and bureaucratic, but were not normally involved in priestly duties. They did, however, perform music for religious functions. Certain scribes mastered mathematics, such as tables of multiplication, reciprocals, squares, and square roots. Some spent their entire lives in scribal service, especially those involved in astronomical observations. It

[36] Pierce, "Scribes and Scholars," IV:2270-2272; Oppenheim, *Ancient Mesopotamia*, 238-243.

is likely that some *ṭupšar Enūma Anu Enlil* positions were passed through families from father to son.[37]

Babylonians believed that good or bad fortune was forewarned by fortuitous events. These omens were sought by several methods, but ultimately became primarily celestial in nature. Kings ordered observation of astronomical occurrences that were recorded by temple scribes and interpreted by priests. The scribes also prepared reports of the omens and the actions taken against them. Over time, observations of astrology grew to include those with astronomical purposes. Extensive data, coupled with Babylonian mathematics, enabled the scholar-scribes to amass an unprecedented understanding of the heavens.[38]

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[37] Oppenheim, *Ancient Mesopotamia*, 242; Pierce, "Scribes and Scholars," IV:2271-2273; Hadingham, *Early Man and the Cosmos*, 12.

[38] Erica Reiner, "Babylonian Celestial Divination," in *Ancient Astronomy and Celestial Divination*, ed. N.M. Swerdlow (Cambridge: MIT Press, 1999), 21-23; Pierce, "Scribes and Scholars," IV:2274-75.

Chapter 4

Mathematics

Mathematics was a logical outgrowth of the same fiscal requirements driving the invention of cuneiform writing in fourth-millennium Sumeria. The need to record financial aspects of business transactions was fulfilled by development of a sexigesimal numbering system with place-value notation. Mesopotamian mathematics was that of meeting practical demands, such as measuring tracts of land, and computing areas, volumes, and yields. Early designs for sexigesimal symbols are found in the same clay token system that inspired the Sumerian invention of cuneiform writing.[39]

Records of advanced Babylonian mathematics became evident during the reign of Hammurapi in the First Babylonian Dynasty (c. 1800–1600 BC). By this time sexigesimal calculations evolved into geometric problems in algebraic form. Records of the teaching of mathematics are evident beginning around 2200 BC. Most teaching, however, seems to have been oral with students learning by listening and repeating. Advantageous features of the sexigesimal system were

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[39] O. Neugebauer, *Astronomy and History: Selected Essays* (New York: Springer-Verlag, 1983), 27-28; Marvin Powell, "Metrology and Mathematics in Ancient Mesopotamia," in *Civilizations of the Ancient Near East*, ed. Jack M. Sasson, 4 vols. (Peabody, MA: Hendrickson Publishers, 2000), III:1941-1949; von Soden, *The Ancient Orient*, 166.

later critically important in the development of Babylonian theoretical astronomy.[40]

Place-value notation, or the use of a small number of symbols to represent different values, was an important invention in Babylonian mathematics. It greatly facilitated work with fractions and became essential in mathematical astronomy. In sexigesimal notation, symbols for one and ten are used to represent the numbers 1 through 59. Sixty is denoted by 1,0 (using modern sexigesimal notation). 1,10 represents 70 (60 + 10). 1,20 is 80 (60 + 20). 2,10 is 130 (120 + 10), and so on. The fraction 1/4 is 0;15, 1/3 is 0;20, and 1/2 is 0;30. The number 5.41 would be denoted as 5;24,36 or 5 + 24/60 + 36/3600. Prior to the Seleucid period Mesopotamians had no real concept of, or symbol for zero, which led to possible ambiguities resolved only in the context of the reading.[41]

Mathematical tables were developed to simplify practical applications, as in computing compound interest. Tables for a variety of processes were developed, such as multiplication, division, reciprocals, squares, square roots, cubes, and exponential functions. The following is a simple example:

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[40] Powell, "Metrology and Mathematics," III:1943-1949; Neugebauer, *Astronomy and History*, 27-29.

[41] O. Neugebauer, *The Exact Sciences in Antiquity* (New York: Dover, 1969), 16; Evans, *History and Practice*, 13-14; Powell, "Metrology and Mathematics," III:1948-1951; Neugebauer, *Astronomy and History*, 18-20.

2 X 30 = 1,0	(2 X 30 = 60)
2 X 0;30 = 1	(2 X 1/2 = 1)
0;2 X 30 = 1	(1/30 X 30 = 1)
0;2 X 0;30 = 0;1	(1/30 X 1/2 = 1/60) [42]

A tablet was found that depicts the determination of the length of a diagonal of a square, c, from its sides, a and b ($a^2 + b^2 = c^2$), showing that this concept was known 1000 years before it was later attributed to the Greeks and Pythagoras of Samos. Babylonians developed the ability to solve second-degree and other equations, and discovered algebraic methods of geometry.[43] Algebra was always of prime interest in Mesopotamia, fulfilling the practical needs of finance.[44]

Temple scribes used sexigesimal concepts to develop a sophisticated mathematical astronomy for prediction of celestial events. Arithmetic progressions, such as linear zigzag and step functions, became significant in the Babylonian theory of the planets. The sexigesimal system was so well adapted to astronomical applications that it remained in use for such by Claudius Ptolemy (c.

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[42] Neugebauer, *Exact Sciences*, 32; Oppenheim, *Ancient Mesopotamia*, 306-307.

[43] Geometry is dealt with algebraically through problems solving for the area of squares, triangles, and other geometric shapes.

[44] Neugebauer, *Exact Sciences*, 36; Powell, "Metrology and Mathematics," IV:1945.

AD 146) and Nicolaus Copernicus (AD 1473-1543). We continue to use the sexigesimal system today in both measurements of time and angular degrees.[45]

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[45] Neugebauer, *Astronomy and History*, 50; Neugebauer, *Exact Sciences*, 18,36; von Soden, *The Ancient Orient*, 168; Britton, "Astronomy and Astrology," 55-57.

Chapter 5

Cosmology and Religion

The Mesopotamians believed the Cosmos to exist on three primary levels: liquid masses "Above" and "Below" and, in-between them, the earth and humankind.[46]

In the eighteenth century, King Hammurapi brought Babylon to prominence in Mesopotamia. An epic tale subsequently emerged telling how Babylon's city-god, Marduk, came to slay Tiamat, the goddess of the primordial seas. *Enūma Eliš*, describing the Babylonian creation, appears several hundred years later, firmly elevating Marduk to the stature of the king of all gods. The main purpose of *Enūma Eliš* appears to be to explain how Marduk came to rule over the gods in the Mesopotamian pantheon.[47]

In this tale, in which Marduk is transformed from city-deity to national-deity, Marduk is asked to save the other gods from Tiamat and several monsters. He agrees to do so only if he will be made the king of all gods. Marduk kills Tiamat and splits her body into two parts, forming heaven and earth. Marduk creates

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[46] Jean-Jacques Glassner, "The Use of Knowledge in Ancient Mesopotamia," in *Civilizations of the Ancient Near East*, ed. Jack M. Sasson, 4 vols. (Peabody, MA: Hendrickson Publishers, 2000), III:1820.

[47] Gerda Lerner, *The Creation of Patriarchy* (New York: Oxford Univ. Press, 1986), 153; W. G. Lambert, "Myth and Mythmaking in Sumer and Akkad," in *Civilizations of the Ancient Near East*, ed. Jack M. Sasson, 4 Vols. (Peabody, MA: Hendrickson Publishers, 2000), III:1834.

humankind to serve the gods by provisioning their temples and tending to their needs.[48]

Mesopotamia was a land of many gods. First-generation gods represented the major elements of the cosmos, while younger gods were associated with such lesser objects as the sun, moon, and planets. Each city-state had its own patron deity residing in the local temple and tended to by the temple staff. Common Babylonians had little to do with the care and feeding of Marduk, however, and only participated in watching official processions and observing the festival of *Akitu* at the New Year celebration. Many worshipped personal gods with offerings and made requests for luck and help. These low-level gods would intercede with the higher gods who would give the actual assistance. If one was unlucky, his god must have been offended. From this developed a sense of sin that included rites of confession, penitence and prayer.[49]

Each god had a purpose, or area of expertise. Ruling the early pantheon were *An*, for heaven, *Enlil* representing air, and *Enki* for the earth. Patron gods of cities tended to govern a principal need of the community, such as fishing, husbandry, or planting. Deities were ranked according to their community's political stature. Natural occurrences, such as the sun traveling across the sky, seeds germinating,

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[48] Lambert, "Myth and Mythmaking," III:1834; von Soden, *The Ancient Orient*, 1985), 212.
[49] Lambert, "Myth and Mythmaking," III:1830; Glassner, "Use of Knowledge," III:1820; Thorkild Jacobsen, "Mesopotamian Religion," in *The Encyclopedia of Ancient Civilizations*, ed. Arthur Cotterell (London: Penguin, 1980), 97, 170-171.

and animals giving birth, were all divinely driven. Many gods served in celestial roles. Marduk became the god of the planet Jupiter. Other astral deities included *Šamaš* (sun), *Sin* (moon), *Nabu* (Mercury), *Ištar* (Venus), *Nergal* (Mars), and *Ninib* (Saturn).[50]

When Marduk defeated Tiamat he split her into two parts and placed the upper skies inside her liver in the heavens. We see evidence of the search for divinatory omens in livers from the second millennium, illustrating the degree to which the Mesopotamians considered nature and society to be one. Marduk created humans to ensure the universe functioned properly. This became the primary responsibility of the king, whom the gods would signal with their portents. Extispicy examined the external conditions of livers of sheep for omens resulting from the gods' responses to human needs.[51]

Temple scribes, such as those at Esangila, were charged with monitoring the heavens for celestial omens that might affect the well-being of the king or the country. Temples were powerful entities in both the city's society and economy. As prescribed by Marduk, the temple was the deity's household where its personal needs were to be tended. The god or goddess was fed, bathed, and clothed daily. These elaborate cultic rituals required a large temple staff. It was

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[50] Lerner, *The Creation of Patriarchy*, 152; Glassner, "Use of Knowledge," III:1817, 1820; Jacobsen, "Mesopotamian Religion," 97, 164-165, 170; Lambert, "Myth and Mythmaking," III:1829.
[51] Glassner, "Use of Knowledge," III:1821; Jacobsen, "Mesopotamian Religion," 97.

believed that the god might abandon the city if his needs were not met. Such an undertaking necessitated great funding. Temples managed large tracts of agricultural land and herds of livestock. City residents made regular offerings of food that ultimately were consumed by the temple staff. Temples gave city inhabitants a visible sense of the presence of their patron deity. Strong relationships developed between the temple and the community.[52]

[52] Robertson, "Ancient Mesopotamian Temples," I:443; Jacobsen, "Mesopotamian Religion," 97.

Chapter 6

Astrology and Astronomy

Celestial observation was influenced by the need for a reliable calendar, but the Babylonian penchant for prognosticating the future came to play the dominant role by the end of the second millennium. Astral events occurred by the divine will of the gods. The five planets, or "interpreters," were of primary importance. Planetary alignments in the zodiac forewarned of impending political, military, and agricultural events. A planet's position in a constellation, how long it remained there, if it met with another planet or the moon, all had ominous consequences for king and country. Omens were sent by the gods and were not causative - their ill effects could be mitigated by appropriate rituals, whence the importance that court astronomers observe these signs and report them, along with the appropriate responses, to the king. Astrology was utilized in such things as determining propitious times for battle and protecting the king's welfare.[53]

Celestial diviners examined the skies for any omens, both astral and meteorological (i.e. atmospheric) – no distinction was made. Eclipses, planetary positions, and even clouds and halos were thought to foretell of events potentially

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[53] Rochberg, "Babylonian Horoscopy," 39; Britton, "Astronomy and Astrology," 43-44; Francesca Rochberg, "Astronomy and Calendars in Ancient Mesopotamia," in *Civilizations of the Ancient Near East*, ed. Jack M. Sasson, 4 vols. (Peabody, MA: Hendrickson Publishers, 2000), III:1927; N. M. Swerdlow, introduction to *Ancient Astronomy and Celestial Divination*, ed. N. M. Swerdlow (Cambridge: MIT Press, 1999), 2; Barton, *Ancient Astrology*, 13.

impacting the nation. The earliest omen records date to the 18th century, but they do not become widespread for a millennium. *Enūma Anu Enlil* was discovered in the library of Assurbanipal in Nineveh. It is a series of seventy tablets containing over 7000 omens and their remedies. These omens were likely compiled during the second millennium and may have reached their final form by around 1000 BC.[54]

Omens took the form of pairs of statements, consisting of a protasis and an apodasis. If a specified phenomena, or protasis, was sighted, the related apodasis forecast the ill consequences. Appropriate ceremonies were performed in the palace or temple to ward off the effect of a negative prediction for the king or nation.[55]

As the ability to make precise projections of astral events increased, so did the use of celestial divination, which, by the 7th century, overtook extispicy as the primary means of prediction. Extispicy was a "solicited" omen where the king's diviner asked the gods for advice prior to the slaughter of the sheep. The answer could be read in the physical condition of the liver. While no longer in the forefront, evidence exists that extispicy survived into the early Christian Era. "Unsolicited" omens were such as eclipses and earthquakes – ominous signals

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[54] Neugebauer, *Exact Sciences*, 101; Barton, *Ancient Astrology*, 11-13; Reiner, "Babylonian Celestial Divination," 22-23; Swerdlow, *Ancient Astronomy*, 14.

[55] Walter Farber, "Witchcraft, Magic, and Divination in Ancient Mesopotamia," in *Civilizations of the Ancient Near East*, ed. Jack M. Sasson, 4 vols. (Peabody, MA: Hendrickson Publishers, 2000), III:1899-1906; Reiner, "Babylonian Celestial Divination," 21; Swerdlow, *Ancient Astronomy*, 3.

from the gods affecting the nation as a whole. The appropriate ceremony or ritual was then required to ward off the ill portent. Celestial omens were a natural extension in the development of divination. Certain "mystical" occurrences could now be accurately forecast. This rise in astral prognostication should be seen within the context of the quest of the priests to achieve credibility with their kings. When they demonstrated the ability to predict recurring celestial events such as eclipses, their forecasts related to other divination became trusted as well.[56]

Interest in celestial divination peaked during the reign of the Sargonid Kings, c. 700-600 BC. It was at this time that compilation of data in the *Astronomical Diaries* began and mathematical astronomy commenced a rapid development. Subsequently, individual horoscopes begin to appear. Mathematical methods enabling prediction of the positions of celestial bodies were required for these individual nativities. The earliest extant horoscopes begin at the end of the 5th century and continue throughout the remainder of the millennium.[57]

Records indicate that as early as 3000 BC Sumerians observed "constellations" in the night sky, and it is likely that they did so much earlier, before any written

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[56] L. B. Van der Meer, *The Bronze Liver of Piacenza* (Amsterdam: J. C. Gieben, 1987), 3, 153; von Soden, *The Ancient Orient*, 157; Barton, *Ancient Astrology*, 11, 13; Reiner, "Babylonian Celestial Divination," 23.

[57] Rochberg, "Babylonian Horoscopy," 39-40; O. Neugebauer, "The History of Ancient Astronomy: Problems and Methods," in *Astronomy and History: Selected Essays* (New York: Springer-Verlag, 1983), 58; Swerdlow, *Ancient Astronomy*, 15; Barton, *Ancient Astrology*, 14; Rochberg, "Astronomy and Calendars," 1927, 1936.

accounts. In the fifth century the Babylonians devised a "zodiac" with 12 equal parts and designated each sign with the corresponding name borrowed from these Sumerian constellations. The purpose of a zodiac with signs of equal length was likely to gain precision for recording of astronomical data. Many of these groupings are familiar to us today: the Bull (Taurus), the Twins (Gemini), the Balance (Libra), the Scorpion (Scorpius), the Archer (Sagittarius), the Fish Goat (Capricorn), the Lion (Leo), and the Tails (Pisces).[58]

Babylonian astronomy centered largely on the ecliptic, or the apparent path of the sun across the sky. The constellations of the zodiac[59] surround the ecliptic circle, and the 31 "normal stars" in the *Diaries* stray no further than ten latitudinal degrees. The Babylonians might have precisely defined this path, or they may only have been interested in the general direction of travel of the sun, moon, and planets. Exact ecliptic measurement could be made by observing heliacal risings and settings near the path of the sun, or during lunar eclipses when the moon is precisely in opposition. This eclipse relationship is the origin of the word "ecliptic."[60]

MUL.APIN is a star calendar dating back to the 7th century, but it appears to

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[58] Richards, *Mapping Time*, 26-27; A. Pannekoek, *A History of Astronomy* (New York: Dover, 1989), 50; Britton, "Astronomy and Astrology", 42; Barton, *Ancient Astrology*, 14.
[59] The equal sign zodiac was mathematical with the ecliptic divided into 12 parts of 30 degrees each. Precession has caused the zodiacal signs to drift out of alignment with their namesake constellations.
[60] Richards, *Mapping Time*, 26; Evans, *History and Practice*, 55.

have been amassed from even older sources. One of these is the omen collection, *Enūma Anu Enlil*, which was mentioned previously. MUL.APIN is a compendium of astronomical knowledge, listing such information as the dates of heliacal risings and denoting 17 constellations that lie in the path of the moon – additional evidence of awareness of the direction of ecliptic travel.[61]

The oldest extant *Astronomical Diary* entries date from 652 BC, but the practice likely began as early as the reign of Nabonassar, 747-734.[62] Through centuries of observations the Babylonians attempted to reduce celestial phenomena to an empirical science. While omen astronomy and mathematical astronomy appear to be distinct disciplines, the origins of the latter likely lie in the former. They were practiced together and often observed by the same individuals. Interest in omens stimulated a desire for reliable forecasts of celestial occurrences, such as eclipses and planetary positions. As the time and location of these phenomena were thought to be ominous, the astrologer's goal became their accurate prediction. The desire to prognosticate by the stars, coupled with a well-developed mathematical system, gave rise to Babylonian mathematical astronomy.[63]

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[61] Neugebauer, *Exact Sciences*, 101; Rochberg, "Astronomy and Calendars," III:1930; Britton, "Astronomy and Astrology," 48-49; Reiner, "Babylonian Celestial Divination," 23.
[62] Claudius Ptolemy uses data from this time in the *Almagest*.
[63] Swerdlow, *Babylonian Theory*, 5, 16-22; Rochberg, "Astronomy and Calendars," 1936; Barton, *Ancient Astrology*, 14; Farber, "Witchcraft, Magic, and Divination," 1907; Britton, "Astronomy and Astrology," 44.

Eclipses were frightening events. The ability to predict arithmetically their occurrence provided astrologers significant credibility and power. Dated eclipse records are also found in the time of Nabonassar. [64]

The first predictions of planetary positions were derived from long-term observations enabling Babylonian scribes to recognize repetitive patterns. Specialized cuneiform texts were created for this purpose and were named "Goal-Year Texts" by Sachs. *Goal-years* made use of the great cycles of the planets, or how long it takes them to repeat their motions in the same part of the zodiac (as much as 83 years for Jupiter). This is a combination of the planets' tropical and synodic periods. A body's tropical period is the interval between successive orbital passages through the equinox. A synodic period is the time required for a planet to return to the same position with respect to the sun as seen from the earth. The Babylonians discovered that a planet's behavior in a particular year would be very similar to that in a previous goal-year. Observations recorded in the *Diaries* were the likely source of much of this data. [65]

Mesopotamian astronomy reached its peak during the last three centuries BC. Scientific prediction of longitudes and dates of phenomena were paramount. While the Greeks took a geometric approach, planetary theory for the

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[64] Barton, *Ancient Astrology*, 13.

[65] Evans, *History and Practice*, 312-14; Reiner, "Babylonian Celestial Divination," 23; Barton, *Ancient Astrology*, 13; Neugebauer, *Exact Sciences*, 119.

Babylonians remained strictly arithmetic. Place-value notation and the ability to solve algebraic equations enabled the scribes to deal with problems in ways not possible with Egyptian or Roman math. Babylonian lunar and planetary theories fall into two broad arithmetic categories – System A, which describes the synodic arc with a step function, and System B, utilizing a linear zigzag function.[66] Babylonian astronomy did not attempt to explain why celestial bodies moved as they did, but the desire to predict positions, when coupled with sufficient mathematics, yielded a sophisticated science well capable of tracking celestial events.[67]

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[66] In a linear zigzag function the resultant value increases or decreases by a constant amount in successive intervals and forms a graphical zigzag pattern. The step function expresses the synodic arc as a function of specific zones of time and resembles a series of steps when presented in graphical form.

[67] Pannekoek, *History of Astronomy*, 63; Britton, "Astronomy and Astrology," 60-63; Swerdlow, *Babylonian Theory*, 35; Neugebauer, *Exact Sciences*, 129.

Chapter 7

Calendar and Timekeeping

Evidence of Mesopotamian time reckoning dates back to the 27th century BC. It was likely the Sumerians who instituted the first formal calendar – a lunar one with months beginning when the new crescent moon was first sighted in the west.[68]

During the 18th century the Babylonians adopted the lunar calendar of the Sumerian city of Nippur. Babylon's status as the Mesopotamian center of culture and power helped this system of time reckoning to proliferate and endure. The year begins with the month of *Nisannu*, on the first new moon after the vernal equinox. The remaining eleven lunations were called: *Ajjaru, Simānu, Du'ūzu, Abu, Ulūlu, Tašrītu, Araḫ-samnu, Kislīmu, Tebētu, Šabāṭu, and Addaru.*[69]

The Babylonian year had two seasons, planting and harvesting. Twelve lunar months each commenced with the first sighting of the new moon at sunset. The days therefore also began at dusk. Each month had either 29 or 30 days (a synodic month ranges 29.26-29.80 days). After the thirtieth day a new month

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[68] E. C. Krupp, *Echoes of the Ancient Skies: The Astronomy of Lost Civilizations* (New York: Harper & Row, 1983), 175.
[69] Britton, "Astronomy and Astrology," 45.

began regardless of any sighting. As with all lunar calendars, this too grew out of step with the seasons.[70]

A year of twelve lunations contains 354 days – about eleven and a quarter days shorter than a solar year. To keep with the seasons, periodic insertions of extra months became necessary. Early years, however, often were intercalated capriciously. Regulating the calendar was the responsibility of the king, who would add an extra month by decree. The following passage is a letter of Hammurapi:

> Tell Sin-iddinam, Hammurapi sends you the following message, 'This year has an additional month. The coming month should be designated as the second month *Ulūlu*, and wherever the annual tax had been ordered to be brought into Babylon on the 24th of the month *Tašrītu* it should now be brought to Babylon on the 24th of the second month *Ulūlu*."[71]

Early intercalary rules were spelled out in MUL.APIN, but little evidence exists that they were ever regularly applied. Inserted months did not follow a definite pattern until the fifth century BC, at which point Babylonian astronomers appear to have realized that the length of 19 solar years and 235 lunar months are nearly equal. The resulting system of intercalation required the insertion of a total

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[70] Robert Wilson, *Astronomy through the Ages* (Princeton: Princeton Univ. Press, 1997), 10; Rochberg, "Astronomy and Calendars," III:1931; Britton, "Astronomy and Astrology," 45.
[71] Britton, "Astronomy and Astrology," 45.

of seven months within each 19 year period (19 X 12 + 7 = 235). The intercalary month, *Addaru II* (near the vernal equinox), was added in years 3, 6, 8, 11, 14, and 19, and *Ulūlu II* (near the autumnal equinox) was added in year 17. 235 divided by 19 equals 12.3684 months, very nearly the 12.3683 months in one solar year. Every nineteen years the moon returns in the same phase to the same ecliptic position. This same 19-year period relationship was later attributed to the Greek astronomer Meton of Athens and is known to us as the Metonic cycle.[72]

In the *Astronomical Diaries* Sachs refers to months by both their transliterations and Roman Numerals. Sumerian month names are thought by E. G. Richards to refer to principle feasts and celebrations regulated by lunar cycles.[73]

Semitic	Sumerian	Transliteration	Month
Nisannu	Barzagga	BAR	I
Ajjaru	Gusisa	GU_4	II
Simānu	Sigga	SIG	III
Du'ūzu	Shunumun	ŠU	IV
Abu	Nenegar	IZI	V
Ulūlu	Kinninni	KIN	VI
Tašrītu	Du	DU_6	VII
Araḫ-samnu	Apindua	APIN	VIII
Kislīmu	Gangan	GAN	IX
Tebētu	Abbae	AB	X
Šabāṭu	Ziz	ZÍZ	XI
Addaru	Shegurku	ŠE	XII

[72] Richards, *Mapping Time*, 148; Evans, *History and Practice*, 185; Britton, "Astronomy and Astrology," 46; Wilson, *Astronomy Through the Ages*, 10; Krupp, *Echoes of the Ancient Skies*, 176-177.
[73] Sachs, *Astronomical Diaries*, I:13-14; Richards, *Mapping Time*, 148; Krupp, *Echoes of the Ancient Skies*, 176.

Night was divided into three equal watches, the length of which varied with the seasons. Three more watches partitioned the day. Time was kept with a water clock and a system of arithmetic progression described the differing volumes of water to be added each month to delimit the duration of the watches. In the summer months the night watches were short, while the corresponding day watches were long. During the winter the relative times were reversed. Night watches peaked in *Kislīmu*, at the time of the winter solstice and were at a minimum at the summer solstice in *Simānu*.[74]

A water clock was filled when the watch began and its emptying signified the end of the watch. Over the centuries the schemes as to when the amounts of water varied changed from four times a year in an Old Babylonian system, to monthly, to every fifteen days, and eventually, in a Late Babylonian table, to five day intervals.[75]

One of these systems was described on a circular star list that dates from a time near the beginning of the *Diaries*. A modern reconstruction shows it with twelve pie-shaped wedges and three internal rings. Each wedge represents a Babylonian month and is divided into three sections by the rings. The wedges provide information concerning the morning risings of stars and the amount of water, in minas, to be added to a water clock to regulate the length of that month's watches.

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[74] Britton, "Astronomy and Astrology," 47; Evans, *Ancient Astronomy*, 10-11; Richards, *Mapping Time*, 147.
[75] Britton, "Astronomy and Astrology," 46-47.

A night watch near the winter solstice required 4 minas of water and one near the summer solstice required two. The months of the equinoxes each specified that three minas be added. The remaining months changed at a constant 20/60 of a mina per month. Watches were further divided into half and quarter watches, thus giving the night twelve equal parts. The number of minas was specified on the outer ring for an entire watch, the middle ring for a half-watch, and on the inner ring for a quarter-watch. The Babylonians, therefore, had devised a scheme by which to vary the amount of water to be added to their water clocks in a pattern that paralleled changes in seasonal hours. I describe in Chapter 9 how I have used a similar arithmetic progression to determine the values of the seasonal hours utilized in my study.[76]

Diary entries list watches as USAN, "first part of the night," $MURUB_4$, "middle part of the night," and ZALÁG, "last part of the night." SAG GE_6, "beginning of the night," is also used frequently. Most entries take place either in the early part of the first watch or in the later part of the last.[77]

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[76] Evans, *History and Practice*, 8-11.
[77] Sachs, *Astronomical Diaries*, I:15.

Chapter 8

Astronomical Diaries

Abraham Sachs began nearly 50 years ago his translation of cuneiform tablets containing diary entries of astronomical observations. His work was completed by Hermann Hunger and published in three volumes with plates. *Astronomical Diaries and Related Texts from Babylonia* contains both Akkadian transliterations and English translations of the original cuneiform record.

Akkadian was the language of first millennium Babylonian astronomy and the term for the *Diaries* was *naṣāru ša ginĕ*, or "regular watching." Scribes recorded these observations on clay tablets for more than 600 years, by far the longest single scientific endeavor in the history of mankind. Tablets recovered to date range between 652 and 61 BC, mostly from Babylon and Uruk. Only after 400 BC are entries extant in any significant number. The scribes of *Enūma Anu Enlil,* at Marduk's temple of Esangila, were responsible for recording celestial events nightly. The *Diaries* include astronomical entries relating positions of the moon and planets to the normal stars, as well as other lunar data, information concerning solstices and equinoxes, Sirius phenomena, meteors and comets. Positions are sometimes predicted rather than observed. Certain entries also relate non-astronomical occurrences regarding weather, prices of commodities, river levels, and historical events. Observational methods appear to have remained essentially the same throughout the entire undertaking. It is estimated that tablets have been recovered for only about five percent of the months during the period of the *Diaries*.[78]

The *Diaries* were compiled in one-half year increments from nightly observational records. If weather obscured the sky, certain positions were estimated. This data was used for several astronomical purposes, one such being the Goal Year Texts. Mathematical astronomy was developed from the data recorded on these tablets.[79]

Hermann Hunger gives the following description of the system he utilizes in the *Diaries* to denote the state of preservation of each cuneiform sign:

> If the right or the left part of a sign is missing, this will be indicated by square brackets: [a]b or a[b]; signs damaged in some other way will be enclosed in half brackets: ⌜ab⌝, regardless of what part is damaged. No dots will be used. Where I have doubts about the reading of a sign a question mark is added after the transliterated sign. In some cases, when a sign or a passage could not be read or restored, I added a drawing of it. In the transliteration I try to guess the size of gaps by putting as many x within square brackets as signs could be restored; .... indicate an indefinite number of missing signs; in the translation, ... mean an indefinite number of missing words. [nn] means that a number is missing, [mm] a missing measure.[80]

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[78] Sachs, *Astronomical Diaries*, I:11-13; Gerd Graßhoff, "Normal Star Observations," 97, 136; Evans, *History and Practice*, 13; Swerdlow, *Babylonian Theory*, 17; Rochberg, "Astronomy and Calendars," III:1936; Hunger, "Non-mathematical Astronomical Texts," 82.

[79] Rochberg, "Astronomy and Calendars," III:1937; Swerdlow, *Babylonian Theory*, 16; Sachs, *Astronomical Diaries*, 12.

[80] Sachs, *Astronomical Diaries*, 37.

Many of the astronomical entries describe topographical relations between celestial bodies. In each case the first body is denoted as being "above," "below," "in front of," or "behind" the second. A distance in cubits (KÙŠ) and/or fingers (SI) is normally included. Most observations are close to sunset or sunrise, allowing the scribe to sleep during the middle of the night.[81]

The *Diaries* never define exact time of observation, units of measure, or the system used to reference these topographical relations. Gerd Graßhoff, of the Max Planck Institute in Berlin, believes that there is an ecliptic coordinate system and that the value of a KÙŠ approximates 2.5 angular degrees. My study will approach these questions graphically, as well as quantitatively, in the hope that visual analysis will provide further insight.[82]

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[81] Graßhoff, "Normal Star Observations," 97; Swerdlow, *Babylonian Theory*, 39; Sachs, *Astronomical Diaries*, 16,23.
[82] Graßhoff, "Normal Star Observations," 110; Swerdlow, *Babylonian Theory*, 36.

Chapter 9

Methodology

Graphical Software

My evaluation of the reference system utilized by Babylonian scribes necessitated examining diary entries pictorially, as well as quantitatively, using graphical astronomical software. James Evans, author of *The History and Practice of Ancient Astronomy*, suggested I consider the program *SkyMap Pro v8.0.3* as it is accurate to plus or minus 6000 years from the present, easily encompassing the first millennium BC time-frame of the *Diaries*. This I ultimately selected as being most suitable for my study.

I verified the accuracy of SkyMap Pro 8 by comparing its positions with those generated by NASA's Jet Propulsion Laboratory (JPL) on their *Horizons* non-graphical ephemeris-calculating site, http://ssd.jpl.nasa.gov/horizons.html. The entering arguments for SkyMap begin with the location of the observer. For that I chose 32° 33' 0" north latitude and 44° 24' 0" east longitude, the geographic coordinates of Babylon.

Babylon is 177 minutes, 36 seconds of time-difference ahead of UT.[83] The standard time zone for this region is 180 minutes ahead of UT. I selected 178

[83] Universal Time Coordinated – worldwide time standardized at Greenwich, England. Babylon's time-difference from Greenwich is calculated by multiplying its geographic longitude by 60 and then dividing by 15.

minutes, the nearest whole value, to increase the accuracy of my Sky Map calculations.

JPL's ephemeris generator enters first with target body selection. Next the observer's location must be established. I manually entered the latitude and longitude of the observer, as in SkyMap. As *Horizons* is an ephemeris[84] generator, a time span must be selected to enable it to create a table of entries. I chose to use one hour before to one hour after my desired time of observation. In *Horizons* the time difference from UT must also be manually entered. Next the "Output Quantities and Format" is selected. *Horizons* generates many possible quantities, but the ones I selected as useful for my study and comparisons were "Apparent RA and DEC," "Apparent AZ and EL," and "Obs-centered apparent ecliptic long. and lat."[85] The reference frame was selected as "J2000" and apparent coordinates as "Airless."[86] In SkyMap equatorial coordinates are uncorrected for refraction[87] and I based my ecliptic conversions on RA and Dec.[88]

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[84] A table of predicted celestial positions.
[85] RA – right ascension; DEC – declination, AZ – azimuth; EL – elevation, long – longitude; lat – latitude.
[86] Epoch is a standard reference year selected because of the earth's precession and nutation. The epoch currently in common use is for January 1, 2000 at 12:00 (J2000). Airless, as if the earth had no atmosphere to refract light.
[87] Atmospheric refraction is the displacement of the apparent position of a celestial object caused by its light passing through the earth's atmosphere.
[88] Which are equatorial coordinates.

SkyMap achieves greater precision with regard to irregularities in the earth's rotation by using Terrestrial Dynamic Time (TDT)[89] internally for its computations. The user specifies time in local time converted to UT that then is internally converted to TDT. The current difference, or *delta T*, between TDT and UT is about 1 minute and increases at less than 1 second per year.[90]

Star positions are computed with corrections for proper motion, precession, nutation, and aberration.[91] The program's primary star catalog is the *Tycho 2 Catalog* (E. Høg et al., Feb. 2000).[92]

Positions for the sun and planets, except Pluto, during the first millennium BC are computed by SkyMap using the Bretagnon and Francou "VSOP87" (Variations Seculaires des Orbites Planetaires) planetary theory. VSOP87 claims precision to within 1" +/- 4000 years from J2000 for Mercury through Mars and somewhat less for Jupiter and Saturn. All planetary position computations in SkyMap begin heliocentrically and are then reduced to geocentric coordinates, with corrections made for light time, gravitational deflection, and aberration.

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[89] A time-scale used to calculate precise geocentric positions. This is also known as Terrestrial Time (TT) and has as its fundamental unit a day of 86,400 seconds.
[90] Marriott, C. A., *SkyMap Pro 8*, "Time Corrections."
[91] Proper motion – the change is a star's position due to its motion relative to the sun; precession – the earth's 25,800 year wobble about its axis; nutation – a periodic oscillation of the earth's pole due to gravitational influences of the sun and moon on the earth's equatorial bulge; aberration – displacement in the image of a star due to the earth's motion about the sun.
[92] Marriott, C. A., *SkyMap Pro 8,* "Star Databases."

Finally the result is converted to topocentric coordinates.[93] Moon positions are computed from the ELP 2000-82B lunar theory (M. Chapront-Touze and J. Chapront, 1988). Accuracy is to within 0.01".[94]

SkyMap Pro 8 proved very capable in accurately plotting ancient celestial positions. Typically, comparisons showed differences of less than two minutes of arc and usually only a few arc seconds. An example, with one of the larger discrepancies that I found during my evaluation of SkyMap, was for "-218 VIII 14," or November 10th, 219 BC at 22:00 hours local time. The apparent right ascension and declination for the moon were given in SkyMap as 2h 51m 38.07s and +11° 53' 03.0." When converted with formulas of spherical trigonometry these became ecliptic coordinates of 44° 1' 35.94" and -4° 33' 34.056". The equatorial coordinates given by JPL for the moon on the same date and time are 2h 51m 42.39s and +11° 53' 19.3". JPL's ecliptic coordinates given were 44° 2' 42.17352" and -4° 33' 29.53188". Simple subtraction yields a difference in latitude of 4.52412 arc seconds and a difference in longitude of 1 arc minute plus 6.23352 arc seconds. Minor variations would be imperceptible to Babylonian scribes who normally measured in cubits and rarely attempted observations finer than 8 fingers, or about 40 arc minutes, thus validating SkyMap Pro 8 as a

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[93] Heliocentric – sun-centered; geocentric – earth-centered; topocentric – observer-centered at a point on the earth's surface. Light time – the time for light to travel from the object to the observer; gravitational deflection – the bending of a beam of light due to the gravitational field of a body.
[94] Marriott, C.A., *SkyMap Pro 8*, "Planets, Sun, and Moon."

valuable tool for graphical analysis of the Mesopotamian skies as described in the *Diaries*. Even the finest measurement of two fingers, found only twice in my study, equates to roughly 10 minutes of arc.

Diary Entries

I selected representative entries from throughout the 591-year span of the *Diaries* according to the following criteria: first I attempted to find months that were very complete in their entries, that is months in which entries for most days have been preserved and translated. Next I tried to find the first such month closest to the beginning of the extant *Diaries*. No suitable entries were found until 568 BC and then they still did not yet reflect months that were complete. Wherever possible I avoided those months missing numerous daily entries or with entries appearing subject to excess interpretation in translation. Months fully satisfying my criteria were not found regularly until 309 BC. Having established a starting point in 568 BC, I attempted to find an acceptable month every 20 – 30 years throughout the span of the *Diaries*. Analyzing entries for entire months had the additional benefit of facilitating the evaluation of monthly patterns of observation by the Babylonians as each lunation progressed.

The *Diaries* were recorded in reference to regnal years, but entry into SkyMap is with Julian dates, thus necessitating a conversion. Sachs and Hunger provided a key for most months to assist in this calculation. As the majority of diary entries are for the moon and the moon travels approximately 13 angular degrees per day, the accuracy of a lunar date calculation is immediately apparent on the graphical charts. Because the Babylonian year began with the vernal equinox, care must be taken with months X through XII.[95] While in the same Babylonian year, parts of month X and all of months XI and XII fall in the next Julian year. Additionally, the Babylonian day begins and ends with the sunset. As a result many entries for "the middle of the night" and all for "the last part of the night" fall in the following Julian day.

I next selected a suitable local hour within the proper context of the specified Babylonian watch of the night. Initially I evaluated the "beginning of the night" as 7 PM standard time, the "first part of the night" as 8 PM, midnight for the "middle of the night" and 5 AM for "the last part of the night." Next I evaluated estimated seasonal hours.[96] I first examined the "beginning of the night" as one seasonal hour after sunset and "first part of the night" as two seasonal hours after sunset. "Middle part of the night" I maintained as the midpoint between sunset and sunrise and for "last part of the night" I used 2 seasonal hours prior to sunrise. Ultimately, for standardization, I decided upon 1 seasonal hour after sunset for "beginning of the night," "first part of the night," and early month unspecified

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[95] The vernal equinox occurs on or about March 21st in the Julian calendar.
[96] Seasonal hours were an attempt to roughly divide the time between sunset and sunrise, both night and day, into the same number of parts throughout the year.

entries.[97] I decided upon one seasonal hour before sunrise for the "last part of the night" and used six seasonal hours after sunset for the "middle part of the night."

Water clocks were used by the Babylonians to measure the watches of the night. Watches and water clocks are described in detail in Chapter 7. The amount of water to be added to the water clock varied each month according to a predetermined arithmetic progression. While there still is a certain amount of uncertainty regarding the specifics of water clocks and seasonal hours, I selected a simple scheme that easily was possible at the time of the beginning of the *Diaries*. The Babylonians frequently used linear zigzag functions in which values changed from step to step in equal increments. I utilized such a function to determine the values of seasonal hours in a manner that parallels a seventh-century scheme that describes the amount of water to be added to a water clock in each successive month of the year. A longest day of 14 hours and 24 minutes is commonly known for Babylon, thus giving a maximum nightly seasonal hour value of 1h 12m in month X, at the time of the winter solstice. This then yields a seasonal hour in month IV, near the summer solstice, at 0h 48m. The equinoxes, in months I and VII, dictate seasonal hours of 1h 0m. To determine the values for the remaining months I utilized a simple zigzag function with the relationship for Babylon of

[97] I discovered no perceptible difference in time between entries described as the beginning and the first part of the night.

M:m = 3:2, where *M* represents the longest night and *m* the shortest. I estimated seasonal hours in each Babylonian month to approximate the following values:[98]

I	1h 0m
II	0h 56m
III	0h 52m
IV	0h 48m
V	0h 52m
VI	0h 56m
VII	1h 0m
VIII	1h 4m
IX	1h 8m
X	1h 12m
XI	1h 8m
XII	1h 4m

This is a simplistic estimation of seasonal hours, but one that easily could have been adopted by pre-Seleucid Babylonians, and the procedures for compilation of the *Diaries* appear to have changed very little over the centuries. Variations between this scheme and any other should make little or no difference upon my study as the exact times of observation are unknown and scribal recordings of data would not change with time differences of only few minutes.

Charts

Perhaps the most immediate and telling evidence supporting an ecliptic related frame of reference is that found in the software-generated star charts drawn of the

[98] Neugebauer, *Astronomy and History*, 239-242; Britton, "Astronomy and Astrology," 46-47; Evans, *History and Practice*, 8-11, 121-125.

Babylonian sky. During the initial setup for each use of the program I took the following steps:

1. Select Bayer Letter captions for the stars depicted.
2. Select magnitude limits at 5.5.
3. Select the celestial equator and grids for horizon and ecliptic coordinates.
4. Select the coordinates for Babylon.
5. Set the Julian equivalent of the specified Babylonian day.
6. Set the appropriate time of the night.

The program also is set to outline and label each constellation in the field of view. These entries produce a chart of the night sky at the specified date and time in central Mesopotamia.

Next I recorded program data relating the time of sunrise and sunset for that particular day. Then I reentered the appropriate time as being one seasonal hour after sunset, one seasonal hour before sunrise, or six seasonal hours after sunset.[99] I next centered the first body on the screen. I visually confirmed that the position of the bodies matched the scribe's description in the *Diaries*. At this point I recorded altitude, azimuth, right ascension, and declination for each of the two specified objects. The equatorial coordinates for the moon and planets are "apparent topocentric" for the position of the observer. I reduced right ascension and declination trigonometrically to topocentric ecliptic coordinates. Star positions are given in SkyMap as apparent equatorial and also were reduced to

[99] One advantage in taking observations close to sunset and sunrise is that doing so helps to determine the position of the ecliptic.

their ecliptic equivalents.

I generated a chart for every position selected for my study and captioned each with the reference date given that day by Sachs and Hunger (e.g., -372 I 12).

The first specified body is centered in the middle of each chart. The second body is normally found near the first. Horizon coordinates and grid lines run from the bottom to the top of the depiction. In the horizon coordinate system celestial positions are given by the number of degrees currently above the horizon and the number of degrees measured in a clockwise circle beginning at north.[100] The zero-degree horizontal grid line represents the horizon, below which any body is no longer in the observer's field of view. Also depicted is the celestial equator with its associated right ascension. In the equatorial system the earth's equator and poles are projected on to the celestial sphere. Right ascension begins at the vernal equinox and is measured from zero to twenty-four hours. Declination is measured north and south of the celestial equator. Additional gridlines represent the ecliptic coordinate system. In the ecliptic system, coordinates relate to the apparent path of the sun. Celestial longitude begins at the vernal equinox and is measured to the east. Celestial latitude is measured above and below the ecliptic.

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[100] There is some disagreement on where the starting point of horizontal azimuth should begin. Most navigators choose North as their starting point, while some astronomers instead use South. SkyMap Pro 8 has elected to reference all of its azimuth measurements to North.

The bar at the bottom of each chart lists time and day in both local time and UT. The geographic location of the observer is cited, as is Sidereal Time and the Julian Day.[101] The equatorial coordinates described are for the body that has been centered at the middle of the chart. Except when magnified, the charted field of view is always 90 degrees.

Spherical Trigonometry

In my study it was necessary to examine entries from the *Diaries* with relation to the ecliptic. SkyMap does not give apparent topocentric ecliptic coordinates and gives heliocentric ecliptic coordinates only for the planets. As my requirements were for topocentric ecliptic coordinates of all bodies, it became necessary to perform transformations to the proper format. To perform this task I wrote the necessary formulas of spherical trigonometry into a Microsoft Excel spreadsheet. I began with apparent right ascension and declination given for the specified bodies.

The following terms are used in the formulas of transformation from equatorial to ecliptic coordinates:

> α – *right ascension* expressed in hours, minutes, and seconds and also in decimal degrees.
>
> δ – *declination* that is positive if north of the celestial equator and negative if south.

[101] Sidereal time is time measured with reference to the stars. It is the same as the right ascension of the stars on the observer's meridian.

λ – *longitude* measured along the ecliptic from the vernal equinox.

β – *latitude* that is positive north of the ecliptic and negative when south.

ε – *obliquity of the ecliptic* as the angle between the ecliptic and the celestial equator. The obliquity of the ecliptic changes over time and must be determined in a separate calculation.[102]

The first step in converting equatorial to ecliptic coordinates is to ascertain the Epoch 2000 Julian Ephemeris Day (JDE) at the time of observation.[103] This is given by the SkyMap database. JDE is then used to compute T, or time in Julian centuries from Epoch J2000 according to the following formula:

$$T = (\mathrm{JDE} - 2451545)/36525$$

The resultant value is used to compute the mean obliquity of the ecliptic, which changes over time and is found by the relationship:

$$\varepsilon_o = 23^\circ\ 26'\ 21''.448 - 46''.8150T - 0''.00059T^2 + 0''.001813T^3$$

Over a 2000 year period the error in ε_o may reach 1" of an arc-degree.

The values of ε_o, α, and δ of the body are required to transform equatorial coordinates to the ecliptic reference system by the following formulas of spherical trigonometry:

$$\lambda = \tan^{-1}[(\sin\alpha\cos\varepsilon + \tan\delta\sin\varepsilon)/\cos\alpha]$$

$$\beta = \sin^{-1}[\sin\delta\cos\varepsilon - \cos\delta\sin\varepsilon\sin\alpha]$$

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102 Jean Meeus, *Astronomical Algorithms*, (Richmond, VA: Willmann-Bell, 1991), 87-88.
103 The number of days since 12:00 UT on January 1st, 4713 BC.

I constructed a spreadsheet to facilitate ecliptic conversion. Required terms are JDE, α in hours, minutes, and seconds, and δ in degrees, minutes, and seconds. Values of α and δ are converted to decimal degrees for the required trigonometric calculations. Results of γ and β are given in both decimal degrees and degrees, minutes, and seconds. To resolve the ambiguity caused by taking $\tan^{-1}$ of y/x, longitudes were calculated for each quadrant. Comparison with body position on the associated chart quickly revealed which value of celestial longitude was correct for the observation. These coordinates were then recorded for further analysis.

Tables

I utilized a second spreadsheet to collect and analyze coordinates and data derived for each of the selected diary observations. This description is given again in Appendix 1. Columns are presented in the following order:

Date – Given as the reference date assigned by Sachs and Hunger in the *Diaries* (e.g., -567 I 8).[104]

Sunset – The local time of sunset on the specified date.

Sunrise – The local time of sunrise on the specified date.

[104] Although months X, XI, XII, and XII2 have dates falling in the following Julian year, Sachs and Hunger keep with the convention of referring to the same year from Nisannu (BAR) through Addaru (ŠE).

Watch – Given as *beg, first, mid,* or *last* as appropriate with the diary entry as beginning, first, middle, or last part of the night. *None* is used when no watch is specified.

Selected Time of Entry – The local time selected and entered into the software for the observation on each selected date.[105]

1st Body 2nd Body – The two bodies specified in the diary entry.

Ecl Long Decimal – Ecliptic longitude specified in decimal degrees.

Ecl Lat Decimal – Ecliptic latitude specified in decimal degrees.

Ang Dist – Angular distance in both celestial longitude and celestial latitude. Difference taken as absolute values with formulas written to the spreadsheet. The upper value is the difference between the two bodies in celestial longitude in angular degrees. The lower value is the difference between the two bodies in celestial latitude in angular degrees.

Cubits(c)/Fingers(f) – Dimensions taken from *Diary* entry descriptions. Specified in cubits, fractions of a cubit, and in fingers. The relationship between cubits and fingers is taken with the Late Babylonan convention that 24 fingers equal one cubit.

Dec Dist in Cubits – The decimal distance equivalent of the specified number of cubits and fingers as related in the diary entry. One cubit is taken as 24 fingers.

Ang Deg/Cubit – The appropriate angular distance divided by the specified decimal distance to yield the number of angular degrees per cubit. Taken by formulas written to the spreadsheet.

Topo Rel – Topographical relations as taken from descriptions in diary entries.

+Abv/Ifo –Blw/Bhd – Difference taken with formulas written to the spreadsheet. Celestial latitude is used if "above" or "below." If the difference is positive then the first body is "above" the second

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[105] One seasonal hour after sunset or before sunrise or six seasonal hours after sunset, as appropriate.

body. A negative difference indicates the first body is "below" the second. Celestial longitude is used if "in front of" or "behind." If the difference is positive then the first body is "in front of" the second body. If the difference is negative then the first body is "behind" the second body.

Procedure

Each selected entry from the *Diaries* was processed and analyzed in the following manner:

1. Whenever the graphical software was initialized, the following selections were made or confirmed:
   a. Bayer letter captions
   b. Magnitude limit of 5.5
   c. Reference lines for horizontal coordinates
   d. Reference lines for ecliptic coordinates
   e. Celestial equator
   f. Constellation diagrams and labels
   g. Geographic location selected.
2. The date of the desired diary entry was converted to the Julian calendar and entered.
3. Local time of entry was selected and entered.
4. Sunrise and sunset times for that day were recorded. Seasonal hours were applied appropriately and the adjusted time was reentered.
5. A graphical depiction of the Mesopotamian night sky at the desired moment in time was then produced.
6. The first body was centered on the screen.
7. Depictions were visually checked for correlation with diary descriptions.

8. The following information was derived from the graphical software:

   a. Apparent topocentric coordinates for α and δ of the first and second bodies.

   b. JDE.

   c. A printed graphical depiction of the Mesopotamian sky for each selected entry. Under "Map Title" the reference date was written as given by Sachs and Hunger for the desired entry (e.g., -308 VI 15). This appears as the title at the top of the chart.

9. Data was then recorded in the "Diary Analysis" spreadsheet. (Date, Watch, Time of Entry, Sunset, Sunrise, and First and Second bodies.)

10. The "Ecliptic Conversion" spreadsheet was used to determine celestial longitude and celestial latitude. Enter JDE, equatorial coordinates of α as hours, minutes, and seconds and δ as degrees, minutes, and seconds. Obtain resultant λ and β in degrees, minutes, and seconds and in decimal degrees. Resolve ambiguity of λ through visual confirmation in the graphical depiction.

11. Data was entered to the remaining columns of the "Diary Analysis" spreadsheet.

    a. Record ecliptic decimal coordinates.

    b. Angular Distance in degrees as given by formulas written in the spreadsheet.

    c. Record the diary description of distance in cubits and fingers.

    d. Convert and record this distance in decimal cubits.

e. Angular Distance in degrees per cubit is given by formulas written in the spreadsheet.

f. Record the topographical relation of "In front of," "Behind," "Above," or "Below" as given in the diary entry.

g. Positive signs denoting "Above" and "In front of" or negative signs denoting "Below" and "Behind" are given by formulas written in the spreadsheet.

12. Each diary entry was compared with the tabular data and the corresponding sky depictions on the star-charts. These findings are presented in Chapter 10.

Chapter 10

Analysis

Each entry of this study was individually evaluated and those findings follow in this chapter. Numerical results are compiled on tables presented in Appendix 1. Star-charts depicting the Mesopotamian night sky at the time of each entry are included in Appendix 2. The charts and tables are intended for reference while reading these analytical findings. All three documents incorporate the dating system employed by Sachs (e.g., -567 I 9) and can be cross-referenced with such. Entries are arranged chronologically.

The main body of this chapter is divided into three sections, one for each volume of the *Diaries*. The year and month are listed first and are then followed by the reference date and its Julian equivalent. The text of the scribal entry is given in italics and is followed by my analysis. These analyses include the introduction of the Akkadian and modern names of the normal stars, the position of the first body in relation to the second body in angular degrees of longitude or latitude, the associated angular equivalent of a cubit in degrees of longitude or latitude, analytical observations and comments, and page references for the corresponding star-chart(s). When an estimate of the time of observation can be made, that information is included here, as are errata discovered through graphical analysis of the diary entries.

Certain entries contain multiple dimensions. These become more prevalent during the time of Parthian rule. The techniques for astronomical observations may have become better refined by this time, or the astronomers may simply have wanted to be more precise in their descriptions. Some of these entries specify four directions and thereby pinpoint the position of the body fairly well.

My efforts to estimate actual times of observation are sometimes fixed by astronomical events, such as risings and settings of the celestial bodies in question. At other times they reflect a supposition based upon the assumed size of a cubit in angular degrees. The "Ang Deg/Cubit" column that is found in Appendix 1 lists the value of a cubit in angular degrees for each selected diary entry. The figure in this column is a simple arithmetic calculation of the difference either between the "Ecl Long Decimal" of the two bodies for "in front of" and "behind," or the "Ecl Lat Decimal" for "above" and "below." Coordinates for the moon are somewhat sensitive to variations in the "Selected Time of Entry." As observation times were never clearly defined by the Babylonians, those utilized here are only an estimate for the purposes of analysis. I have chosen to standardize my times as being one seasonal hour after sunset for the evening entries, one seasonal hour before sunrise for the morning entries, and six seasonal hours after sunset for entries in the middle of the night. Seasonal hours are described in the "Diary Entries" section of Chapter 9.

I found that the value of angular degrees per cubit varied considerably among the entries that I examined. Therefore precise estimation of the size of a cubit proved somewhat elusive. I performed an analysis to determine both the arithmetic mean and the median of the values in the "Ang Deg/Cubit" column for the study as a whole and also for smaller sub-populations. For the overall results I utilized the values for all entries except for two that were originally added only to illustrate errata in their corresponding diary descriptions. The results, in angular degrees per cubit, are as follows:

	Samples	Mean	Median
Overall	200	2.38	2.29

The positions of the planets as a first body are not as sensitive to variations in the time of entry as are those for the moon. I evaluated the planets separately with these results:

	Samples	Mean	Median
Planets	28	2.44	2.41

Entries of "above" and "below" in celestial latitude are also not subject to time changes to the same extent as are those of celestial longitude. I evaluated them both as follows:

	Samples	Mean	Median
Latitude	82	2.42	2.36
Longitude	118	2.36	2.23

I examined the entries as distributed through each of the three volumes of the *Diaries* and include those results here:

	Samples	Mean	Median
Volume I	68	2.38	2.36
Volume II	70	2.40	2.37
Volume III	62	2.37	2.21

Astronomy thrived in Babylonia during the period of Archaemenid rule from 539-333 BC. The Seleucid Era lasted from 323 BC, following the death of Alexander the Great, until 140. Babylonian mathematical astronomy reached full maturity during this time and began to greatly influence the astronomy of the Greeks. The Parthians, from Persia, controlled Babylon for the next three and a half centuries, including the last years of the *Diaries*, from 140 to 61 BC. I examined the cubit dimensions relative to each of these three periods of time with the following results:

	Samples	Mean	Median
Archaemenid[106]	37	2.47	2.39
Seleucid	101	2.36	2.35
Parthian	62	2.37	2.21

[106] Includes entries prior to this period for the year 568 BC.

Through my analysis I found no distinct difference between values derived from each of the three volumes of the *Diaries*. The three historical periods remain fairly constant as well. The entries selected from Volume III are also the same as those for the Parthian period. The median value does decrease somewhat during this time.

Gerd Graßhoff has postulated the angular size of a cubit to be approximately 2.4 degrees. Others, however, maintain that this figure is closer to 2.2 degrees. My overall arithmetic mean of 2.38 is closer to Graßhoff's value, while the median of 2.29 more nearly approximates the lower figure.

Both the planetary entries and also those measuring celestial longitude produced values similar to the overall results. As these categories are less time sensitive, this finding adds to my assumption that the observations took place approximately one seasonal hour after sunset or one seasonal hour before sunrise.

My study has not been extensive enough to definitively isolate the angular dimension of a cubit. To do so I would want to examine a much greater population throughout the entire span of the *Diaries*. In the analysis of the individual entries to follow, any mention of adjusting the time of entry in order to increase or decrease the number of degrees per cubit is made with the assumption that the size lies somewhere in the range of 2.2 to 2.4.

VOLUME I – DIARIES FROM 652 BC TO 262 BC

NEBUKADNEZAR II YEAR 37, *Nisannu* (BAR)

-567 I 9
(30 April – 1 May 568 BC)

> *Night of the 9th (error for: 8th), beginning of the night, the moon stood 1 cubit in front of β Virginis.*

The common name for β Virginis (β Vir) is *Zavijava,* known to the Babylonian's as "The rear foot of the Lion." The transliteration, as written in the *Astronomical Diaries,* is GÌR *ár šá* A. While Babylonians grouped this star with Leo, modern placement of *Zavijava* is in Virgo. The moon was called *Sin.*

At 19:32 the moon was 10.87 degrees of longitude behind β Vir at 10.87 degrees per cubit. The moon was not near β Vir, but instead was closer to γ Virginis (γ Vir). This is *Porrima,* "The Single star in front of the Furrow," also DELE *šá* IGI ABSIN. The moon's position near γ Vir is quickly recognizable as that representing one-day's travel from the vicinity of β Vir. On –567 I 8 at 19:32 the moon was 1.91 angular degrees of longitude in front of β Vir at 1.91 degrees per cubit (–567 I 8, page 191 and –567 I 9, page 192).

A mistake has likely been made regarding this observation. On –567 I 9 the moon was nearly 11 degrees of celestial longitude east of where it was recorded as being, while on –567 I 8 the moon was very close to where it was described in the diary entry. It is probable that the date is in error and should be the 8th instead of the 9th. Sachs and Hunger noted this in the diary translation as "(error for: 8th)."

NEBUKADNEZAR II YEAR 37, *Ajjaru* (GU_4)

-567 II 1

(22 - 23 May 568 BC)

> *...the moon became visible while the sun stood there, 4 cubits below β Geminorum; it was thick; there was earthshine [...]*

This entry is for the first day of the month and does not specify a watch. The common name for β Geminorum (β Gem) is *Pollux*, one of the twin stars of Gemini. Transliterated from cuneiform, it is MAŠ-MAŠ *ár*, or "The rear Twin star." Castor, or α Geminorum (α Gem), is "The front Twin star," MAŠ-MAŠ IGI. In ecliptic orientation Pollux has a greater celestial longitude than does Castor; therefore Castor is in front of Pollux, thus the names *front* and *rear*.

At 19:43 the moon was 7.50 degrees of latitude below β Gem at 1.88 degrees per cubit (–567 II 1, page 193). The sun has just set and the new crescent moon is about 11 degrees above the western horizon. The star-charts are constructed with reference to the horizon so that altitude runs straight up and down and azimuth is left and right. In this system the moon was to the left of β Gem. In the ecliptic frame of reference, if the chart is turned so that the ecliptic is horizontal, the moon lies almost directly below β Gem. The moon was also below β Gem in the equatorial system, but was over 22 degrees above the celestial equator.

NEBUKADNEZAR II YEAR 37, *Simānu* (SIG)

-567 III 1

(20 – 21 June 568 BC)

> *...the moon became visible behind Cancer, it was thick, sunset to moonset: 20 deg; the north wind blew. At that time, Mars and Mercury were 4 cubits in front of α [Leonis...]*

This entry is at the beginning of the lunar month and the crescent moon, Mercury, Mars, and α Leonis (α Leo) are just above the western horizon. *Regulus* is the common name for α Leo and the corresponding transliteration is LUGAL, or "The King." The Babylonian scribe decided not to use the moon in this observation and I've chosen to measure the angular distance to Mars instead of Mercury. Mars is AN, also know to the Babylonians as *Nergal*, the god of war and pestilence. Mercury is GU_4-UD.

At 1955 Mars was 7.36 angular degrees in front of α Leo at 1.84 degrees per cubit. Orienting the chart (-567 III 1, page 194) so that the ecliptic is horizontal, Mars was in front of α Leo, both almost on the ecliptic.

NEBUKADNEZAR II YEAR 37, *Simānu* (SIG)

-567 III 1

(20 – 21 June 568 BC)

> *...the moon became visible behind Cancer, it was thick, sunset to moonset: 20 deg; the north wind blew. At that time, Mars and Mercury were 4 cubits in front of α [Leonis...]*

This entry is at the beginning of the lunar month and the crescent moon, Mercury, Mars, and α Leonis (α Leo) are just above the western horizon. *Regulus* is the common name for α Leo and the corresponding transliteration is LUGAL, or "The King." The Babylonian scribe decided not to use the moon in this observation and I've chosen to measure the angular distance to Mars instead of Mercury. Mars is AN, also know to the Babylonians as *Nergal*, the god of war and pestilence. Mercury is GU_4-UD.

At 1955 Mars was 7.36 angular degrees in front of α Leo at 1.84 degrees per cubit. Orienting the chart (-567 III 1, page 194) so that the ecliptic is horizontal, Mars was in front of α Leo, both almost on the ecliptic.

above α Sco and between it and the moon, but was not mentioned in this diary entry.

-567 III 12

(1 – 2 July 568 BC)

> *...Mars was 2/3 cubit above α Leonis...*

At 19:59 Mars was 0.86 degrees of latitude above α Leonis (α Leo) at 1.28 degrees per cubit, a value that is a little lower than expected. (See both the normal and enlarged charts for –568 III 12 on pages 197-198). Mars was almost directly above α Leo with respect to the ecliptic and both were low on the western horizon.

ARTAXERXES I YEAR I, *Ulūlu* (KIN)

-463 VI 22

(29 - 30 September 464 BC)

> *...Night of the 22nd, last part of the night, the moon was balanced 3 cubits below α Leonis.*

At 04:55 the moon was 5.33 angular degrees of latitude below α Leo at 1.78 degrees per cubit. With reference to the ecliptic, the moon was directly below α Leo (-463 VI 22, page 199).

DARIUS II YEAR 5, *Nisannu* (BAR)

-418 I 7

(1 – 2 April 419 BC)

> *...night of the 7th, first part of the night, Venus was 8 fingers below β Tauri, Venus having passed 4 fingers to the east.*

Venus was known to the Babylonians as *dele-bat* and represented *Išhtar*, the goddess of love and fertility. β Tauri (β Tau) is known to us as *El Nath*, but to the Babylonians it was "The northern … of the Chariot" and written as ŠUR GIGIR *šă* SI. While we include *El Nath* with Taurus, the Babylonians placed it in Auriga, the Charioteer. The orientations of north and south again appear to refer to the ecliptically related travel of the planets. ŠUR GIGIR *šă* ULÙ means "The southern … of the Chariot," a star we know as ζ Tauri (ζ Tau), which has no official common name. Both β Tau and ζ Tau are aligned north and south in ecliptic latitude, respectively (-418 I 7, page 200).

At 19:15 Venus was 0.8 angular degrees of latitude below β Tau at 2.42 degrees per cubit. The enlarged view (-418 I 7, page 201) shows Venus low and behind β Tau in relation to the ecliptic. The diary description has Venus 4 fingers to the east of β Tau, which is clearly shown on the enlarged star chart.

-418 I 9

(4 – 5 April 419 BC)

> *Night of the 9th, middle part of the night, the moon was 3 fingers in front of Mars, the moon being a little low to the south.*

At 00:16 the moon was 0.61 degrees of longitude in front of Mars at 4.89 degrees per cubit, and "a little low to the south" (-418 I 9, pages 202-203). If this observation were made one seasonal hour later at 01:16, the moon would be 0.16 degrees of longitude in front of Mars at 1.28 degrees per cubit (-418 I 9, pages 204-205). I have chosen to evaluate *middle part of the night* as six seasonal hours after sunset. If recorded accurately, this observation may have occurred sometime between the sixth and seventh hours.

DARIUS II YEAR 5, *Ajjaru* (GU_4)

-418 II 7

(1 – 2 May 419 BC)

> *...night of the 7th, the moon was 2/3 cubit in front of Mars, the moon being a little high to the north.*

At 19:30 the moon was 2.56 angular degrees of longitude in front of Mars at 3.84 degrees per cubit (-418 II 7, page 206). When viewed in relation to the ecliptic, it was also "a little high to the north." If the entry were made one seasonal hour later, it would reduce the value of degrees per cubit somewhat.

-418 II 9

(3 – 4 May 419 BC)

Night of the 9th, Mars was 4 cubits below θ Leonis.

θ Leonis (θ Leo) is *Chertan*, or to the Babylonians "The Rump of the Lion," written as GIŠ.KUN A.

At 19:31 Mars was 7.97 degrees of latitude below θ Leo at 1.99 degrees per cubit (-418 II 9, page 207).

DARIUS II YEAR 5, *Addaru II* (DIR-ŠE)

-418 XII_2 13

(28 – 29 March 418 BC)

> *Night of the 13th, beginning of the night, Mercury was 1 2/3 cubit in front of η Tauri.*

Addaru II is an intercalary month added to the calendar every 3rd, 6th, 8th, 11th, 14th, and 19th year of the 19-year cycle devised by the Babylonians to keep the lunar months and solar years in alignment. *Addaru II* is the last month of the year and is designed to draw the beginning of the year back near the vernal equinox.[107]

η Tauri (η Tau) is *Alcyone*, one of the seven sisters of the Pleiades. The Pleiades figure prominently in the astronomical observations of many ancient cultures. To the Babylonians this was MÚL-MÚL, or "The Bristle."

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[107] When evaluating intercalary months I have elected to apply the same seasonal hour value as in the month previous.

At 19:17 Mercury was 4.49 degrees of longitude in front of η Tau at 2.70 degrees per cubit. In the horizon system Mercury was below η Tau (-418 XII_2 13, page 208), and in reference to the celestial equator it was low to the right. The description best fits an orientation with the ecliptic.

If this entry had been made at two seasonal hours after sunset, instead of one, Mercury would have set below the western horizon (-418 XII_2 13, page 209).

ARTAXERXES II YEAR 20, *Addaru* (ŠE)

-384 XII 4

(3 – 4 March 384 BC)

> *[Night of the 4th, beginning of the night, the moon was] 2 cubits 8 fingers [behind] α Tauri.*

The Babylonians called α Tauri (α Tau) "The Jaw of the Bull," or *is* le_{10}. Today's common name for α Tau is *Aldebaran.*

At 19:01 the moon was 3.17 degrees of longitude behind α Tau at 2.33 degrees per cubit.

With reference to the ecliptic the moon is directly behind α Tau, when oriented to the horizon it is above it and, in relation to the celestial equator it is both above in declination and behind in right ascension (-383 XII 4, page 210).

-384 XII 5

(4 – 5 March 384 BC)

> *Night of the 5th, beginning of the night, the moon was 14 fingers behind ζ Tauri, behind Saturn […]*

At 19:02 the moon was 1.76 degrees of longitude behind ζ Tau at 3.04 degrees per cubit (-384 XII 5, page 211). Sunset occurred at 17:58, so this observation likely took place close to 19:02, shortly after ζ Tau, a 3.00 magnitude star, first became visible.

ARTAXERXES II YEAR 32, *Nisannu* (BAR)[108]

-372 I 4

(31 March – 1 April 373 BC)

> *[…Night of the 4th, beginning of the night,] the moon was 2 2/3 cubits [behind] μ Geminorum; Mercury's [first appearance] in the west, 1 cubit 6 fingers above Jupiter, Mercury being a little? …*

The Babylonians called μ Geminorum (μ gem) "The rear star of the Twins' feet." This transliterates as MÚL *ár šá še-pít* MAŠ-MAŠ. η Geminorum (η Gem) is *Propus*, or "The front star of the Twins' feet," transliterated as MÚL IGI *šá še-pít* MAŠ-MAŠ. The direction in both cases once again correlates to celestial longitude and the direction of planetary travel across the sky.

At 19:15 the moon was 5.28 degrees of longitude behind μ gem at 1.98

[108] In this year fairly complete months of entries become more common.

degrees per cubit. The moon was actually closest to ε Gem, but this is not one of the normal stars used in the *Diaries*. In relation to the horizon, the moon was above and slightly right of μ gem, and when aligned with the celestial equator it was behind and above (-372 I 4, page 212).

At 19:15 Mercury was 2.76 degrees of latitude above Jupiter at 2.20 degrees per cubit. Mercury set below the western horizon prior to the next seasonal hour (-372 I 4, page 213). Mercury was directly above Jupiter, if viewed with an ecliptic perspective.

-372 I 5

(1 – 2 April 373 BC)

> *[...Night of the 5th, beginning of the ni]ght, the moon was ½ cubit behind β Geminorum.*

At 19:16 the moon was 1.44 degrees of longitude behind β Gem at 2.88 degrees per cubit (-372 I 5, page 214).

-372 I 7

(3 – 4 April 373 BC)

> *Night of the 7th, first part of the night, Mercury was 2/3 cubit below η Tauri.*

At 19:17 Mercury was 1.40 degrees of latitude below η Tau at 2.10 degrees per cubit (-372 I 7, page 215). Mercury set prior to the second seasonal hour.

-372 I 8

(4 – 5 April 373 BC)

> *[...Night of the 8th, beginn]ing of the night, the moon was 2 ½ cubits behind α Leonis; Venus was 2 2/3 cubits above α Tauri.*

At 19:18 the moon was 6.74 degrees behind α Leo at 2.70 degrees per cubit. A nearby normal star, often used in the diaries, is ρ Leonis (ρ Leo), or MÚL TUR *šá* 4 KÙŠ *ár* LUGAL, "The small star which is 4 cubits behind the King." The moon most likely either occulted ρ Leo or obscured it by its brilliance (-372 I 8, page 216). Instead the entry was made with reference to α Leo.

At the same time Venus was 6.27 degrees of latitude above α Tau at 2.35 degrees per cubit (-372 I 8, page 217).

-372 I 12

(8 – 9 April 373 BC)

> *[Night of the 12th], first part of the night, the moon was 2 cubits behind α Virginis.*

The Babylonian name for α Virginis (α Vir) was transliterated as SA_4 *šá* ABSIN, or "The bright star of the Furrow." We know it as *Spica*.

At 19:20 the moon was 4.08 degrees of longitude behind α Vir at 2.04 degrees per cubit. In this lunation the moon has passed below α Vir in relation to the ecliptic and has traveled 4 degrees beyond (-372 I 12, page 218).

-372 I 16

(12 - 13 April 373 BC)

> *<Night> of the 16th, last part of the night, the moon was ½ cubit below θ Ophiuchi, the moon being 1 cubit…*

θ Ophiuchi (θ Oph) is another star commonly used in diary entries. It is "The bright star on the tip of Pabilsag's arrow," or MÚL KUR *šá* KIR_4 *šil* PA.

This observation was made in "the last part of the night," with sunrise at 05:38. At 04:38 the moon was 3.01 degrees of latitude below θ Oph at 6.02 degrees per cubit (-372 I 16, page 219). As the moon's path across the sky roughly parallels that of the ecliptic, varying the time of entry will do little to reduce latitude discrepancies in degrees per cubit. This may have been a poor observation.

-372 I 18

(13 – 14 April 373 BC)

> *Night of the 18th, first part of the night, Venus was 1 ½ cubits below β Tauri.*

In the Julian calendar this observation was made in the evening of the same day as the previous morning entry. At 19:23 Venus was 4.10 degrees of latitude below β Tau at 2.73 degrees per cubit. It was positioned both below and slightly in front of β Tau (-372 I 18, page 220).

-372 I 21

(17 – 18 April 373 BC)

> *<Night> of the 21st, first part of the night, Venus was 1 ½ cubits above ζ Tauri.*

At 19:25 Venus was 3.73 degrees of latitude above ζ Tau at 2.49 degrees per cubit. In the ecliptic system Venus was above and slightly behind ζ Tau. In reference to the celestial equator it was more directly above, and relative to the horizon Venus was both above and to the left (-372 I 21, page 221).

ARTAXERXES III YEAR 12, *Kislīmu* (GAN)

-346 IX 8

(9 – 10 December 347 BC)

> *Night of the 8th, beginning of the night, the moon was ½ cubit behind η Piscium; [last part of the ni]ght, Jupiter, while moving back to the west, was 8 fingers above ρ Leonis.*

At 18:07 the moon was 0.11 degrees of longitude behind η Psc at 0.22 degrees per cubit. While the moon is behind η Psc, the two bodies are almost in ecliptic vertical alignment. It takes up to four seasonal hours to significantly increase this separation in longitude. This observation is difficult to reconcile with the *beginning of the night* (-346 IX 8, pages 222 – 224).

Later that same Babylonian night, at 05:46 Jupiter was 1.01 degrees of latitude above ρ Leo at 3.06 degrees per cubit (-346 IX 8, pages 225-226). The star ρ Leo is interesting because its Babylonian name specifies that it is 4 cubits behind α

Leo. They both are pretty much on the ecliptic and are 6.41 degrees of celestial longitude apart. Divided by 4, however, this gives only 1.6 degrees per cubit.

This description of Jupiter has the planet in retrograde motion.

-346 IX 9

(10 – 11 December 347 BC)

> *Night of the [9th], first part of the night, the moon stood 2 cubits in front of Mars to the west; it was overcast.*

At 18:07 the moon was 7.40 degrees of longitude in front of Mars at 3.70 degrees per cubit (-346 IX 9, page 227). A later observation would decrease the number of degrees per cubit, but would become so late that it no longer would fit the *first part of the night* description.

-346 IX 12

(13 – 14 December 347 BC)

> *Night of the 12th, beginning of the night, the moon was 1 cubit below ζ Tauri.*

At 18:07 the moon was 2.91 degrees of latitude below ζ Tau at 2.91 degrees per cubit and the moon was directly beneath ζ Tau in relation to the ecliptic (-346 IX 12, page 228).

-346 IX 13

(14 – 15 December 347 BC)

> *Night of the 13th, moonrise to sunset: 11 degrees, measured (despite) clouds; beginning of the night, the moon was 20 fingers above γ Geminorum, the moon having passed 1 cubit to the east.*

The common name for γ Geminorum (γ Gem) is *Alhena*, a second magnitude star on the eastern end of Gemini. The Babylonians referred to γ Gem as "The Twins' star near the Shepherd." The transliteration is written as MAŠ-MAŠ *šá* SIPA.

At 18:07 the moon was 2.28 degrees of latitude above γ Gem at 2.75 degrees per cubit. In reference to the ecliptic the moon is both above and behind γ Gem (-346 IX 13, page 229).

-346 IX 16

(17 - 18 December 347 BC)

> *Night of the 16th, last part of the night, the moon was ½ cubit behind α Leonis, it stood 2 cubits in front of Jupiter to the west.*

At 05:52 the moon was 1.09 degrees of longitude behind α Leo at 2.18 degrees per cubit. Sunrise on this date occurred at 07:00. The moon was also 4.80 degrees of longitude in front of Jupiter at 2.40 degrees per cubit (-346 IX 16, page 230).

-346 IX 18

(19 - 20 December 347 BC)

> *Night of the 18th, last part [of the night, the moon] was 1 cubit behind β Virginis.*

At 05:54 the moon was 2.52 degrees of longitude behind β Vir at 2.52 degrees per cubit. The moon was east of β Vir, and only slightly higher (-346 IX 18, page 231).

-346 IX 20

(21 - 22 December 347 BC)

> *Night of the 20th, last part of the night, the moon was 2/3 cubit behind α Virginis, ½ cubit above Saturn, the moon having passed 8 fingers to the east.*

At 05:55 the moon was 1.60 degrees of longitude behind α Vir at 2.39 degrees per cubit (-346 IX 20, page 232).

The moon was also 1.28 degrees of latitude above Saturn and 1.26 degrees of longitude behind the planet. Included is an enlarged view (-346 IX 20, page 233).

-346 IX 22

(23 - 24 December 347 BC)

> *[...Night of the 22nd, last part of the night, the moon was] 1 ½ cubits below β Librae.*

At 05:56 the moon was 4.02 degrees of latitude below β Lib at 2.68 degrees per cubit. The moon lies below β Lib (-346 IX 22, page 234).

-346 IX 23

(24 - 25 December 347 BC)

> *Night of the 23rd, last part of the night, the moon was 1 ½ cubits above β Scorpii, the m[oon] being 8 fingers back to the west.*

The common name for β Scorpii (β Sco) is *Graffias*. *Graffias* is a second-magnitude star at the western end of *Scorpius*. It transliterates as MÚL *e šá* SAG GÍR-TAB or, as the Babylonians knew it, "The upper star of the Head of the Scorpion." Once again an orientation to the path of the planets across the sky appears to have been used when naming these bodies. "The middle star of the Head of the Scorpion" is δ Scorpii (δ Sco) and is written in as MÚL $MURUB_4$ *šá* SAG GÍR-TAB. It later became known as *Dschubba*, another second-magnitude star, also at the western end of *Scorpius* and below *Graffias*. A third star of the second magnitude below the other two, π Scorpii (π Sco), is referenced as "The [lower] star of the Head of the Scorpion." Transliterated, this is MÚL SIG *šá*

SAG GÍR-TAB. The directions of upper, middle, and lower all correlate with celestial latitude (-346 IX 23, pages 235-236).

At 05:56 the moon was 3.54 degrees of latitude above β Sco at 2.36 degrees per cubit.

ALEXANDER IV YEAR 8, *Ulūlu* (KIN)
-308 VI 4
(6 - 7 September 309 BC)

> *Night of the 4th, beginning of the night, the moon was 4 cubits above α Scorpii, the moon having passed ½ cubit to the east.*

At 19:20 the moon was 8.46 degrees of latitude above α Sco at 2.12 degrees per cubit. It also lies just east of α Sco in celestial longitude (-308 VI 4, page 237).

-308 VI 6

(8 – 9 September 309 BC)

> *Night of the 6th, beginning of the night, the moon stood 2 2/3 cubits in front of Saturn to the west.*

At 19:17 the moon was 5.70 degrees of longitude in front of Saturn at 2.14 degrees per cubit. The moon was west of Saturn in longitude, and was also a little north of the planet in latitude (-308 VI 6, page 238).

-308 VI 8

(10 – 11 September 309 BC)

> *Night of the 8th, beginning of the night, the moon was ½ cubit in front of β Capricorni.*

At 19:15 the moon was 0.90 degrees of longitude in front of β Cap at 1.80 degrees per cubit. Sunset was at 18:19. An earlier observation would increase the rate per cubit, but there is not enough time remaining between sunset and 19:15 (-308 VI 8, page 239).

-308 VI 15

(17 – 18 September 309 BC)

> *[Night of the 15th, beginning of the ni]ght, the moon was 2/3 cubit in front of η Piscium; last part of the night, Mars was 3 ½ cubits below ε Leonis.*

The Babylonians referred to η Piscium (η Psc) as "The bright star of the Ribbon of the Fishes," which transliterated from cuneiform is MÚL KUR *šá* DUR nu-nu. *Ras Elased Australis* is the common name for ε Leonis (ε Leo). This is written as SAG A and means "The Head of the Lion."

At 19:06 the moon was actually 0.91 degrees east of η Psc, not west as recorded by the scribe (-308 VI 15, page 240). The sun set at 18:10, but the moon did not rise until 18:37. As a third magnitude star, η Psc requires the sky to darken considerably before becoming visible. Repositioning the moon "in front of" η Psc requires an observation over two hours earlier to minimally place the moon on the west side. This entry quite possibly contains an error in either the recording of the observation, or in its translation.

At 04:46 Mars was 8.38 degrees of latitude below ε Leo at 2.39 degrees per cubit, a much better measurement than earlier in the night (-308 VI 15, page 241).

-308 VI 19

(21 - 22 September 309 BC)

> *Night of the 19th, last part of the night, <the moon> was 2 ½ cubits in front of ζ Tauri.*

At 04:49 the moon was 4.79 degrees of longitude in front of ζ Tau at 1.92 degrees per cubit. The moon was both in front of ζ Tau, and just slightly low (-308 VI 19, page 242).

-308 VI 22

(24 - 25 September 309 BC)

> *[...Night of the 22nd, last part of the night, the moon was] 2 2/3 cubits [behind] β Geminorum.*

At 04:52 the moon was 5.76 degrees of longitude behind β Gem at 2.16 degrees per cubit. The moon was behind and below β Gem (-308 VI 22, page 243).

-308 VI 23

(25 - 26 September 309 BC)

> *Night of the 23rd, last part of the night, the moon was 2 cubits behind δ Cancri.*

Cancer is another excellent example of the directional orientations of the names of Babylonian stars. The Babylonian name for δ Cancri (δ Cnc) is "The rear star of the Crab to the south." In its transliteration it is written as MÚL *ár šá* ALLA *šá* ULU. The common name for δ Cnc is *Asellus Australis*. "The front star of the Crab to the south" is θ Cancri (θ Cnc), and is transliterated as MÚL IGI *šá* ALLA *šá* ULU. "The front star of the Crab to the north" is η Cancri (η Cnc). Transliterated this is MÚL IGI *šá* ALLA *šá* SI. *Asellus Borealis* is γ Cancri (γ Cnc), or "The rear star of the Crab to the north." It is transliterated as MÚL *ár šá* ALLA *šá* SI. These four star names each contain two directions - front, rear, north, or south. All relate to positioning relative to the motion of the planets across the sky (-308 VI 23, page 244).

At 04:52 the moon was 4.42 degrees of longitude behind δ Cnc at 2.21 degrees per cubit.

-308 VI 24

(26 - 27 September 309 BC)

> *Night of the 24th, last part of the night, the moon was 1 cubit in front of α Leonis, behind […]*

At 04:53 the moon was 2.71 degrees of longitude in front of α Leo at 2.71 degrees per cubit. The moon is directly in front of α Leo, and both are on the ecliptic. In the horizon system the moon is above α Leo, and in reference to the celestial equator the moon is smaller in right ascension (-308 VI 24, page 245).

-308 VI 27

(29 - 30 September 309 BC)

> *Night of the 27th, beginning of the night, lightning flashed continuously between north and west; last part of the night, the moon was ½ cubit behind γ Virginis […]*

At 04:55 the moon was 1.61 degrees of longitude behind γ Vir at 3.22 degrees per cubit (-308 VI 27, page 246). The moon first rose about two seasonal hours prior to sunrise.

SELEUCID ERA YEAR 23, *Tašrītu* (DU_6)

-288 VII 4

(25 – 26 September 289 BC)

> *[...] Night of the 4^th^, beginning of the night, the moon was 1 ½ cubits above θ Ophiuchi.*

At 18:59 the moon was 3.14 degrees of latitude above θ Oph at 2.09 degrees per cubit (-288 VII 4, page 247). The moon was both above in latitude and behind in longitude.

-288 VII 7

(28 – 29 September 289 BC)

> *[...Night] of the 7^th^, beginning of the night, the moon was 2 cubits behind β Capricorni.*

To the Babylonians β Capricorni (β Cap) was SI MÁŠ, "The Horn of the Goat-fish." The common name for β Cap is *Dabih*.

At 18:55 the moon was 5.53 degrees of longitude behind β Cap at 2.77 degrees per cubit. The moon was both behind and below β Cap (-288 VII 7, page 248).

-288 VII 8

(29 – 30 September 289 BC)

> *Night of the 8th, beginning of the night, the moon was 6 fingers below δ Capricorni.*

Capricorn, too, has stars named by the Babylonians in reference to the direction of ecliptic travel. *Deneb Algedi* is δ Capricorni (δ Cap), named "The rear star of the Goat-fish" by the Babylonians. The transliteration is MÚL *ár šá* SUḪUR MÁŠ. *Nashira*, or γ Capricorni (γ Cap), is "The front star of the Goat-fish" and is written as MÚL IGI *šá* SUḪUR MÁŠ. First in longitude is γ Cap, which is followed closely by δ Cap as "front" and "rear."

At 18:54 the moon was 0.76 degrees below δ Cap at 3.04 degrees per cubit (-288 VII 8, page 249). Angular distances in fingers appear to have been a challenge to measure accurately.

-288 VII 15
(6 - 7 October 289 BC)

> *Night of the 15th, last part of the night, the moon was 1 cubit behind η Tauri.*

At 04:57 the moon was 0.33 degrees of longitude behind η Tau at 0.33 degrees per cubit (-288 VII 15, page 250). Sunrise occurred at approximately 05:57, thus leaving insufficient time to increase the value of degrees per cubit significantly.

This discrepancy might be attributable to imprecise recording or copying on the part of the scribe.

-288 VII 18

(9 - 10 October 289 BC)

> *Night of the 18th, middle part of the night, the moon was 8 fingers below μ Geminorum.*

At 23:41 the moon was 0.99 degrees of latitude below μ Gem at 3.00 degrees per cubit. The moon was directly below μ Gem in relation to the ecliptic (-288 VII 18, page 251). Midnight begins the next Julian day.

-288 VII 22

(13 - 14 October 289 BC)

> *Night of the 22nd, last part of the night, the moon was 2 cubits in front of α Leonis.*

At 05:02 the moon was 4.90 degrees of longitude in front of α Leo at 2.45 degrees per cubit. The moon was both lesser in celestial longitude and greater in celestial latitude than was α Leo (-288 VII 22, page 252).

-288 VII 23

(14 - 15 October 289 BC)

> *[...Night of the 23rd, last part of the night, the moon was] 1 cubit [behind ρ Leo]nis.*

At 05:03 the moon was 1.13 degrees of longitude behind ρ Leo at 1.13 degrees per cubit (-288 VII 23, page 253). Sunrise occurred at 06:03, not allowing sufficient time to increase the value of degrees per cubit. Additionally, with a magnitude of 3.85, ρ Leo would quickly disappear in the morning twilight.

-288 VII 25

(16 - 17 October 289 BC)

> *Night of the 25th, last part of the night, the moon stood 2 cubits in front of Saturn to the [west].*

At 05:05 the moon was 5.75 degrees of longitude in front of Saturn at 2.88 degrees per cubit. Both bodies were in Virgo and the moon was above as well as in front of Saturn (-288 VII 25, page 254).

-288 VII 27

(18 - 19 October 289 BC)

> *Night of the 27th, last part of the night, the moon stood 2 cubits in front of Jupiter to the west.*

A rather significant error was made in this diary entry. Jupiter was actually in Gemini, over 95 degrees of celestial longitude west of the moon on this day and at this time. Mercury, however, can be found in Virgo nearly where Jupiter was described (-288 VII 27, pages 255-256). This observation was in relation to Mercury and not Jupiter. There may have been an error in recording or in translation.

At 05:07 the moon was 3.65 degrees of longitude in front of Mercury at 1.82 degrees per cubit.

SELEUCID ERA YEAR 50, *Kislīmu*, (GAN)

-261 IX 3

(25 – 26 November 262 BC)

> *[...Ni]ght of the 3rd, the moon was 1 cubit behind δ Capricorni.*

At 18:08 the moon was 2.12 degrees of longitude behind δ Cap at 2.12 degrees per cubit. One seasonal hour of the moon's movement relative to the ecliptic can be seen as the moon passes μ Cap (-261 IX 3, pages 257-258). The moon was both behind δ Cap in longitude and above it in latitude.

-261 IX 7

(29 – 30 November 262 BC)

> *Night of the 7th, beginning of the night, the moon was 2 cubits in front of η Piscium.*

At 18:07 the moon was 5.25 degrees of longitude in front of η Psc at 2.63 degrees per cubit (-261 IX 7, page 259). Eta Piscium was frequently used for observations listed as "in front of" or "behind." On this lunation the moon was almost directly "in front of" η Psc, but at other times it still was referred to as such while being somewhat above or below in latitude.

-261 IX 11

(3 – 4 December 262 BC)

> *Night of the 11th, beginning of the night, the moon was 5 cubits above α Tauri.*

At 18:07 the moon was 9.41 degrees of latitude above α Tau at 1.88 degrees per cubit. The moon was also behind α Tau in celestial longitude (-261 IX 11, page 260).

-261 IX 14

(6 - 7 December 262 BC)

> *Night of the 14th, sunset to moonrise: 3 degrees 20 minutes; measured (despite) clouds; last part of the night, the moon was 1 2/3 cubits below β Geminorum.*

At 05:45 the moon was 5.57 degrees of latitude below β Gem at 3.34 degrees per cubit. The moon was directly below β Gem (-261 IX 14, page 261) and passed at a relatively constant latitude. These value of degrees per cubit may be due to an imprecise observation or transcription.

-261 IX 15

(7 - 8 December 262 BC)

> *Ni[ght of the 15th, last part of the] night, the moon was 1 ½ cubits in front of δ Cancri.*

At 05:45 the moon was 2.82 degrees of longitude in front of δ Cnc at 1.88 degrees per cubit. The moon was directly in front of δ Cnc and both were on the ecliptic (-261 IX 15, page 262).

-261 IX 18

(10 - 11 December 262 BC)

> *Night of the 18th, last part of the night, the moon was 1 ½ cubits in front of θ Leonis, 1 ½ cubits below Saturn, the moon being ½ cubit back to the west.*

At 05:47 the moon was 1.70 degrees of longitude in front of θ Leo at 1.13 degrees per cubit (-261 IX 18, page 263). An earlier time of observation would increase degrees per cubit somewhat.

The moon was also 4.77 degrees of latitude below Saturn at 3.18 degrees per cubit. As this is a measurement of latitude, the error is possibly another due to scribal imprecision.

-261 IX 19

(11 - 12 December 262 BC)

> *[...Night of the 19th, last part of the night, the moon was 1] cubit 8 fingers [in front of β Virginis,] it stood 1 cubit in front of Mars to the west.*

At 05:48 the moon was 2.84 degrees of longitude in front of β Vir at 2.14 degrees per cubit. The moon was also 0.76 degrees of longitude in front of Mars at 0.76 degrees per cubit. The 0.76-degree per cubit value is low, but Mars is the secondary reference. Secondary references may have been subject to a greater amount of estimation. The moon was below as well as in front of both β Vir and Mars (-261 IX 19, page 264).

-261 IX 20

(12 - 13 December 262 BC)

> *Night of the 20th, last part of the night, the moon was 1 ½ cubits in front of γ Virginis.*

At 05:49 the moon was 3.95 degrees of longitude in front of γ Vir at 2.63 degrees per cubit. The moon was both in front of and below γ Vir (-261 IX 20, page 265).

-261 IX 23

(15 - 16 December 262 BC)

> *Night of the 23rd, last part of the night, the moon was [nn] cubits below α Librae, it stood 2 ½ cubits behind Jupiter to the east...*

At 05:51 the moon was 6.31 degrees of latitude below α Lib. If a cubit is taken to be between 2.2 - 2.4 angular degrees, then [nn] could be a value ranging from about 3 to 2 ½ cubits (-261 IX 23, page 266).

The moon is 10.44 degrees behind Jupiter at 4.18 degrees per cubit, possibly due to an imprecise observation. Data for the moon would have to be recorded in "the middle of the night" to significantly reduce the value of degrees per cubit.

-261 IX 25

(17 - 18 December 262 BC)

> *[...Night] of the 25th, last part of the night, the moon was 1 cubit 8 fingers behind α Scorpii.*

At 05:52 the moon was 3.74 degrees of longitude behind α Sco at 2.81 degrees per cubit. The waxing crescent moon was low on the southeastern horizon prior to sunrise (-261 IX 25, page 267).

SELEUCID ERA YEAR 65, *Nisannu* (BAR)

-246 I 4

(17-18 April 247 BC)

> *Night of the 4th, the moon was 1 2/3 cubits in front of α Geminorum.*

At 19:26 the moon was 5.27 degrees of longitude in front of α Gem at 3.16 degrees per cubit. At 20:26 the moon was 4.79 degrees of longitude in front of α Gem at 2.87 degrees per cubit (-246 I 4, pages 268-269). In this case an entry at two seasonal hours after sunset is an improvement over an entry taken at one.

-246 I 5

(18-19 April 247 BC)

> *Night of the 5th, beginning of the night, very overcast, gusty wind, lightning, thunder, thick rain, PISAN DIB; beginning of the night, the moon was 2 cubits 8 fingers behind β Geminorum.*

At 19:26 the moon was 5.25 degrees behind β Gem at 2.25 degrees per cubit (-246 I 5, page 270).

-246 I 7

(20-21 April 247 BC)

> *Night of the 7th, beginning of the night, the moon was 1 2/3? cubits above α Leonis, the moon being 2/3 cubit back to the west.*

At 19:28 the moon was 4.21 degrees of latitude above α Leo at 2.52 degrees per cubit (-246 I 7, page 271). With reference to the ecliptic, the moon is both above and in front of α Leo. In reference to the celestial equator, the moon is above α Leo only.

-246 I 8

(21-22 April 247 BC)

> *Night of the 8th, beginning of the night, the moon was 1 ½ cubits in front of θ Leonis.*

At 19:28 the moon was 1.92 degrees of longitude in front of θ Leo at 1.28 degrees per cubit (-246 I 8, page 272). An earlier observation would increase the degrees per cubit value, but was not likely because sunset occurred at 18:28 and θ Leo is a third magnitude star.

-246 I 10

(23-24 April 247 BC)

> *Night of the 10th, beginning of the night, the moon was 10 fingers above γ Virginis, the moon being 8 fingers back to the west.*

At 19:30 the moon was 1.10 degrees of latitude below γ Vir at 2.62 degrees per cubit. The scribe's description says that the moon was 10 fingers above γ Vir when it actually was below by 10 fingers (-246 I 10, pages 273-274). It also is presently east, not west. An earlier time of entry would help, but only 1 hour has passed since sunset.

-246 I 11

(24-25 April 247 BC)

> *Night of the 11th, beginning of the night, the moon was 1 cubit above α Virginis, the moon having passed 2/3 cubit to the east.*

At 19:30 the moon was 2.35 degrees of latitude above α Vir at 2.35 degrees per cubit (-246 I 11, page 275). In reference to the ecliptic the moon is both above and behind α Vir. In the equatorial system it is not above α Vir, but to the east. The moon is to the left of α Vir in relation to the horizon.

-246 I 12

(25-26 April 247 BC)

> *Night of the 12th, beginning of the night, the moon was 2 5/6 cubits in front of α Librae.*

At 19:31 the moon was 5.49 degrees of longitude in front of α Lib at 1.94 degrees per cubit. Both were nearly on the ecliptic (-246 I 12, page 276).

-246 I 13

(26-27 April 247 BC)

> *Night of the 13th, moonrise to sunset: 14 degrees; I did not watch; beginning of the night, the moon was 3 ½ cubits in front of δ Scorpii.*

At 19:32 the moon was 7.85 degrees of longitude in front of δ Sco at 2.24 degrees per cubit. With reference to the ecliptic, the moon was directly in front of δ Sco (-246 I 13, page 277). In the equatorial system it was both in front of and above. *I did not watch* (NU PAP) was used when the sky was obscured by weather that prevented the observation of anticipated time intervals, such as *moonrise to sunset*. A predicted interval was calculated and recorded instead.

-246 I 14

(27-28 April 247 BC)

> *Night of the 14th, moonrise to moonset: [x] + 1 degree, measured (despite) clouds; beginning of the night, the moon was ½ cubit in front of α Scorpii, it was balanced to its lower horn.*

At 19:32 the moon was 1.09 degrees of longitude in front of α Sco at 2.18 degrees per cubit (-246 I 14, page 278).

-246 I 15

(28-29 April 247 BC)

> *Night of the 15th, beginning of the night, very overcast, gusty wind, rain DUL; [last part of the night,] the moon was 1 2/3 cubits behind θ Ophiuchi.*

At 04:18 the moon was 4.77 degrees of longitude behind θ Oph at 2.86 degrees per cubit. The moon was both behind and below θ Oph on this lunation (-246 I 15, page 279).

-246 I 17

(30 April - 1 May 247 BC)

> *Night of the 17th, clouds were in the sky, gusty wind; last part of the night, [the moon was] 5 ½ cubits [in front of] β Capricorni.*

At 04:15 the moon was 11.62 degrees of longitude in front of β Cap at 2.11 degrees per cubit (-246 I 17, page 280).

-246 I 19

(2-3 May 247 BC)

> *Night of the 19th, [last part of the night, the moon was] 1 2/3 cubits [in fr]ont of γ Capricorni, the m[oon...]*

At 04:13 the moon was 4.07 degrees of longitude in front of γ Cap at 2.44 degrees per cubit (-246 I 19, page 281).

SELEUCID ERA YEAR 93, *Araẖ-samnu* (APIN)

-218 VIII 4

(31 October – 1 November 219 BC)

> *Night of the 4th, beginning of the night, the moon was 1 cubit behind β Capricorni, it stood 2 cubits behind Saturn to the east.*

At 18:21 the moon was 3.15 degrees behind β Cap at 3.15 degrees per cubit. The moon also was 3.77 degrees of longitude behind Saturn at 1.88 degrees per cubit (-218 VIII 4, page 282). If the observation were to be taken earlier, then Saturn's degrees per cubit would be too small. If it were taken at a later time, then β Cap's degrees per cubit would grow too large.

-218 VIII 5

(1-2 November 219 BC)

> *Night of the 5th, beg[inning of the night, ...] [last part of the night, Venus] was 5 cubits below β Librae.*

At 05:15 Venus was 7.41 degrees of latitude below β Lib at 1.48 degrees per cubit (-218 VIII 5, page 283). It was just above the eastern horizon before sunrise.

-218 VIII 10

(6-7 November 219 BC)

> *[...Night of the 10th, beginning of the night, the moon was] 1 cubit [...η] Piscium; last part of the night, Mars, while moving back to the west, was 3 ½ cubits above γ Geminorum.*

At 18:15 the moon was 1.30 degrees of longitude in front of η Psc for an estimated 1.30 degrees per cubit (-218 VIII 10, page 284). At 05:20 Mars was 8.53 degrees of latitude above γ Gem at 2.44 degrees per cubit (-218 VIII 10, page 285).

-218 VIII 11

(7-8 November 219 BC)

> *Night of the 11th, beginning of the night, the moon was 2 ½ cubits [below] α Arietis [...]*

Aries contains the final pair of directionally-named Babylonian normal stars in this study. *Hamal* is the common name for α Arietis (α Ari). The Baylonians named it "The rear star of the head of the Hired Man." Transliterated it is MÚL *ár šá* SAG H̱UN. MÚL IGI *šá* SAG H̱UN, "The front star of the head of the Hired Man," is *Sheratan*, or β Arietis (β Ari). The first of the pair in celestial longitude is β Ari, followed by α Ari. This puts β Ari "in front of" α Ari (-218 VIII 11, page 286).

At 18:14 the moon was 11.92 degrees of latitude below α Ari at 4.77 degrees per cubit. As shown on the star chart, the moon was directly below α Ari, but the scribe seems to have made a poor estimation of the distance. In reference to the celestial equator the moon was well behind α Ari.

-218 VIII 14

(10-11 November 219 BC)

> *[...] Night of the 14th, moonrise to sunset: 4 degrees 20 minutes, measured; beginning of the night, the moon was 1 cubit behind α Tauri, 1 ½ cubits below Jupiter, the moon having passed ½ cubit to the east.*

At 18:12 the moon was 3.57 degrees of longitude behind α Tau at 3.57 degrees per cubit (-218 VII 14, page 287). *Aldebaran* (α Tau) is a first magnitude star and can be seen soon after sunset. There is insufficient time since sunset, however, to significantly decrease the value of degrees per cubit. This observation may be a case of poor measurement by the scribe.

The moon also was 3.63 degrees of latitude below Jupiter at 2.42 degrees per cubit.

-218 VIII 15

(11-12 November 219 BC)

> *[...Night of the 15th, sunset to moonrise: nn degrees; last part of the night, the moon was] 2 cubits behind ζ Tauri.*

At 05:24 the moon was 4.58 degrees of latitude behind ζ Tau at 2.29 degrees per cubit. The moon was both behind and slightly below ζ Tau (-218 VIII 15, page 288).

-218 VIII 16

(12-13 November 219 BC)

> *Night of the 16th, last part of the night, the moon was 1 ½ cubits behind γ Geminorum.*

At 05:25 the moon was 2.28 degrees of longitude behind γ Gem at 1.52 degrees per cubit (-218 VIII 16, page 289). To make a significant increase in degrees per cubit, the time of observation would have to be moved past sunrise.

-218 VIII 17

(13-14 November 219 BC)

> *[...] Night of the 17th, last part of the night, the moon was 5 cubits below β Geminorum.*

At 05:27 the moon was 11.83 degrees of latitude below β Gem at 2.37 degrees per cubit. The moon was directly below β Gem (-218 VIII 17, page 290).

-218 VIII 18

(14-15 November 219 BC)

> *Night of the 18th, last part of the night, the moon was 1 cubit in front of δ Cancri.*

At 05:27 the moon was 2.94 degrees of longitude in front of δ Cnc at 2.94 degrees per cubit. A later time of observation would help decrease degrees per cubit, but sunrise approaches at 06:31 and δ Cnc has a magnitude of 3.93 (-218

VIII 18, page 291). On this lunation the moon passed below δ Cnc and the ecliptic by 5 degrees of celestial latitude.

-218 VIII 20

(16-17 November 219 BC)

> *[Night of the 20th, last part of the night,] the moon was 1 ½ cubits below α Leonis, the moon having passed ½ cubit to the east; last part of the night, Mars was [(nn cubits)] 4 fingers above μ Geminorum.*

At 05:29 the moon was 4.47 degrees of latitude below α Leo at 2.98 degrees per cubit (-218 VIII 20, page 292). The moon has passed to the east of α Leo, and an observation nearer sunrise would bring the distance closer to the specified ½ cubit. In the equatorial frame of reference the moon was below, but not behind (east of) α Leo.

-218 VIII 22

(18-19 November 219 BC)

> *[...Night of the 22nd, last part of the night,] the moon was 1 cubit below β Virginis, the moon having passed 2/3 cubit to the east; clouds were in the sky.*

At 05:31 the moon was 2.89 degrees of latitude below β Vir at 2.89 degrees per cubit. With reference to the ecliptic the moon was directly below β Vir (-218 VIII 22, page 293).

-218 VIII 23

(19-20 November 219 BC)

> *Night of the 23rd, last part of the night, [the moon was] 1 ½ cubits below γ Virginis, the moon having passed ½ cubit to the east.*

At 05:32 the moon was 3.93 degrees of latitude below γ Vir at 2.62 degrees per cubit. The moon has moved just barely east of γ Vir by 0.36 degrees of longitude (-218 VIII 23, page 294). A later entry might help somewhat, but sunrise occurred at 06:36 on this day. As before, the secondary direction often seems to be less precise than the first. One possibility is that the primary direction was measured, while the secondary one was subject to a greater degree of estimation.

-218 VIII 25

(21-22 November 219 BC)

> *Night of the 25th, overcast [...; last part of the night, the moon was] 2 ½ cubits [in front of α Lib]rae;*

At 05:34 the moon was 6.02 degrees of longitude in front of α Lib at 2.41 degrees per cubit. The moon was directly in front of α Lib, just above the ecliptic (-218 VIII 25, page 295).

-218 VIII 26

(22-23 November 219 BC)

> *[...Night of the 2]6th, last part of the night, the moon was 2/3 [cubit] behind β Librae.*

At 05:35 the moon was 3.97 degrees of longitude behind, β Lib at 5.93 degrees per cubit (-218 VIII 26, page 296). If this observation were made two seasonal hours earlier it still would not reduce the value of degrees per cubit significantly. This is likely an example of an imprecise observation or poor copying by the scribe.

SELEUCID ERA YEAR 121, *Simānu* (SIG)

-190 III 1

(24-25 May 191 BC)

> *[Month III, the first...the moon was 1 ½ cubits in front of α Geminorum, it stood 2/3 cubit behind Venus to the east.*

At 19:42 the moon was 2.98 degrees of longitude in front of α Gem at 1.99 degrees per cubit. The moon also was 0.34 degrees of longitude behind Venus at 0.51 degrees per cubit (-190 III 1, page 297). A later observation would increase the angular rate for Venus, but at the same time it would decrease it for α Gem.

-190 III 2

(25-26 May 191 BC)

> *Night of the 2nd, [the moon was] 1 ½ cubits [behind] β Geminorum, it stood 1 ½ cubits behind Mercury to the east; first part of the night, [Mercury was nn cubits below β Geminorum.]*

At 19:43 the moon was 5.70 degrees of longitude behind β Gem at 3.80 degrees per cubit. The moon also was 4.31 degrees of longitude behind Mercury at 2.87 degrees per cubit (-190 III 2, page 298). Again, changing the time of entry improves one value of degrees per cubit while deteriorating the other.

-190 III 3

(26-27 May 191 BC)

> *[Night] of the 3rd, the moon was 1 ½ cubits above δ Cancri, the moon having passed ½ cubit to the east.*

At 19:44 the moon was 2.50 degrees of longitude behind δ Cnc at 1.67 degrees per cubit. The moon was both behind and above δ Cnc (-190 III 3, page 299). In this case the scribe chose to use δ Cnc even though γ Cnc is closer. The magnitude of γ Cnc, however, is 4.65, making it more difficult to sight than the 3.93 magnitude δ Cnc.

-190 III 4

(27-28 May 191 BC)

> *Ni[ght of the 4th, beginning] of the night, the moon was 1 cubit behind ε Leonis;*

At 19:44 the moon was 2.47 degrees of longitude behind ε Leo at 2.47 degrees per cubit. The moon was both behind and below ε Leo (-190 III 4, page 300).

-190 III 5

(28-29 May 191 BC)

> *[...Night of the 5th, beginning] of the night, the moon was 2/3 cubit in front of ρ Leonis.*

At 19:45 the moon was 1.16 degrees of longitude in front of ρ Leo at 1.73 degrees per cubit. The moon was both in front of and above ρ Leo (-190 III 5, page 301).

-190 III 6

(29-30 May 191 BC)

> *Night of the 6th, beginning of the night, the moon was 2 ½ cubits [behind θ Leo]nis, the moon having passed a little to the east.*

At 19:46 the moon was 4.08 degrees of longitude behind θ Leo at 1.63 degrees per cubit. The moon was both behind and below θ Leo (-190 III 6, page 302).

-190 III 8

(31 May – 1 June 191 BC)

> *Night of the 8th, very overcast, lightning flashed, thunder, rain shower; beginning of the night, [the moon was] 1 cubit [behind γ] Virginis; first part of the night, Venus was 3 ½ cubits below β Geminorum.*

At 19:47 the moon was 2.59 degrees of longitude behind γ Vir at 2.59 degrees per cubit (-190 III 8, page 303). Venus set that night approximately at 20:30, so an additional seasonal hour adjustment to 20:39 places it below the horizon. The moon's measurement was recorded as "beginning of the night" and Venus's as "first part of the night." Sunset occurred at 18:55, so both observations had to be recorded during the 1 hour and 35 minutes elapsing between sunset and the setting of Venus (-190 III 8, pages 304-306). At 19:47 Venus was 5.24 degrees of latitude below Β Gem at 1.50 degrees per cubit.

-190 III 9

(1-2 June 191 BC)

> *Night [of the 9th, beginning of the night, the moon was] 1 cubit [behind] α Virginis.*

At 19:47 the moon was 2.02 degrees of longitude behind α Vir at 2.02 degrees per cubit (-190 III 9, page 307).

-190 III 10

(2-3 June 191 BC)

> *Night of the 10th, beginning of the night, the moon was 2 ½ cubits in front of α Librae.*

At 19:48 the moon was 5.51 degrees of longitude in front of α Lib at 2.20 degrees per cubit (-190 III 10, page 308).

-190 III 11

(3-4 June 191 BC)

> *Night [of the 11th, beginning of the ni]ght, the moon was 1 ½ cubits behind β Librae.*

At 19:49 the moon was 3.70 degrees of longitude behind β Lib at 2.47 degrees per cubit. The moon was both behind and well below β Lib (-190 III 11, page 309).

-190 III 13

(5-6 June 191 BC)

> *[Night of the 13th, beginning] of the night, the moon was 2 ½ cubits below θ Ophiuchi.*

At 19:50 the moon was 3.21 degrees of latitude below θ Oph at 1.28 degrees per cubit (-190 III 13, page 310).

-190 III 16

(8-9 June 191 BC)

> *[Night of the 1]6th, last part of the night, the moon was 4 cubits in front of γ Capricorni.*

At 03:55 the moon was 9.08 degrees of longitude in front of γ Cap at 2.27 degrees per cubit (-190 III 16, page 311).

-190 III 18

(10-11 June 191 BC)

> *Night of the 1[8th, last part of the night, the m]oon was 1 2/3 cubits behind δ Capricorni.*

At 03:55 the moon was 19.08 degrees of longitude behind δ Cap at 11.43 degrees per cubit (-190 III 18, page 313). However, on the 17th at 03:55 the moon was 4.52 degrees of longitude behind δ Cap at 2.71 degrees per cubit (-190 III 17, page 312). When 4.52 is subtracted from 19.08 the remainder is 14.56 degrees, or a slightly greater distance than the moon might travel in a 1-day period. This observation must have taken place on the 17th and not the 18th. There may have been an error in translation from the cuneiform tablet.

-190 III 21

(13-14 June 191 BC)

> *Ni[ght] of the 21st, last part of the night, the moon was 2 ½ cubits in front of η Piscium, the moon being ...[...]*

At 03:54 the moon was 2.70 degrees of longitude in front of η Psc at 1.08 degrees per cubit (-190 III 21, page 314). This observation would have to take place in the middle of the night to significantly increase the degrees per cubit.

-190 III 24

(16-17 June 191 BC)

> *Night of the 24th, last part of the night, the moon was 2/3 cubit below η Tauri.*

At 03:54 the moon was 1.46 degrees of latitude below η Tau at 2.18 degrees per cubit (-190 III 24, page 315). *Alcyone*, or η Tau, can be seen clearly amid the other stars of the Pleiades in the accompanying enlargement (-190 III 24, page 316).

-190 III 25

(17-18 June 191 BC)

> *[...Night of the 25th, last part of the night, the moon was 5 cubits above α Tauri, the moon [having passed] a little to the east.*

At 03:54 the moon was 8.75 degrees of latitude above α Tau at 1.75 degrees per cubit. The moon was both above and behind α Tau (-190 III 25, page 317).

-190 III 26

(18-19 June 191 BC)

> *[...Night of the 26th, last part of the night, the m]oon was 1 ½ cubits below β Tauri, the moon [having passed] 2/3$^{?}$ cub[it to the east...]*

At 03:54 the moon was 1.47 degrees of latitude below β Tau at 0.98 degrees per cubit (-190 III 26, page 318). The moon was greater than 2/3 cubit to the east.

-190 III 27

(19-20 June 191 BC)

> *[...Night of the 27$^{th?}$, first] part of the night, Jupiter was 6 fingers above β Virginis;*

At 19:56 Jupiter was 0.65 degrees of latitude above β Vir at 2.60 degrees per cubit. The enlargement shows that Jupiter was both above and in front of β Vir (-190 III 27, pages 319-320).

SELEUCID ERA YEAR 143, *Abu* (IZI)

-168 V 1

(17-18 August 169 BC)

> *[Year] 143, king Antiochus. Month V, the 1st...the moon was 2 cubits in front of α Virginis, the moon being 1 cubit 8 fingers [low] to the sou[th,] it stood 2 ½ cubits [in front of Sat]urn to the west, the moon being 3 cubits 8 fingers low to the south.*

At 19:37 the moon was 5.31 degrees of longitude in front of α Vir at 2.66 degrees per cubit and 2.89 degrees of latitude below α Vir at 2.17 degrees per cubit. The moon also was 6.22 degrees of longitude in front of Saturn at 2.49 degrees per cubit and 7.15 degrees of latitude below Saturn at 2.15 degrees per cubit. All four values match the descriptions of the scribe (-168 V 1, page 321).

-168 V 2

(18-19 August 169 BC)

> *Night of the 2nd, the moon [stood] 2 ½ cubits behind Mars t[o the east, the moon being ...] low to the south; the north wind blew.*

At 19:36 the moon was 4.15 degrees of longitude behind Mars at 1.66 degrees per cubit (-168 V 2, page 322).

-168 V 3

(19-20 August 169 BC)

> *Night of the 3rd, the moon was 3 cubits below α Librae, the moon [having passed] a little to the east.*

At 19:35 the moon was 6.59 degrees of latitude below α Lib at 2.20 degrees per cubit (-168 V 3, page 323). In equatorial reference, the moon was instead west of α Lib.

-168 V 4

(20-21 August 169 BC)

> *[Night] of the 4th, beginning of the night, the moon was 2 cubits in front of π Scorpii.*

At 19:34 the moon was 4.42 degrees in front of π Sco at 2.21 degrees per cubit. On this lunation the moon is directly in front of π Sco (-168 V 4, page 324).

-168 V 5

(21-22 August 169 BC)

> *Night of the 5th, beginning of the night, the moon was ½ cubit behind α Scorpii.*

At 19:33 the moon was 1.65 degrees of longitude behind α Sco at 1.10 degrees per cubit (-168 V 5, page 325). Delaying the time of entry by 1 or 2 seasonal hours will increase this value.

-168 V 6

(22-23 August 169 BC)

> *[...Night of the 6th, be]ginning of the night, the moon was 2 cubits below θ Ophiuchi, the moon having passed ½ cubit to the east.*

At 19:32 the moon was 3.38 degrees of latitude below θ Oph at 1.69 degrees per cubit. The moon was below and east of θ Oph (-168 V 6, page 326).

-168 V 9

(25-26 August 169 BC)

> *[Night] of the 9th, beginning of the night, the moon was 3 cubits in front of β Capricorni, the moon being 3 cubits low to the south.*

At 19:29 the moon was 4.70 degrees of longitude in front of β Cap at 1.57 degrees per cubit. The moon was also 7.14 degrees of latitude below β Cap at 2.38 degrees per cubit (-168 V 9, page 327). Both directions fit the scribal description.

-168 V 10

(26-27 August 169 BC)

> *Night of the 10th, beginning of the ni[ght, the moon was] 3 cubits [behind β Capricorni?.]*

At 19:28 the moon was 7.30 degrees of longitude behind β Cap at 2.43 degrees per cubit (-168 V 10, page 328).

-168 V 17

(2-3 September 169 BC)

> *Night of the 17th, last part of the night, the moon was [nn] cubits behind α Arietis, the moon being 2 ½ cubits low to the south.*

At 04:40 the moon was 5.82 degrees of longitude behind α Ari, resulting in a probable value for [nn] in the range of 2 to 3 cubits. The moon also was 4.85 degrees of latitude below α Ari at 1.94 degrees per cubit (-168 V 17, page 329).

-168 V 18

(3-4 September 169 BC)

> *Night of the 18th, last part of the night, the moon was ½ cubit in front of η Tauri, [the moon being…] low to the south.*

At 04:41 the moon was 2.78 degrees of longitude in front of η Tau at 5.56 degrees per cubit (-168 V 18, page 30). A later time of observation would be better, but this entry was 52 minutes before sunrise. The moon is low to the south.

-168 V 19

(4-5 September 169 BC)

> *Night of the 19th, last part of the night, the moon was 4 cubits above α Tauri, last part of the night, Jupiter was 2 fingers above α Leonis.*

At 04:41 the moon was 10.08 degrees of latitude above α Tau at 2.52 degrees per cubit (-168 V 19, page 331). Jupiter was 0.34 degrees above α Leo at 4.25 degrees per cubit (-168 V 19, pages 332-333). Close proximity of the bodies, again, seems to make estimating distance problematic. The enlargement better shows the relationship between Jupiter and α Leo.

-168 V 20

(5-6 September 169 BC)

> *Night of the 20th, ...last part of the night, the moon was 2 cubits above ζ Tauri, the moon being ½ cubit back to the west.*

At 04:42 the moon was 6.27 degrees of latitude above ζ Tau at 3.14 degrees per cubit. The moon also was 0.38 degrees of longitude behind ζ Tau at 0.76 degrees per cubit (-168 V 20, page 334). To match the description of "½ cubit back to the west" the time of entry would be much better if taken as at least two seasonal hours earlier.

-168 V 21

(6-7 September 169 BC)

> *Night of the 21st, last part of the night, the moon was 4 cubits above γ Geminorum.*

At 04:43 the moon was 9.87 degrees above γ Gem at 2.47 degrees per cubit (-168 V 21, page 335). The moon was directly above γ Gem.

-168 V 22

(7-8 September 169 BC)

> *Night of the 22nd, last part of the night, the moon was 2 cubits below β Geminorum [...]*

At 04:44 the moon was 4.75 degrees of latitude below β Gem at 2.38 degrees per cubit (-168 V 22, page 336).

-168 V 23

(8-9 September 169 BC)

> *Night of the 23rd, clouds were in the sky, ZI IR; last part of the night, the moon was 2/3 cubit above δ Cancri.*

At 04:44 the moon was 0.53 degrees above δ Cnc at 0.67 degrees per cubit. The enlargement shows the proximity of the moon to δ Cnc (-168 V 23, pages 337-338). This appears to be another example of a close distance that is difficult to measure.

-168 V 24

(9-10 September 169 BC)

> *Night of the 24th, last part of the night, the moon was 1 ½ cubits behind ε Leonis, the moon being 4 [cubits low to the south.]*

At 04:45 the moon was 1.91 degrees of longitude behind ε Leo at 1.27 degrees per cubit (-168 V 24, page 339). A later time of entry would increase degrees per cubit, but sunrise was at 05:37. The moon was also 10.31 degrees of latitude below ε Leo at 2.58 degrees per cubit. The moon was below and behind ε Leo.

-168 V 25

(10-11 September 169 BC)

> *Night of the 25th, last part of the night, the moon was 2/3 cubit below ρ Leonis, the moon having passed a little to the east, it stood 3 cubits behind Jupiter to the east, the moon [being...low to the south.]*

At 04:46 the moon was 2.05 degrees of latitude below ρ Leo at 3.06 degrees per cubit. The moon was also 5.86 degrees of longitude behind Jupiter at 1.95 degrees per cubit (-168 V 25, page 340).

-168 V 26

(11-12 September 169 BC)

> *Night of the 26th, last part of the night, the moon was 2 ½ cubits behind θ Leonis, the moon being 6 cubits low to the south.*

At 04:47 the moon was 8.05 degrees of longitude behind θ Leo at 3.22 degrees per cubit. The moon was also 12.77 degrees of latitude below θ Leo at 2.13 degrees per cubit (-168 V 26, page 341). The moon was both behind and below in reference to the ecliptic. In reference to the celestial equator the moon was only below θ Leo.

-168 V 27

(12-13 September 169 BC)

> *Night of the 27th, first part of the night, Mars was 4 fingers below α Librae, Mars having passed 2 fingers to the east.*

At 19:07 Mars was 0.61 degrees of latitude below α Lib at 3.59 degrees per cubit. The close proximity of the bodies appears to have contributed to an inaccurate measurement. The enlargement shows the relationship between Mars and α Lib (-168 V 27, pages 342-343).

SELEUCID ERA YEAR 171, *Šabāṭu* (ZÍZ)

-140 XI 1

(1-2 February 140 BC)

> *Ni[ght of the 1st ...]...last part of the night, Mars was 2 cubits? below? β Capricorni.*

At 05:52 Mars was 5.61 degrees of latitude below β Cap at 2.81 degrees per cubit (-140 XI 1, page 344).

-140 XI 4

(4-5 February 140 BC)

> *Night of the 4th, beginning of the night, the moon was 6? cubits [below] β Arietis, the moon having passed ½ cubit to the east...*

At 18:45 the moon was 13.75 degrees of latitude below β Ari at 2.29 degrees per cubit (-140 XI 4, page 345). The moon was both below and behind β Ari in relation to the ecliptic.

-140 XI 6

(6-7 February 140 BC)

> *Night of the 6th, clouds were in the sky; beginning of the night, the moon was 1 ½ cubits behind η Tauri, the moon being 4 cubits low to the south.*

At 18:47 the moon was 0.77 degrees of longitude behind η Tau at 0.51 degrees per cubit (-140 IX 6, page 346). Two seasonal hours later, at 21:03, the moon was approximately 1.46 degrees of longitude behind η Tau at 0.97 degrees per cubit (-140 IX 6, page 347). This appears to be an inaccurate entry in the *Diaries*. The moon was also 8.73 degrees of latitude below η Tau at 2.18 degrees per cubit.

-140 XI 7

(7-8 February 140 BC)

> *Night of the 7th, beginning of the night, the moon was 1 cubit 8 fingers behind α Tauri.*

At 18:47 the moon was 3.38 angular degrees of longitude behind α Tau at 2.54 degrees per cubit (-140 XI 7, page 348).

-140 XI 8

(8-9 February 140 BC)

> *Night of the 8th, beginning of the night, the moon was 8 fingers below ζ Tauri, the moon having passed ½ cubit to the east.*

At 18:48 the moon was 1.07 degrees of latitude below ζ Tau at 3.24 degrees per cubit (-140 XI 8, page 349).

-140 XI 9

(9-10 February 140 BC)

> *Night of the 9th, clouds were in the sky; beginning of the night, [the moon was] 2 cubits above γ Geminorum, the moon having passed a little to the east;*

At 18:49 the moon was 4.42 degrees of latitude above γ Gem and 2.21 degrees per cubit (-140 XI 9, page 350).

-140 XI 10

(10-11 February 140 BC)

> *Night of the 10th, clouds were in the sky, lightning flashed; beginning of the night, the moon was [...] in front of β Geminorum, the moon being 2 cubits low to the south.*

At 18:50 the moon was 1.33 degrees of longitude in front of β Gem (-140 XI 10, page 351). A possible term to fill the above description might then be 20 fingers. The moon was also 7.94 degrees of latitude below β Gem at 3.97 degrees per cubit. This could be due to a poor estimation of cubits below β Gem.

-140 XI 11

(11-12 February 140 BC)

> *Night of the 11th, beginn[ing of the night, the m]oon was 1 ½ cubits in front of δ Cancri.*

At 18:51 the moon was 2.57 degrees of longitude in front of δ Cnc at 1.71 degrees per cubit (-140 XI 11, page 352).

-140 XI 12

(12-13 February 140 BC)

> *Night of the 12th, first part of the night, the moon was 3 cubits below ε Leonis, the moon having passed ½ cubit to the east.*

At 18:52 the moon was 8.45 degrees of latitude below ε Leo at 2.82 degrees per cubit. The moon was directly below and slightly behind ε Leo (-140 XI 12, pages 353) and could be described as having passed to the east.

-140 XI 14

(14-15 February 140 BC)

> *Night of the 14th, moonrise to moonset: 8 degrees, measured; first part of the night, the moon was 1 cubit behind θ Leonis, the moon being 4 cubits low to the south.*

At 18:53 the moon was 7.57 degrees of longitude behind θ Leo at 7.57 degrees per cubit (-140 XI 14, page 354). An earlier entry is needed to decrease the value of degrees per cubit, but sunset occurred at 17:45.

-140 XI 15

(15-16 February 140 BC)

> *Night of the 15th, sunset to moonrise: 10 degrees, measured (despite) clouds; clouds were in the sky, the north wind blew; last part of the night, the moon was 1 cubit behind γ Virginis, it stood 3 cubits in front of Saturn to the west.*

At 05:40 the moon was 0.67 degrees of longitude behind γ Vir at 0.67 degrees per cubit (-140 XI 15, page 355). A later observation is necessary to increase the value of degrees per cubit; however sunrise occurred 52 minutes later. The moon was also 8.72 degrees of longitude in front of Saturn at 2.91 degrees per cubit. The value for γ Vir, as recorded by the scribe, is likely imprecise.

-140 XI 16

(16-17 February 140 BC)

> *Night of the 16th, thin clouds were in the sky; last part of the night, the moon was [...] behind α Virginis, the moon being 3 cubits high to the north.*

At 05:39 the moon was 2.22 degrees of longitude behind α Vir. A value of 1 cubit might be appropriate to fill the blank in the above diary entry. The moon was also 6.25 degrees of latitude above α Vir at 2.08 degrees per cubit (-140 XI 16, page 356).

-140 XI 17

(17-18 February 140 BC)

> *Night of the 17th, all night clouds were in the sky; last part of the night, the moon was 1 ½ cubits in front of α Librae, the moon being 2 cubits high to the north.*

At 05:38 the moon was 3.49 degrees of longitude in front of α Lib at 2.33 degrees per cubit. The moon was also 4.80 degrees of latitude above α Lib at 2.40 degrees per cubit (-140 XI 17, page 357).

-140 XI 18

(18-19 February 140 BC)

> *Night of the 18th, cl[ouds? ...]; last part of the night, the moon was 3 ½ cubits in front of β Scorpii.*

At 05:37 the moon was 7.11 degrees of longitude in front of β Sco at 2.03 degrees per cubit (-140 XI 18, page 358).

-140 XI 19

(19-20 February 140 BC)

> *Night of the 19th, last part of the night, the moon was 4 cubits above α Scorpii.*

At 05:36 the moon was 7.76 degrees of latitude above α Sco at 1.94 degrees per cubit (-140 XI 19, page 359).

-140 XI 20

(20-21 February 140 BC)

> *Night of the 20th, last part of the night, the moon was 2 cubits below θ Ophiuchi, the moon having passed ½ cubit to the east.*

At 05:35 the moon was 4.20 degrees of latitude above θ Oph, not below it (-140 XI 20, page 360). This equates to 2.00 degrees per cubit. The error may have been one of recording during observation or one of translation.

-140 XI 22

(22-23 February 140 BC)

> *Night of the 22nd, clouds were in the sky; last part of the night, the moon was 1 cubit behind Jupiter; last part of the night, Mars was ½ cubit above γ Capricorni.*

At 05:33 the moon was 1.93 degrees of longitude behind Jupiter at 1.93 degrees per cubit. Both bodies were essentially on the ecliptic (-140 XI 22, page 361). Mars was 1.36 degrees of latitude above γ Cap at 2.72 degrees per cubit. Mars was both above and in front of γ Cap (-140 XI 22, page 362).

-140 XI 23

(23-24 February 140 BC)

> *Night of the 23rd, last part of the night, the moon was one cubit in front of β Capricorni, the moon being 3 ½ cubits low to the south.*

At 05:32 the moon was 0.46 degrees of longitude in front of β Cap at 0.46 degrees per cubit (-140 XI 23, page 363). An earlier time of entry increases the value of degrees per cubit, as is shown in the charts for 04:24 and 03:16 (-140 XI 23, pages 364-365).

-140 XI 24

(24-25 February 140 BC)

> *Night of the 2[4th, last part of the night, the moon was] 3 cubits in front of γ Capricorni.*

At 05:31 the moon was 5.67 degrees of longitude in front of γ Cap at 1.89 degrees per cubit (-140 XI 24, page 366). The moon was directly in front of γ Cap with relation to the ecliptic.

-140 XI 25

(25-26 February 140 BC)

> *Night of the 25th, last part of the night, the moon was 2 ½ cubits behind γ Capricorni, it stood 2 ½ cubits behind Mars to the east; last part of the night, Mars was ½ cubit above δ Capricorni.*

At 05:29 the moon was 6.63 degrees of longitude behind γ Cap at 2.65 degrees per cubit (-140 XI 25, page 367). Mars was 1.38 degrees of latitude above δ Cap at 2.76 degrees per cubit.

SELEUCID ERA YEAR 200, *Nisannu* (BAR)

-111 I 8

(28-29 April 112 BC)

> *[Night of the 8th, beginning of the night, the moon was] 2 cubits [behind] ρ Leonis, the moon being 1 2/3 cubits low to the south.*

At 19:34 the moon was 4.92 degrees of longitude behind ρ Leo at 2.46 degrees per cubit (-111 I 8, page 368). The moon was both behind and below ρ Leo.

-111 I 9

(29-30 April 112 BC)

> *Night of the 9th, beginning of the ni[ght, the moon was...] below β Virginis [...]*

At 19:34 the moon was 5.38 degrees of latitude below β Vir. Two cubits might be an appropriate substitution for the missing value in this diary entry (-111 I 9, page 369).

-111 I 10

(30 April - 1 May 112 BC)

> *[Night of the 10th, beginning of the night, the moon was] 1 cubit [in front of γ] Virginis, the moon being 4 cubits low to the south.*

At 19:35 the moon was 1.90 degrees of longitude in front of γ Vir at 1.90 degrees per cubit. The moon was also 8.09 degrees of latitude below γ Vir at 2.02 degrees per cubit (-111 I 10, page 370).

-111 I 14

(4-5 May 112 BC)

> *[...Night of the 14th], beginning of the night, the moon was 1 ½ cubits in front of α Scorpii.*

At 19:38 the moon was 2.65 degrees of longitude in front of α Sco at 1.77 degrees per cubit. The moon was directly in front of α Sco (-111 I 14, page 371).

-111 I 18

(8-9 May 112 BC)

> *Night of the 18th, first part of the night, Mercury was 1 ½ cubits above η Geminorum; last part of the night, the moon was 1? ½ cubits behind β Capricorni, the moon being 2 cubits low to the south...]*

At 19:40 Mercury was 3.40 degrees of latitude above η Gem at 2.27 degrees per cubit (-111 I 18, page 372). Mercury is close to setting on the western horizon. At 04:06 the moon was 7.17 degrees of longitude behind β Cap at 4.78 degrees per cubit. The moon was also 4.25 degrees of latitude below β Cap at 2.13 degrees per cubit (-111 I 18, page 373). An observation early enough to significantly decrease the value of degrees per cubit would need to have been taken during the middle part of the night.

-111 I 19

(9-10 May 112 BC)

> *[...Night of the 19th, first part of the night, Mer]cury was 1 ½ cubits above μ Geminorum; last part of the night, the moon was 1 ½ cubits above δ Capricorni, the moon having passed a little to the east.*

At 19:41 Mercury was 3.33 degrees of latitude above μ Gem at 2.22 degrees per cubit (-111 I 19, page 374). At 04:05 the moon was 4.21 degrees of latitude above δ Cap at 2.81 degrees per cubit (-111 I 19, page 375).

-111 I 21

(11-12 May 112 BC)

> *[Night of the 21st, first part of the night, Mercury was] 4 ½ cubits [above γ Gemi]norum.*

At 19:42 Mercury was 9.17 degrees of latitude above γ Gem at 2.04 degrees per cubit (-111 I 21, page 376). Mercury is close to setting on the western horizon.

It is interesting to note the increasing number of planetary observations in the "first part of the night" that are now taken later in the month. In earlier years most late-month observations of any type were during the "last part of the night" only. The planets have always been visible in the "first part of the night," but there now seems a new interest in recording them, as well as the later moon observation. Lunar entries are, of necessity, made in the latter part of the night during the second half of the month. As in the previous entry for –111 I 19, dual observations required the scribe to perform his duties both in the evening and early in the morning. Prior to this new trend the scribes appeared to be required to do only one or the other, but not both.

-111 I 25

(15-16 May 112 BC)

> *Night of the 25th, last part of the night, the moon was 1 ½ cubits behind α Arietis, the moon being 2 ½ cubits [low] to the south [...]*

At 04:00 the moon was 5.25 degrees of longitude behind α Ari at 3.50 degrees per cubit (-111 I 25, page 377). An earlier entry would improve the value of degrees per cubit.

-111 I 26

(16-17 May 112 BC)

> *[...Night of the 26th, last part of the night, the m]oon was 2 ½ cubits above Venus, the moon being ½ cubit back to the west.*

At 03:59 the moon was 4.31 degrees of latitude above Venus at 1.72 degrees per cubit (-111 I 26, page 378).

-111 I 28

(18-19 May 112 BC)

> *Night of the 28th, first [part of the night, Mer]cury was 4 cubits below α Geminorum.*

At 19:47 Mercury was 8.27 degrees of latitude below α Gem at 2.07 degrees per cubit (-111 I 28, page 379).

SELEUCID ERA YEAR 225, *Addaru II* (DIR-ŠE)

-86 XII_2 2

(18-19 March 87 BC)

> *[...Night of the 2^{nd}, the moon was ...below η Tauri,] the moon being ½ cubit back to the west.*

At 19:12 the moon was 8.51 degrees of latitude below η Tau. Values between 3 and 4 could be used for the missing number of cubits in the above diary entry. The moon was also 3.45 degrees of longitude in front of η Tau at 6.90 degrees per cubit (-86 XII_2 2, page 380). The secondary reference again appears to be less precise.

-86 XII_2 4

(20-21 March 87 BC)

> *Night of the 4^{th}, beginning of the night, the moon was 5 cubits below β Tauri, the moon being ½ cubit back to the west.*

At 19:14 the moon was 10.61 degrees of latitude below β Tau at 2.12 degrees per cubit. The moon also was 1.46 degrees of longitude in front of β Tau at 2.92 degrees per cubit (-86 XII_2 4, page 381).

-86 XII_2 6

(22-23 March 87 BC)

> *Night of the 6th, beginning of the night, the moon was 1 cubit in front of α Geminorum, the moon being 6 cubits low to the south.*

At 19:15 the moon was 3.65 degrees of longitude in front of α Gem at 3.65 degrees per cubit. The moon also was 15.08 degrees of latitude below α Gem at 2.51 degrees per cubit (-86 XII_2 6, page 382). The moon was well below and slightly in front of α Gem.

-86 XII_2 8

(24-25 March 87 BC)

> *Night of the 8th, beginning of the night, the moon was 2 ½ cubits behind δ Cancri;*

At 19:16 the moon was 4.94 degrees of longitude behind δ Cnc at 1.98 degrees per cubit (-86 XII_2 8, page 383).

-86 XII_2 10

(26-27 March 87 BC)

> *[...Night of the 10th, beginning of the night, the moon was...in front of θ Leonis,] the moon being 5 ½ cubits low to the south.*

At 19:17 the moon was 1.15 degrees of longitude in front of θ Leo. A value of ½ cubit would work for the missing term in the above diary entry (-86 XII_2 10, page 384). The moon also was 11.23 degrees of latitude below θ Leo at 2.04 degrees per cubit. The moon was both below and in front of θ Leo.

-86 XII_2 14

(30-31 March 87 BC)

> *[...Night of the 14th...last part of the night, the moon was] 1 ½ cubits [above α Librae,] the moon having passed a little to the east.*

At 04:50 the moon was 2.62 degrees of latitude above α Lib at 1.75 degrees per cubit (-86 XII_2 14, page 385). The moon was both above and behind α Lib.

-86 XII_2 15

(31 March - 1 April 87 BC)

> *Night of the 15th, last part of the night, the moon was 1 cubit above β Scorpii, the m[oon being...]*

At 04:48 the moon was 2.67 degrees of latitude above β Sco at 2.67 degrees per cubit (-86 XII_2 15, page 386).

-86 XII_2 20

(5-6 April 87 BC)

> *[...Night of the 20th,] last part of the night, the moon was 3 cubits behind β Capricorni.*

At 04:41 the moon was 7.58 degrees of longitude behind β Cap at 2.53 degrees per cubit (-86 XII_2 20, page 387).

SELEUCID ERA YEAR 234, *Du'ūzu* (ŠU)

-77 IV 3

(5-6 July 78 BC)

> *Night of the 3rd, the moon was 4 ½ cubits below θ Leonis, the moon being ½ cubit back to the west; last part of the night, Venus was 4 cubits below α Geminorum.*

At 19:56 the moon was 9.56 degrees of latitude below θ Leo at 2.12 degrees per cubit. The moon also was 2.05 degrees to the east, not west, of θ Leo at 4.10 degrees per cubit (-77 IV 3, page 388). This entry should likely read "back to the east" instead of "back to the west." At 04:03 Venus was 9.99 degrees of latitude below α Gem at 2.50 degrees per cubit (-77 IV 3, page 389).

-77 IV 4

(6-7 July 78 BC)

Night of the 4th, beginning of the night, the moon was 1 cubit behind β Virginis.

At 19:56 the moon was 2.85 degrees of longitude behind β Vir at 2.85 degrees per cubit (-77 IV 4, page 390).

-77 IV 5

(7-8 July 78 BC)

Night of the 5th, beginning of the night, the moon was 1 cubit behind γ Virginis, the moon being 1 cubit low to the south.

At 19:56 the moon was 3.68 degrees of longitude behind γ Vir at 3.68 degrees per cubit. As this entry is taken 48 minutes after sunset, the number of degrees per cubit cannot be significantly reduced. The moon was also 5.27 degrees of latitude below γ Vir at 5.27 degrees per cubit (-77 IV 5, page 391). This likely is an imprecise observation.

-77 IV 6

(8-9 July 78 BC)

Night of the 6th, beginning of the night, the moon was 1 ½ cubits behind α Virginis.

At 19:56 the moon was 3.42 degrees of longitude behind α Vir at 2.28 degrees per cubit (-77 IV 6, page 392).

-77 IV 7

(9-10 July 78 BC)

> *Night of the 7th, very overcast; beginning of the night, the moon was 1 ½ cubits in front of α Librae, the moon being 2 cubits low to the south; last part of the night, Venus was 4 cubits below β Geminorum.*

At 19:56 the moon was 2.50 degrees of longitude in front of α Lib at 1.67 degrees per cubit. The moon also was 5.17 degrees of latitude below α Lib at 2.59 degrees per cubit (-77 IV 7, page 393). The moon was in front of and below α Lib. At 04:05 Venus was 6.40 degrees of latitude below β Gem at 1.60 degrees per cubit (-77 IV 7, page 394).

-77 IV 8

(10-11 July 78 BC)

> *Night of the 8th, beginning of the night, the moon was 3 cubits in front of π Scorpii, 2 ½ cubits behind Saturn, the moon being 3 cubits low to the south.*

At 19:56 the moon was 6.16 degrees of longitude in front of π Sco at 2.05 degrees per cubit. The moon also was 5.88 degrees of longitude behind Saturn at 2.35 degrees per cubit. Additionally the moon was 7.76 degrees of latitude below Saturn at 2.59 degrees per cubit (-77 IV 8, page 395).

-77 IV 9

(11-12 July 78 BC)

> *Night of the 9th, beginning of the night, the moon was 2/3 cubit behind α Scorpii.*

At 19:55 the moon was 1.35 degrees of longitude behind α Sco at 2.01 degrees per cubit (-77 IV 9, page 396).

-77 IV 10

(12-13 July 78 BC)

> *Night of the 10th, beginning of the night, the moon was 2? ½ cubits behind θ Ophiuchi, the moon being 2 ½ cubits low to the south.*

At 19:55 the moon was 3.71 degrees of longitude behind θ Oph at 1.48 degrees per cubit. The moon also was 4.37 degrees of latitude below θ Oph at 1.75 degrees per cubit (-77 IV 10, page 397).

-77 IV 13

(15-16 July 78 BC)

> *Night of the 13th, moonrise to sunset: 11 degrees 30', measured; beginning of the night, the moon was 5 cubits below β Capricorni, the moon having passed a little to the east.*

At 19:55 the moon was 9.43 degrees of latitude below β Cap at 1.89 degrees per cubit (-77 IV 13, page 398).

-77 IV 19

(21-22 July 78 BC)

> *Night of the 19th, last part of the night, the moon was 1 cubit 8 fingers below η Piscium, the moon being 2/3 cubit back to the west, it stood 2 cubits in front of Jupiter to the west, the moon being 1 ½ cubits high to the north.*

At 04:12 the moon was 2.95 degrees of latitude below η Psc at 2.22 degrees per cubit. The moon was also 1.42 degrees of longitude in front of η Psc at 2.12 degrees per cubit. Additionally the moon was 3.76 degrees of longitude in front of Jupiter at 1.88 degrees per cubit and 3.89 degrees of latitude above Jupiter at 2.59 degrees per cubit (-77 IV 19, page 399). Multiple dimensions in a single diary entry are becoming more common. These four are fairly accurate and provide a solid positioning of the moon.

-77 IV 20

(22-23 July 78 BC)

> *Night of the 20th, last part of the night, the moon was 3 cubits [below] α Arietis.*

At 04:13 the moon was 6.61 degrees of latitude below α Ari at 2.20 degrees per cubit (-77 IV 20, page 400).

-77 IV 21

(23-24 July 78 BC)

> *Night of the 21st, last part of the night, Mars was 2 cubits below η Tauri.*

At 04:13 Mars was 5.79 degrees of latitude below η Tau at 2.90 degrees per cubit (-77 IV 21, page 401).

-77 IV 22

(24-25 July 78 BC)

> *Night of the 22nd, last part of the night, η Tauri was not seen with the moon, it was as if it had come close; (the moon) stood 1 2/3 cubits behind Mars to the east, the moon being 2 ½ cubits low to the south.*

At 04:14 the moon was 3.32 degrees of longitude behind Mars at 1.99 degrees per cubit (-77 IV 22, page 402). The moon was high to the north, not low to the south. Also of interest is the note concerning η Tau. This statement implies that the Babylonians anticipated which bodies to observe and that they looked for them. Moonlight may have hidden η Tau from view.

-77 IV 23

(25-26 July 78 BC)

> *Night of the 23rd, last part of the night, the moon was 1 cubit behind α Tauri, the moon being 4 cubits high to the north. Around the 23rd, when Jupiter became stationary to the east, it became stationary 1 cubit 8 fingers behind η Piscium, being 2 ½ cubits low to the south.*

At 04:15 the moon was 3.97 degrees of longitude behind α Tau at 3.97 degrees per cubit. The moon also was 10.38 degrees of latitude above α Tau at 2.59 degrees per cubit (-77 IV 23, page 403). When Jupiter reached its station it was 2.33 degrees of longitude behind η Psc at 1.75 degrees per cubit. Jupiter also was 6.86 degrees of latitude below η Psc at 2.74 degrees per cubit (-77 IV 23, page 404).

-77 IV 24

(26-27 July 78 BC)

> *Night of the 24th, last part of the night, the moon was 1 cubit behind β Tauri.*

At 04:15 the moon was 3.60 degrees of longitude behind β Tau at 3.60 degrees per cubit. The moon was directly behind β Tau (-77 IV 24, page 405).

-77 IV 25

(27-28 July 78 BC)

> *Night of the 25^th^, last part of the night, the moon was 5 cubits above γ Geminorum, the moon being ½ cubit back to the west.*

At 04:16 the moon was 11.67 degrees of latitude above γ Gem at 2.33 degrees per cubit. The moon also was 0.20 degrees of longitude in front of γ Gem at 0.40 degrees per cubit (-77 IV 25, page 406). An earlier time of entry will increase the value of degrees per cubit, as is shown on the chart for 02:40 (-77 IV 25, page 407).

-77 IV 26

(28-29 July 78 BC)

> *Night of the 28^th^, last part of the night, the moon was 2 cubits in front of β Geminorum.*

At 04:17 the moon was 1.61 degrees of longitude in front of β Gem at 0.81 degrees per cubit (-77 IV 26, page 408). As shown in the chart for 02:41, an earlier observation will increase the value of degrees per cubit (-77 IV 26, page 409).

-77 IV 27

(29-30 July 78 BC)

> *Night of the 27th, last part of the night, the moon was 1 cubit above η Cancri, the moon being ½ cubit back to the west.*

At 04:18 the moon was 2.21 degrees of latitude above η Cnc at 2.21 degrees per cubit. The moon also was 0.11 degrees of longitude in front of η Cnc at 0.11 degrees per cubit (-77 IV 27, page 410).

-77 IV 28

(30-31 July 78 BC)

> *Night of the 28th, last part of the night, the moon was 1 cubit in front of Venus, the moon being 1 cubit high to the north.*

At 04:18 the moon was 2.34 degrees of longitude in front of Venus at 2.34 degrees per cubit. The moon also was 1.77 degrees of latitude above Venus at 1.77 degrees per cubit (-77 IV 28, page 411). *Du'ūzu* has the shortest seasonal hours of the year at 48 minutes. As Venus rose on the northeastern horizon at 04:12, this observation could not have been made any earlier. Sunrise was at 05:06.

Conclusions

I have examined the possibility of an ecliptic orientation of the Babylonian astronomical diaries from both historical and graphical perspectives. To put this into proper context, one must first ask "why?" Indeed, what did inspire Mesopotamian celestial interest? The answer was that of practical value – value in devising and regulating a lunar calendar and, more importantly, in developing and refining the ability to detect omens foretelling the future of the nation.

Nearly as early as written records exist we find references to stars in proximity to the sun, moon, and planets. As interest in celestial omens grew, so did the attention paid to these heavenly bodies. The planets' relative positions were thought to relate messages from the gods, messages warning the king of impending danger. Close attention was paid to their exact location, the stars they were near, their proximity to one another, and the courses they followed across the sky. It is this interest that taught the Babylonians of the celestial path traveled by the planets and ultimately inspired their invention of the zodiac as a system of reference for omen observations. While the Babylonians may or may not have defined the ecliptic as precisely as we do today, they were most definitely aware of the direction of travel taken by the bodies they called "interpreters."[109]

[109] Swerdlow, *Ancient Astronomy*, 2.

This "ecliptic region" appears to have been a primary focus of Babylonian astronomy and astrology. All 31 "normal stars" selected for reference in the *Diaries* lie within ten degrees of the sun's path. Passages in MUL.APIN and *Enūma Anu Enlil* highlight celestial bodies within this same vicinity. Divining the future focused attention on the moon and the planets and this, in turn, gave the Babylonians an ecliptic-related frame of reference.

Strong implications of this focus can be found in the nomenclature that the Babylonians used for their stars. Twenty-two of the "normal stars" have names that specify "front," "rear," "northern," "southern," or, in the instance of Scorpius, "upper," "middle," and "lower." In each case these directional names correspond respectively with celestial longitude or celestial latitude. Zubeneschamali is beta Librae, "The northern part of the Scales," and has greater celestial latitude than does Zubenelgenubi, or alpha Librae, "The southern part of the Scales." Pollux, or beta Geminorum, "The rear Twin star," has greater celestial longitude than does Castor, or alpha Geminorum, "The front Twin star." The orientation of "front" and "rear" appears to be in direct relation to the diurnal travel of celestial bodies. The object rising and setting first is "front," while the trailing body is "rear." This correlation also holds true in the *Diaries* where topographical relations of "in front of" and "behind" follow the same convention. Northern, southern, upper, middle, and lower all relate to celestial latitude and are essentially perpendicular to the path of planetary travel. The same holds true in the *Diaries* for topographical relations of "above" and "below."

After tracing the historical evidence supporting an ecliptic frame of reference I next began my quantitative and graphical analyses. It was my goal to determine whether or not the Babylonians referred to the ecliptic when recording their diary entries and to evaluate the size that they may have assigned to a cubit. I included in my research a new perspective by generating and evaluating representations of the night sky as viewed by the Babylonians over two millennia ago.

Substantiating scribal reference to the ecliptic path of travel worked very well, both quantitatively and graphically. Subtracting the values of celestial longitudes for "in front of" and "behind" and celestial latitudes for "above" and "below" resulted in 99.5% of the entries supporting ecliptic orientation. This is shown, in the extreme right-hand column of Appendix 1, as a positive value if the first body is greater in celestial longitude or latitude than the second body. The value is negative when celestial coordinates are greater for the second body than the first.

This dependence becomes much easier to see when viewed graphically with the star-charts included in Appendix 2. These pictorial representations, more clearly than any other evidence, demonstrate direct correlation between the topographical relations and the direction of ecliptic travel. The chart for –567 II 1 provides a very distinct example. As the new crescent moon is setting in the west it is described as being below beta Geminorum. Viewed strictly in relation to the nearing horizon, the moon is to the left of the star, not beneath it. However, when the chart is rotated counter-clockwise so that the ecliptic is horizontal, then the moon is almost directly below beta Geminorum. The chart for –567 III 1 includes a diary description that has Mars and Mercury in front of alpha Leonis. This portrayal is logical when viewed in the context that the two planets precede alpha Leonis on the ecliptic as they all head across the sky for the western horizon. My charts are replete with such examples. It is important to note, however, that these relations are only of a general nature.

In this study I also examined the size of a cubit in angular degrees. My computations were strictly an arithmetic calculation of the difference in either celestial longitude or celestial latitude. The overall arithmetic mean of all values found in the "Angular Degrees/Cubit" column of the tables of Appendix 1 gives a cubit as being 2.38 angular degrees, very close to the number that was originally suggested by Graßhoff.[110] The overall median value is 2.29 degrees. These results are discussed more fully in the introductory section of Chapter 10. The values remain fairly consistent throughout the centuries of the diary observations, however there are many outliers in the population. Only 33% of the values are between 2.0 and 2.5 angular degrees per cubit. There are 32% of them below 2.0 and 35% above 2.5. Five percent of the values are between 0 and 1.0,

[110] Graßhoff's research gave him medium values of 2.37 degrees for "above" relations and 2.43 degrees for "below." He ultimately argues for a 2.5 degree approximation.

with one being as low as 0.22 degrees. Sixteen percent are above 3.0 and as high as 7.57. Such erratic figures suggest that they may not have been precisely measured against any specific coordinate system.

In entries with dual relations, the second reference often seems less precise than the first. One possibility might be that the convention was to measure the primary reference, while only making a good estimate of the second. Accuracy seemed difficult to attain also in entries involving very large or very small distances. We do not know exactly how these observations were measured, but it is possible that the instrument used was not designed to measure cubit distances of these extremes and a certain amount of estimation was required here as well.

Seasonal hours and water clocks are discussed in Chapters 7 and 9. My choice to establish times of entry at sunset plus or sunrise minus one seasonal hour worked quite well. The actual times of observation still are uncertain, as is how the Babylonians would measure a quarter-watch. As discussed previously, a circular tablet was found that describes an amount of water appropriate for each watch, half-watch, and quarter-watch. Since this smaller amount was specified, there may have been a capability allowing for the calculation of what would amount to one seasonal hour. It was desirable to record observations at these times for reasons such as ecliptic alignment on the horizon and to keep the scribe's work as early in the evening and late in the morning as possible.

I found no real difference in entries specifying "beginning of the night" or "first part of the night." The Babylonians may have had some other meaning or reasons for utilizing these terms. A number of entries for the "first part of the night" showed, due to rising and setting times of the moon and planets, that there could be no observation at the time of a second seasonal hour.

My effort to isolate the actual time of observation for suitable scribal entries was purely speculative, but proved to be most interesting. "Selected time of entry" was the point I chose to begin each analysis. In many entries I noted that adjustments to this time, particularly in cases relative to the moon, could be used to refine discrepancies of celestial longitude that were evidenced by cubit dimensions much larger or smaller than my results of 2.2 – 2.4 degrees. With the assumption that the scribe recorded an accurate entry, this time adjustment might possibly indicate a closer approximation of when the astronomer actually did his night's work. In a number of cases the proximity of the body to the horizon at rising or setting and the time of sunrise or sunset narrowly defined the possible window in which the observation could have occurred. Such an example is that of –77 IV 28 where at 04:12 Venus began to rise on the eastern horizon. By 04:18, the time of one seasonal hour before sunrise, Venus was just above the horizon, and enough so to be measured by the scribe. Sunrise occurred at 05:06, narrowing the possible range of time for this entry. While there certainly are exceptions, the great majority of entries seem to imply that their data was recorded within two seasonal hours of sunset or sunrise. This practice was logical in keeping with an observational program designed to produce dependable long-term results as it allowed scribes to get a reasonable amount of rest. Some entries do occur during the middle of the night, but they are by far in the minority.

Later in the *Diaries* I found that "dual entries," those taken both in the evening and in the morning, became more frequent. It might be interesting to determine what, if any, factors drove this effort to gather additional data. At a time when Babylonian astronomy was at its peak, a requirement for more extensive information very well may have existed.

Babylonian scribes were well versed in their work and anticipated the bodies that would be observed on specific evenings. A good example of this is found in the text of the entry for –77 IV 22, "…alpha Tauri was not seen with the moon, it was as if it had come close…." Often when an anticipated entry could not be accomplished through observation it was completed by calculation instead. In such cases the scribe would add NU PAP, or "I did not watch," to his diary description.

Also of considerable interest are the errata I discovered in the diaries through graphical analysis. Visual display on the star-charts proved to be a most valuable tool. Some diary entries were so far off that no time adjustment could make them right. In a few cases two directions were cited that contained opposing errors so that a change in time might correct one while worsening the other. In the entries chosen for this study alone 3%, or six cases, were found to have positions given that were entirely wrong. The entry for –567 I 9 was one day off and was so noted by Sachs and Hunger. On –288 VII 27 the entry describes Jupiter when Mercury actually was located nearest the specified position. A relation of 10 fingers above is given on –246 I 10 when the body is really 10 fingers below. The entry for –190 III 18 is also one day off but, in this instance, was not described as being so in the diary notes. In –140 XI 20 the moon is above, not below, and in –77 IV 3 it is east and not west.

Certain months contain multiple minor discrepancies inferring the possibility that poor-quality measurements were made for those diary entries. These may imply differing levels of skill or precision among the scribes. Most seem exacting in their work, but a few, perhaps, might have been somewhat careless.

As early as records exist the Babylonians recorded with fascination what they observed in the heavens. The *Astronomical Diaries* appear to have been compiled to refine celestial divination and its search for omens with keys to the future. Priests and scribes followed closely the positions of the moon and planets. This gave rise to an orientation regarding the direction that these bodies traveled, and stars were named accordingly. My tabular data shows that "in front of" and "behind" relate to differences in what we know to be celestial longitude and "above" and "below" to that of celestial latitude. The corresponding star-charts clearly depict these relationships. While early Babylonians might have perceived the precise path of the sun across the stars of the zodiac, they would not have had to for these purposes. One need only observe nightly celestial travel to imagine relations of "in front of" or "behind." "Above" and "below" are then easy extensions describing relations perpendicular to this path. Based upon the historical and graphical findings of this study, I conclude it most probable that the topographical relations utilized by Babylonian scribes in the *Astronomical Diaries* were in direct correlation to the general path of ecliptic travel. The star-charts found in Appendix 2 gave fresh perspective and were instrumental in addressing this question. As two-thirds of my cubit values were either less than 2.0 or greater than 2.5 I was unable to confidently isolate the cubit's size and remain skeptical that it is represented by 2.5 angular degrees. Overall I found no evidence, either quantitative or graphical, that would imply that the Babylonians ever used a system of specific ecliptic coordinates for their astronomical diary entries.

Appendix 1

Tables

The methodology utilized in the compilation of these tables is explained in Chapter 9. Column descriptions are reprinted here as a convenience to the reader.

Date – Given as the reference date assigned by Sachs and Hunger in the *Diaries* (e.g., -567 I 8).[111]

Sunset – The local time of sunset on the specified date.

Sunrise – The local time of sunrise on the specified date.

Watch – Given as *beg, first, mid,* or *last* as appropriate with the diary entry as beginning, first, middle, or last part of the night. *None* is used when no watch was specified.

Selected Time of Entry – The time selected and entered into the software for the observation on each selected date. Given as local time.

1st Body 2nd Body – The two bodies specified in the diary entry.

Ecl Long Decimal – Ecliptic longitude specified in decimal degrees.

Ecl Lat Decimal – Ecliptic latitude specified in decimal degrees.

Ang Dist – Angular distance in both celestial longitude and celestial latitude. Difference taken as absolute values with formulas written to the spreadsheet. The upper value is the difference between the two bodies in celestial longitude in angular degrees. The lower value is the difference between the two bodies in celestial latitude in angular degrees.

[111] Although months X, XI, XII, and XII2 have dates falling in the following Julian year, Sachs and Hunger keep with the convention of referencing the same year from Nisannu (BAR) through Addaru (ŠE).

Cubits(c)/Fingers(f) – Dimensions taken from *Diary* entry descriptions. Specified in cubits, fractions of a cubit, and in fingers. The relationship between cubits and fingers is taken with the Late Babylonian convention that 24 fingers equal one cubit.

Dec Dist in Cubits – The decimal distance equivalent of the specified number of cubits and fingers as related in the diary entry. One cubit is taken as 24 fingers.

Ang Deg/Cubit – The appropriate angular distance divided by the specified decimal distance to yield the number of angular degrees per cubit. Taken by formulas written to the spreadsheet.

Topo Rel – Topographical relations as taken from descriptions in diary entries.

+Abv/Ifo –Blw/Bhd – Difference taken with formulas written to the spreadsheet. Celestial latitude is used if "above" or "below." If the difference is positive then the first body is "above" the second body. A negative difference indicates the first body is "below" the second. Celestial longitude is used if "in front of" or "behind." If the difference is positive then the first body is "in front of" the second body. If the difference is negative then the first body is "behind" the second body.

Date	Sunset	Sunrise	Watch	Selected Time of Entry	1st Body 2nd Body	Ecl Long Decimal λ	Ecl Lat Decimal β	Ang Dist λ β	Cubits(c) Fingers(f)	Dec Dist in Cubits (24f/c)	Ang Deg/ Cubit	Topo Rel	+ Abv/Ifo - Blw/Bhd
-567 I 8	1832	0519	beg	1932	moon	139.03	3.79	1.91	1c	1.00	1.91	ifo	1.91
					β Vir	140.94	0.64	3.15					
-567 II 1	1847	0456	none	1943	moon	78.58	-1.02	0.60	4c	4.00	1.88	blw	-7.50
					β Gem	77.98	6.48	7.50					
-567 III 1	1903	0445	none	1955	Mars	106.97	1.23	7.36	4c	4.00	1.84	ifo	7.36
					α Leo	114.33	0.35	0.88					
-567 III 8	1906	0446	first	1958	moon	193.70	4.48	0.02	2 1/2c	2.50	1.71	blw	-4.27
					β Lib	193.68	8.75	4.27					
-567 III 10	1906	0447	first	1958	moon	217.99	3.37	3.89	3 1/2c	3.50	2.17	abv	7.60
					α Sco	214.10	-4.23	7.60					
-567 III 12	1907	0447	none	1959	Mars	113.90	1.20	0.43	2/3c	0.67	1.28	abv	0.86
					α Leo	114.33	0.35	0.86					
-463 VI 22	1756	0551	last	0455	moon	116.64	-4.98	0.86	3c	3.00	1.78	blw	-5.33
					α Leo	115.78	0.35	5.33					
-418 I 7	1815	0554	first	1915	Venus	49.43	4.39	0.46	8f	0.33	2.42	blw	-0.80
					β Tau	48.97	5.19	0.80					
-418 I 9	1816	0552	mid	0016	moon	121.66	2.38	0.61	3f	0.13	4.89	ifo	0.61
					Mars	122.27	2.67	0.28					

Date	Sunset	Sunrise	Watch	Selected Time of Entry	1st Body 2nd Body	Ecl Long Decimal λ	Ecl Lat Decimal β	Ang Dist λ β	Cubits(c) Fingers(f)	Dec Dist in Cubits (24f/c)	Ang Deg/ Cubit	Topo Rel	+ Abv/Ifo - Blw/Bhd
-418 I 9	1816	0552	mid	0116	moon	122.12	2.33	0.16	3f	0.13	1.28	ifo	0.16
					Mars	122.28	2.67	0.34					
-418 II 7	1834	0515	none	1930	moon	128.15	3.28	2.56	2/3c	0.67	3.84	ifo	2.56
					Mars	130.71	1.72	1.56					
-418 II 9	1835	0513	none	1931	Mars	131.51	1.67	1.72	4c	4.00	1.99	blw	-7.97
					α Leos	129.79	9.64	7.97					
-418 XII2 13	1813	0600	beg	1917	Mercury	21.92	2.96	4.49	1 2/3c	1.67	2.70	ifo	4.49
					η Tau	26.41	3.78	0.82					
-384 XII 4	1757	0633	beg	1901	moon	39.81	-5.46	3.17	2c 8f	2.33	1.36	bhd	-3.17
					α Tau	36.64	-5.63	0.17					
-384 XII 5	1758	0631	beg	1902	moon	53.43	-5.39	1.76	14f	0.58	3.04	bhd	-1.76
					ζ Tau	51.67	-2.51	2.88					
-372 I 4	1815	0555	beg	1915	moon	67.62	2.37	5.28	2 2/3c	2.67	1.98	bhd	-5.28
					μ Gem	62.34	-1.13	3.50					
-372 I 4	1815	0555	beg	1915	Mercury	22.33	1.82	0.06	1c 6f	1.25	2.20	abv	2.76
					Jupiter	22.39	-0.94	2.76					
-372 I 5	1816	0553	beg	1916	moon	82.09	1.20	1.44	1/2c	0.50	2.88	bhd	-1.44
					β Gem	80.65	6.50	5.30					

Date	Sunset	Sunrise	Watch	Selected Time of Entry	1st Body 2nd Body	Ecl Long Decimal λ	Ecl Lat Decimal β	Ang Dist λ β	Cubits(c) Fingers(f)	Dec Dist in Cubits (24f/c)	Ang Deg/ Cubit	Topo Rel	+ Abv/Ifo - Blw/Bhd
-372 I 7	1817	0550	first	1917	Mercury η Tau	27.41 27.07	2.20 3.60	0.34 1.40	2/3c	0.67	2.10	blw	-1.40
-372 I 8	1818	0549	beg	1918	moon α Leo	123.77 117.03	-2.39 0.36	6.74 2.75	2 1/2c	2.50	2.70	bhd	-6.74
-372 I 8	1818	0549	beg	1918	Venus α Tau	37.37 36.80	0.64 -5.63	0.57 6.27	2 2/3c	2.67	2.35	abv	6.27
-372 I 12	1820	0543	first	1920	moon α Vir	175.00 170.92	-5.10 -1.90	4.08 3.20	2c	2.00	2.04	bhd	-4.08
-372 I 16	1822	0538	last	0438	moon θ Oph	227.59 228.44	-4.54 -1.53	0.85 3.01	1/2c	0.50	6.02	blw	-3.01
-372 I 18	1823	0537	first	1923	Venus β Tau	49.41 49.61	1.09 5.19	0.20 4.10	1 1/2c	1.50	2.73	blw	-4.10
-372 I 21	1825	0532	first	1925	Venus ζ Tau	53.01 51.82	1.22 -2.51	1.19 3.73	1 1/2c	1.50	2.49	abv	3.73
-346 IX 8	1659	0654	beg	1807	moon η Psc	354.34 354.23	-4.75 5.25	0.11 10.00	1/2c	0.50	0.22	bhd	-0.11
-346 IX 8	1659	0654	last	0546	Jupiter ρ Leo	123.77 123.80	1.03 0.02	0.03 1.01	8f	0.33	3.06	abv	1.01

Date	Sunset	Sunrise	Watch	Selected Time of Entry	1st Body 2nd Body	Ecl Long Decimal λ	Ecl Lat Decimal β	Ang Dist λ β	Cubits(c) Fingers(f)	Dec Dist in Cubits (24f/c)	Ang Deg/ Cubit	Topo Rel	+ Abv/Ifo - Blw/Bhd
-346 IX 9	1659	0655	first	1807	moon	8.34	-5.38	7.40	2c	2.00	3.70	ifo	7.40
					Mars	15.74	1.03	6.41					
-346 IX 12	1659	0657	beg	1807	moon	52.32	-5.42	0.13	1c	1.00	2.91	blw	-2.91
					ζ Tau	52.19	-2.51	2.91					
-346 IX 13	1659	0658	beg	1807	moon	67.68	-4.73	1.16	20f	0.83	2.75	abv	2.28
					γ Gem	66.52	-7.01	2.28					
-346 IX 16	1700	0700	last	0552	moon	118.48	-0.52	1.09	1/2c	0.50	2.18	bhd	-1.09
					α Leo	117.39	0.36	0.88					
-346 IX 16	1700	0700	last	0552	moon	118.48	-0.52	4.80	2c	2.00	2.40	ifo	4.80
					Jupiter	123.28	1.07	1.59					
-346 IX 18	1701	0702	last	0554	moon	146.58	1.95	2.52	1c	1.00	2.52	bhd	-2.52
					β Vir	144.06	0.64	1.31					
-346 IX 20	1701	0703	last	0555	moon	172.88	3.77	1.60	2/3c	0.67	2.39	bhd	-1.60
					α Vir	171.28	-1.90	5.67					
-346 IX 20	1701	0703	last	0555	moon	172.88	3.77	1.26	1/2c	0.50	2.56	abv	1.28
					Saturn	171.62	2.49	1.28					
-346 IX 22	1702	0704	last	0556	moon	197.24	4.71	0.49	1 1/2c	1.50	2.68	blw	-4.02
					β Lib	196.75	8.73	4.02					

Date	Sunset	Sunrise	Watch	Selected Time of Entry	1st Body 2nd Body	Ecl Long Decimal λ	Ecl Lat Decimal β	Ang Dist λ β	Cubits(c) Fingers(f)	Dec Dist in Cubits (24f/c)	Ang Deg/ Cubit	Topo Rel	+ Abv/Ifo - Blw/Bhd
-346 IX 23	1703	0704	last	0556	moon	208.87	4.83	1.28	1 1/2c	1.50	2.36	abv	3.54
					β Sco	210.15	1.29	3.54					
-308 VI 4	1824	0534	beg	1920	moon	218.02	4.19	0.50	4c	4.00	2.12	abv	8.46
					α Sco	217.52	-4.27	8.46					
-308 VI 6	1821	0536	beg	1917	moon	245.37	3.07	5.70	2 2/3c	2.67	2.14	ifo	5.70
					Saturn	251.07	0.73	2.34					
-308 VI 8	1819	0537	beg	1915	moon	271.09	1.23	0.90	1/2c	0.50	1.80	ifo	0.90
					β Cap	271.99	4.85	3.62					
-308 VI 15	1810	0542	beg	1906	moon	355.67	-5.21	0.91	2/3c	0.67	1.36	ifo	-0.91
					η Psc	354.76	5.25	10.46					
-308 VI 15	1810	0542	last	0446	Mars	108.29	1.15	0.33	3 1/2c	3.50	2.39	blw	-8.38
					ε Leo	108.62	9.53	8.38					
-308 VI 19	1805	0545	last	0449	moon	47.92	-4.79	4.79	2 1/2c	2.50	1.92	ifo	4.79
					ζ Tau	52.71	-2.50	2.29					
-308 VI 22	1801	0548	last	0452	moon	87.28	-2.37	5.76	2 2/3c	2.67	2.16	bhd	-5.76
					β Gem	81.52	6.50	8.87					
-308 VI 23	1759	0548	last	0452	moon	101.04	-1.21	4.42	2c	2.00	2.21	bhd	-4.42
					δ Can	96.62	-0.02	1.19					

Date	Sunset	Sunrise	Watch	Selected Time of Entry	1st Body 2nd Body	Ecl Long Decimal λ	Ecl Lat Decimal β	Ang Dist λ β	Cubits(c) Fingers(f)	Dec Dist in Cubits (24f/c)	Ang Deg/ Cubit	Topo Rel	+ Abv/Ifo - Blw/Bhd
-308 VI 24	1758	0549	last	0453	moon	115.19	0.04	2.71	1c	1.00	2.71	ifo	2.71
					α Leos	117.90	0.36	0.32					
-308 VI 27	1754	0551	last	0455	moon	159.66	3.51	1.61	1/2c	0.50	3.22	bhd	-1.61
					γ Vir	158.05	2.84	0.67					
-288 VII 4	1759	0548	beg	1859	moon	234.66	1.60	5.25	1 1/2c	1.50	2.09	abv	3.14
					θ Oph	229.41	-1.54	3.14					
-288 VII 7	1755	0551	beg	1855	moon	277.80	-2.04	5.53	2c	2.00	2.77	bhd	-5.53
					β Cap	272.27	4.85	6.89					
-288 VII 8	1754	0551	beg	1854	moon	291.75	-3.18	0.10	6f	0.25	3.04	blw	-0.76
					δ Cap	291.85	-2.42	0.76					
-288 VII 15	1745	0557	last	0457	moon	28.54	-4.22	0.33	1c	1.00	0.33	bhd	-0.33
					η Tau	28.21	3.79	8.01					
-288 VII 18	1741	0559	mid	2341	moon	63.41	-2.11	0.10	8f	0.33	3.00	blw	-0.99
					μ Gem	63.51	-1.12	0.99					
-288 VII 22	1736	0602	last	0502	moon	113.28	2.43	4.90	2c	2.00	2.45	ifo	4.90
					α Leo	118.18	0.36	2.07					
-288 VII 23	1735	0603	last	0503	moon	125.73	3.38	1.13	1c	1.00	1.13	bhd	-1.13
					ρ Leo	124.60	0.03	3.35					

Date	Sunset	Sunrise	Watch	Selected Time of Entry	1st Body 2nd Body	Ecl Long Decimal λ	Ecl Lat Decimal β	Ang Dist λ β	Cubits(c) Fingers(f)	Dec Dist in Cubits (24f/c)	Ang Deg/ Cubit	Topo Rel	+ Abv/Ifo - Blw/Bhd
-288 VII 25	1733	0605	last	0505	moon	151.69	4.63	5.75	2c	2.00	2.88	ifo	5.75
					Saturn	157.44	2.07	2.56					
-288 VII 27	1730	0607	last	0507	moon	179.27	4.91	3.65	2c	2.00	1.82	ifo	3.65
					Mercury	182.92	2.28	2.63					
-288 VII 27	1730	0607	last	0507	moon	179.27	4.91	95.29	2c	2.00	47.65	ifo	-95.29
					Jupiter	83.98	-0.08	4.99					
-261 IX 3	1700	0642	none	1808	moon	294.33	0.92	2.12	1c	1.00	2.12	bhd	-2.12
					δ Cap	292.21	-2.42	3.34					
-261 IX 7	1659	0645	beg	1807	moon	350.16	4.44	5.26	2c	2.00	2.63	ifo	5.26
					η Psc	355.42	5.25	0.81					
-261 IX 11	1659	0649	beg	1807	moon	41.74	3.79	3.39	5c	5.00	1.88	abv	9.41
					α Tau	38.35	-5.62	9.41					
-261 IX 14	1658	0653	last	0545	moon	82.09	0.94	0.09	1 2/3c	1.67	3.34	blw	-5.57
					β Gem	82.18	6.51	5.57					
-261 IX 15	1658	0653	last	0545	moon	94.47	-0.18	2.82	1 1/2c	1.50	1.88	ifo	2.82
					δ Cnc	97.29	-0.02	0.16					
-261 IX 18	1659	0655	last	0547	moon	130.28	-3.33	1.70	1 1/2c	1.50	1.13	ifo	1.70
					θ Leo	131.98	9.65	12.98					

Date	Sunset	Sunrise	Watch	Selected Time of Entry	1st Body 2nd Body	Ecl Long Decimal λ	Ecl Lat Decimal β	Ang Dist λ β	Cubits(c) Fingers(f)	Dec Dist in Cubits (24f/c)	Ang Deg/ Cubit	Topo Rel	+ Abv/Ifo - Blw/Bhd
-261 IX 18	1659	0655	last	0547	moon	130.28	-3.33	0.10	1 1/2c	1.50	3.18	blw	-4.77
					Saturn	130.38	1.44	4.77					
-261 IX 19	1659	0656	last	0548	moon	142.42	-4.20	2.84	1c 8f	1.33	2.14	ifo	2.84
					β Vir	145.26	0.65	4.85					
-261 IX 19	1659	0656	last	0548	moon	142.42	-4.20	0.76	1c	1.00	0.76	ifo	0.76
					Mars	143.18	3.02	7.22					
-261 IX 20	1659	0657	last	0549	moon	154.77	-4.91	3.95	1 1/2c	1.50	2.63	ifo	3.95
					γ Vir	158.72	2.84	7.75					
-261 IX 23	1659	0659	last	0551	moon	193.18	-5.71	0.18	n/a	n/a	n/a	blw	-6.31
					α Lib	193.00	0.60	6.31					
-261 IX 23	1659	0659	last	0551	moon	193.18	-5.71	10.44	2 1/2c	2.50	4.18	bhd	-10.44
					Jupiter	182.74	1.39	7.10					
-261 IX 25	1700	0700	last	0552	moon	221.77	-4.83	3.74	1c 8f	1.33	2.81	bhd	-3.74
					α Sco	218.03	-4.27	0.56					
-246 I 4	1826	0531	none	1926	moon	73.85	4.84	5.27	1 2/3c	1.67	3.16	ifo	5.27
					α Gem	79.12	9.93	5.09					
-246 I 5	1826	0530	beg	1926	moon	87.61	5.06	5.25	2c 8f	2.33	2.25	bhd	-5.25
					β Gem	82.36	6.51	1.45					

Date	Sunset	Sunrise	Watch	Selected Time of Entry	1st Body 2nd Body	Ecl Long Decimal λ	Ecl Lat Decimal β	Ang Dist λ β	Cubits(c) Fingers(f)	Dec Dist in Cubits (24f/c)	Ang Deg/ Cubit	Topo Rel	+ Abv/Ifo - Blw/Bhd
-246 I 7	1828	0527	beg	1928	moon	115.84	4.58	2.92	1 2/3c	1.67	2.52	abv	4.21
					α Leo	118.76	0.37	4.21					
-246 I 8	1828	0526	beg	1928	moon	130.25	3.88	1.92	1 1/2c	1.50	1.28	ifo	1.92
					θ Leo	132.17	9.65	5.77					
-246 I 10	1830	0524	beg	1930	moon	159.45	1.74	0.53	10f	0.42	2.62	abv	-1.10
					γ Vir	158.92	2.84	1.10					
-246 I 11	1830	0522	beg	1930	moon	174.10	0.44	1.44	1c	1.00	2.35	abv	2.35
					α Vir	172.66	-1.91	2.35					
-246 I 12	1831	0521	beg	1931	moon	188.43	-0.90	5.49	2 5/6c	2.83	1.94	ifo	5.49
					α Lib	193.92	0.60	1.50					
-246 I 13	1832	0520	beg	1932	moon	203.02	-2.17	7.85	3 1/2c	3.50	2.24	ifo	7.85
					δ Sco	210.87	-1.72	0.45					
-246 I 14	1832	0519	beg	1932	moon	217.10	-3.30	1.09	1/2c	0.50	2.18	ifo	1.09
					α Sco	218.19	-4.28	0.98					
-246 I 15	1833	0518	last	0418	moon	234.69	-5.04	4.77	1 2/3c	1.67	2.86	bhd	-4.77
					θ Oph	229.92	-1.55	3.49					
-246 I 17	1834	0515	last	0415	moon	261.24	-5.94	11.62	5 1/2c	5.50	2.11	ifo	11.62
					β Cap	272.86	4.84	10.78					

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-246 I 19	1835	0513	last	0413	moon	286.64	-5.80	4.07	1 2/3c	1.67	2.44	ifo	4.07
					γ Cap	290.71	-2.37	3.43					
-218 VIII 4	1717	0618	beg	1821	moon	276.40	4.91	3.15	1c	1.00	3.15	bhd	-3.15
					β Cap	273.25	4.84	0.07					
-218 VIII 4	1717	0618	beg	1821	moon	276.40	4.91	3.77	2c	2.00	1.88	bhd	-3.77
					Saturn	272.63	-0.13	5.04					
-218 VIII 5	1716	0619	last	0515	Venus	199.24	1.31	0.73	5c	5.00	1.48	blw	-7.41
					β Lib	198.51	8.72	7.41					
-218 VIII 10	1711	0624	beg	1815	moon	354.71	-1.07	1.30	1c	1.00	n/a	n/a	1.30
					η Psc	356.01	5.25	6.32					
-218 VIII 10	1711	0624	last	0520	Mars	68.14	1.54	0.15	3 1/2c	3.50	2.44	abv	8.53
					γ Gem	68.29	-6.99	8.53					
-218 VIII 11	1710	0625	beg	1814	moon	6.69	-2.13	0.20	2 1/2c	2.50	4.77	blw	-11.92
					α Ari	6.89	9.79	11.92					
-218 VIII 14	1708	0627	beg	1812	moon	42.51	-4.69	3.57	1c	1.00	3.57	bhd	-3.57
					α Tau	38.94	-5.62	0.93					
-218 VIII 14	1708	0627	beg	1812	moon	42.51	-4.69	2.32	1 1/2c	1.50	2.42	blw	-3.63
					Jupiter	40.19	-1.06	3.63					

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-218 VIII 15	1707	0628	last	0524	moon	58.55	-5.00	4.58	2c	2.00	2.29	bhd	-4.58
					ζ Tau	53.97	-2.49	2.51					
-218 VIII 16	1707	0629	last	0525	moon	70.57	-5.27	2.28	1 1/2c	1.50	1.52	bhd	-2.28
					γ Gem	68.29	-6.99	1.72					
-218 VIII 17	1706	0630	last	0526	moon	82.69	-5.32	0.07	5c	5.00	2.37	blw	-11.83
					β Gem	82.76	6.51	11.83					
-218 VIII 18	1705	0631	last	0527	moon	94.94	-5.14	2.94	1c	1.00	2.94	ifo	2.94
					δ Cnc	97.88	-0.02	5.12					
-218 VIII 20	1704	0633	last	0529	moon	119.99	-4.10	0.84	1 1/2c	1.50	2.98	blw	-4.47
					α Leo	119.15	0.37	4.47					
-218 VIII 22	1703	0635	last	0531	moon	146.11	-2.24	0.26	1c	1.00	2.89	blw	-2.89
					β Vir	145.85	0.65	2.89					
-218 VIII 23	1703	0636	last	0532	moon	159.71	-1.09	0.40	1 1/2c	1.50	2.62	blw	-3.93
					γ Vir	159.31	2.84	3.93					
-218 VIII 25	1702	0638	last	0534	moon	188.17	1.38	6.02	2 1/2c	2.50	2.41	ifo	6.02
					α Lib	194.19	0.60	0.78					
-218 VIII 26	1701	0639	last	0535	moon	202.49	2.54	3.97	2/3c	0.67	5.93	bhd	-3.97
					β Lib	198.52	8.72	6.18					

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-190 III 1	1850	0454	none	1942	moon α Gem	76.91 79.89	4.59 9.93	2.98 5.34	1 1/2c	1.50	1.99	ifo	2.98
-190 III 1	1850	0454	none	1942	moon Venus	76.91 76.57	4.59 1.07	0.34 3.52	2/3c	0.67	0.51	bhd	-0.34
-190 III 2	1851	0453	none	1943	moon β Gem	88.83 83.13	4.65 6.52	5.70 1.87	1 1/2c	1.50	3.80	bhd	-5.70
-190 III 2	1851	0453	none	1943	moon Mercury	88.83 84.52	4.65 0.80	4.31 3.85	1 1/2c	1.50	2.87	bhd	-4.31
-190 III 3	1852	0452	none	1944	moon δ Cnc	100.75 98.25	4.48 -0.01	2.50 4.49	1 1/2c	1.50	1.67	abv	4.49
-190 III 4	1852	0452	beg	1944	moon ε Leo	112.72 110.25	4.10 9.55	2.47 5.45	1c	1.00	2.47	bhd	-2.47
-190 III 5	1853	0451	beg	1945	moon ρ Leo	124.79 125.95	3.51 0.04	1.16 3.47	2/3c	0.67	1.73	ifo	1.16
-190 III 6	1854	0451	beg	1946	moon θ Leos	137.03 132.95	2.74 9.65	4.08 6.91	2 1/2c	2.50	1.63	bhd	-4.08
-190 III 8	1855	0450	beg	1947	moon γ Vir	162.28 159.69	0.72 2.84	2.59 2.12	1c	1.00	2.59	bhd	-2.59

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-190 III 8	1855	0450	first	1947	Venus β Gem	85.12 83.13	1.28 6.52	1.99 5.24	3 1/2c	3.50	1.50	blw	-5.24
-190 III 9	1855	0449	beg	1947	moon α Vir	175.45 173.43	-0.45 -1.91	2.02 1.46	1c	1.00	2.02	bhd	-2.02
-190 III 10	1856	0449	beg	1948	moon α Lib	188.94 194.45	-1.66 0.60	5.51 2.26	2 1/2c	2.50	2.20	ifo	5.51
-190 III 11	1857	0449	beg	1949	moon β Lib	202.61 198.91	-2.84 8.72	3.70 11.56	1 1/2c	1.50	2.47	bhd	-3.70
-190 III 13	1858	0448	beg	1950	moon θ Oph	232.56 230.58	-4.77 -1.56	1.98 3.21	2 1/2c	2.50	1.28	blw	-3.21
-190 III 16	1859	0447	last	0355	moon γ Cap	282.38 291.46	-5.58 -2.38	9.08 3.20	4c	4.00	2.27	ifo	9.08
-190 III 17	1900	0447	last	0355	moon δ Cap	297.66 293.14	-5.02 -2.43	4.52 2.59	1 2/3c	1.67	2.71	bhd	-4.52
-190 III 18	1900	0447	last	0355	moon δ Cap	312.22 293.14	-4.18 -2.43	19.08 1.75	1 2/3c	1.67	11.43	bhd	-19.08
-190 III 21	1902	0446	last	0354	moon η Psc	353.69 356.39	-0.83 5.25	2.70 6.08	2 1/2c	2.50	1.08	ifo	2.70

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-190 III 24	1903	0446	last	0354	moon	31.33	2.34	1.77	2/3c	0.67	2.18	blw	-1.46
					η Tau	29.56	3.80	1.46					
-190 III 25	1904	0446	last	0354	moon	43.53	3.13	4.21	5c	5.00	1.75	abv	8.75
					α Tau	39.32	-5.62	8.75					
-190 III 26	1904	0446	last	0354	moon	55.59	3.74	3.46	1 1/2c	1.50	0.98	blw	-1.47
					β Tau	52.13	5.21	1.47					
-190 III 27	1904	0446	first	1956	Jupiter	145.76	1.30	0.48	6f	0.25	2.60	abv	0.65
					β Vir	146.24	0.65	0.65					
-168 V 1	1845	0520	none	1937	moon	168.42	-4.79	5.31	2c	2.00	2.66	ifo	5.31
					α Vir	173.73	-1.91	2.88					
-168 V 1	1845	0520	none	1937	moon	168.42	-4.79	6.22	2 1/2c	2.50	2.49	ifo	6.22
					Saturn	174.64	2.35	7.14					
-168 V 2	1844	0521	none	1936	moon	181.98	-5.85	4.15	2 1/2c	2.50	1.66	bhd	-4.15
					Mars	177.83	0.27	6.12					
-168 V 3	1843	0521	none	1935	moon	194.95	-6.00	0.29	3c	3.00	2.20	blw	-6.59
					α Lib	194.66	0.59	6.59					
-168 V 4	1842	0522	beg	1934	moon	208.06	-5.88	4.42	2c	2.00	2.21	ifo	4.42
					π Sco	212.48	-5.22	0.66					

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-168 V 5	1841	0523	beg	1933	moon	220.69	-5.51	1.65	1/2c	1.50	1.10	bhd	-1.65
					α Sco	219.04	-4.29	1.22					
-168 V 6	1840	0524	beg	1932	moon	233.03	-4.94	2.18	2c	2.00	1.69	blw	-3.38
					θ Oph	230.85	-1.56	3.38					
-168 V 9	1837	0526	beg	1929	moon	269.26	-2.31	4.70	3c	3.00	1.57	ifo	4.70
					β Cap	273.96	4.83	7.14					
-168 V 10	1836	0527	beg	1928	moon	281.26	-1.25	7.30	3c	3.00	2.43	bhd	-7.30
					β Cap	273.96	4.83	6.08					
-168 V 17	1827	0532	last	0440	moon	13.40	4.94	5.82	n/a	n/a	n/a	bhd	-5.82
					α Ari	7.58	9.79	4.85					
-168 V 18	1826	0533	last	0441	moon	27.10	4.85	2.78	1/2c	0.50	5.56	ifo	2.78
					η Tau	29.88	3.80	1.05					
-168 V 19	1825	0533	last	0441	moon	40.99	4.46	1.36	4c	4.00	2.52	abv	10.08
					α Tau	39.63	-5.62	10.08					
-168 V 19	1825	0533	last	0441	Jupiter	119.93	0.71	0.09	2f	0.08	4.25	abv	0.34
					α Leo	119.84	0.37	0.34					
-168 V 20	1824	0534	last	0442	moon	55.06	3.79	0.40	2c	2.00	3.14	abv	6.27
					ζ Tau	54.66	-2.48	6.27					

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-168 V 21	1822	0535	last	0443	moon	69.27	2.88	0.29	4c	4.00	2.47	abv	9.87
					γ Gem	68.98	-6.99	9.87					
-168 V 22	1821	0536	last	0444	moon	83.59	1.76	0.15	2c	2.00	2.38	blw	-4.75
					β Gem	83.44	6.51	4.75					
-168 V 23	1820	0536	last	0444	moon	98.00	0.52	0.57	2/3c	0.67	0.79	abv	0.53
					δ Cnc	98.57	-0.01	0.53					
-168 V 24	1819	0537	last	0445	moon	112.47	-0.76	1.91	1 1/2c	1.50	1.27	bhd	-1.91
					ε Leo	110.56	9.55	10.31					
-168 V 25	1817	0538	last	0446	moon	126.93	-2.01	0.67	2/3c	0.67	3.06	blw	-2.05
					ρ Leo	126.26	0.04	2.05					
-168 V 25	1817	0538	last	0446	moon	126.93	-2.01	5.86	3c	3.00	1.95	bhd	-5.86
					Jupiter	121.07	0.73	2.74					
-168 V 26	1816	0539	last	0447	moon	141.31	-3.12	8.05	2 1/2c	2.50	3.22	bhd	-8.05
					θ Leo	133.26	9.65	12.77					
-168 V 27	1815	0539	first	1907	Mars	195.12	-0.02	0.46	4f	0.17	3.59	blw	-0.61
					α Lib	194.66	0.59	0.61					
-140 XI 1	1734	0700	last	0552	Mars	275.36	-0.78	1.02	2c	2.00	2.81	blw	-5.61
					β Cap	274.34	4.83	5.61					

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-140 XI 4	1737	0658	beg	1845	moon	7.02	-5.42	2.76	6c	6.00	2.29	blw	-13.75
					β Ari	4.26	8.33	13.75					
-140 XI 6	1739	0657	beg	1847	moon	31.03	-4.92	0.77	1 1/2c	1.50	0.51	bhd	-0.77
					η Tau	30.26	3.81	8.73					
-140 XI 7	1739	0656	beg	1847	moon	43.40	-4.34	3.38	1c 8f	1.33	2.54	bhd	-3.38
					α Tau	40.02	-5.62	1.28					
-140 XI 8	1740	0655	beg	1848	moon	56.05	-3.55	1.01	8f	0.33	3.24	blw	-1.07
					ζ Tau	55.04	-2.48	1.07					
-140 XI 9	1741	0654	beg	1849	moon	69.07	-2.56	0.30	2c	2.00	2.21	abv	4.42
					γ Gem	69.37	-6.98	4.42					
-140 XI 10	1742	0653	beg	1850	moon	82.50	-1.42	1.33	n/a	n/a	n/a	ifo	1.33
					β Gem	83.83	6.52	7.94					
-140 XI 11	1743	0652	beg	1851	moon	96.39	-0.18	2.57	1 1/2c	1.50	1.71	ifo	2.57
					δ Cnc	98.96	-0.01	0.17					
-140 XI 12	1744	0651	first	1852	moon	110.74	1.10	0.21	3c	3.00	2.82	blw	-8.45
					ε Leo	110.95	9.55	8.45					
-140 XI 14	1745	0649	first	1853	moon	141.22	3.63	7.57	1c	1.00	7.57	bhd	-7.57
					θ Leo	133.65	9.65	6.02					

Date	Sunset	Sunrise	Watch	Selected Time of Entry	1st Body 2nd Body	Ecl Long Decimal λ	Ecl Lat Decimal β	Ang Dist λ β	Cubits(c) Fingers(f)	Dec Dist in Cubits (24f/c)	Ang Deg/ Cubit	Topo Rel	+ Abv/Ifo - Blw/Bhd
-140 XI 15	1746	0648	last	0540	moon	161.06	3.96	0.67	1c	1.00	0.67	bhd	-0.67
					γ Vir	160.39	2.84	1.12					
-140 XI 15	1746	0648	last	0540	moon	161.06	3.96	8.72	3c	3.00	2.91	ifo	8.72
					Saturn	169.78	2.70	1.26					
-140 XI 16	1747	0647	last	0539	moon	176.35	4.34	2.22	n/a	n/a	n/a	bhd	-2.22
					α Vir	174.13	-1.91	6.25					
-140 XI 17	1748	0646	last	0538	moon	191.45	5.39	3.49	1 1/2c	1.50	2.33	ifo	3.49
					α Lib	194.94	0.59	4.80					
-140 XI 18	1749	0645	last	0537	moon	205.91	4.07	7.11	3 1/2c	3.50	2.03	ifo	7.11
					β Sco	213.02	1.26	2.81					
-140 XI 19	1749	0644	last	0536	moon	220.07	3.47	0.07	4c	4.00	1.94	abv	7.76
					α Sco	220.00	-4.29	7.76					
-140 XI 20	1750	0643	last	0535	moon	234.27	2.64	3.09	2c	2.00	2.10	blw	4.20
					θ Oph	231.18	-1.56	4.20					
-140 XI 22	1752	0641	last	0533	moon	261.00	0.56	1.93	1c	1.00	1.93	bhd	-1.93
					Jupiter	259.07	0.24	0.32					
-140 XI 22	1752	0641	last	0533	Mars	291.82	-1.02	0.29	1/2c	0.50	2.72	abv	1.36
					γ Capricorni	292.11	-2.38	1.36					

Date	Sunset	Sunrise	Watch	Selected Time of Entry	1st Body 2nd Body	Ecl Long Decimal λ	Ecl Lat Decimal β	Ang Dist λ β	Cubits(c) Fingers(f)	Dec Dist in Cubits (24f/c)	Ang Deg/ Cubit	Topo Rel	+ Abv/Ifo - Blw/Bhd
-140 XI 23	1752	0640	last	0532	moon β Cap	273.88 274.34	-0.57 4.83	0.46 5.40	1c	1.00	0.46	ifo	0.46
-140 XI 24	1753	0639	last	0531	moon γ Cap	286.44 292.11	-1.67 -2.38	5.67 0.71	3c	3.00	1.89	ifo	5.67
-140 XI 25	1754	0637	last	0529	moon γ Cap	298.74 292.11	-2.70 -2.38	6.63 0.32	2 1/2c	2.50	2.65	bhd	-6.63
-140 XI 25	1754	0637	last	0529	Mars δ Cap	294.04 294.14	-1.05 -2.43	0.10 1.38	1/2c	0.50	2.76	abv	1.38
-111 I 8	1834	0516	beg	1934	moon ρ Leo	131.97 127.05	-3.98 0.04	4.92 4.02	2c	2.00	2.46	bhd	-4.92
-111 I 9	1834	0515	beg	1934	moon β Vir	145.19 147.36	-4.73 0.65	2.17 5.38	n/a	n/a	n/a	blw	-5.38
-111 I 10	1835	0514	beg	1935	moon γ Vir	158.89 160.79	-5.25 2.84	1.90 8.09	1c	1.00	1.90	ifo	1.90
-111 I 14	1838	0510	beg	1938	moon α Sco	217.67 220.32	-4.29 -4.29	2.65 0.00	1 1/2c	1.50	1.77	ifo	2.65
-111 I 18	1840	0506	first	1940	Mercury η Gem	64.30 64.09	2.23 -1.17	0.21 3.40	1 1/2c	1.50	2.27	abv	3.40

Date	Sunset	Sunrise	Watch	Selected Time of Entry	1st Body 2nd Body	Ecl Long Decimal λ	Ecl Lat Decimal β	Ang Dist λ β	Cubits(c) Fingers(f)	Dec Dist in Cubits (24f/c)	Ang Deg/ Cubit	Topo Rel	+ Abv/Ifo - Blw/Bhd
-111 I 18	1840	0506	last	0406	moon	281.92	0.58	7.17	1 1/2c	1.50	4.78	bhd	-7.17
					β Cap	274.75	4.83	4.25					
-111 I 19	1841	0505	first	1941	Mercury	65.90	2.23	0.05	1 1/2c	1.50	2.22	abv	3.33
					μ Gem	65.95	-1.10	3.33					
-111 I 19	1841	0505	last	0405	moon	296.17	1.78	1.65	1 1/2c	1.50	2.81	abv	4.21
					δ Cap	294.52	-2.43	4.21					
-111 I 21	1842	0503	first	1942	Mercury	68.98	2.19	0.78	4 1/2c	4.50	2.04	abv	9.17
					γ Gem	69.76	-6.98	9.17					
-111 I 25	1845	0500	last	0400	moon	13.60	4.24	5.25	1 1/2c	1.50	3.50	bhd	-5.25
					α Ari	8.35	9.79	5.55					
-111 I 26	1846	0459	last	0359	moon	25.67	3.82	4.89	2 1/2c	2.50	1.72	abv	4.31
					Venus	30.56	-0.49	4.31					
-111 I 28	1847	0457	first	1947	Mercury	78.26	1.67	2.72	4c	4.00	2.07	blw	-8.27
					α Gem	80.98	9.94	8.27					
-87 XII2 2	1808	0610	none	1912	moon	27.54	-4.70	3.45	n/a	n/a	n/a	blw	-8.51
					η Tau	30.99	3.81	8.51					
-87 XII2 4	1810	0607	beg	1914	moon	52.10	-5.40	1.46	5c	5.00	2.12	blw	-10.61
					β Tau	53.56	5.21	10.61					

Date	Sunset	Sunrise	Watch	Selected Time of Entry	1st Body 2nd Body	Ecl Long Decimal λ	Ecl Lat Decimal β	Ang Dist λ β	Cubits(c) Fingers(f)	Dec Dist in Cubits (24f/c)	Ang Deg/ Cubit	Topo Rel	+ Abv/Ifo - Blw/Bhd
-87 XII2 6	1811	0605	beg	1915	moon	77.67	-5.14	3.65	1c	1.00	3.65	ifo	3.65
					α Gem	81.32	9.94	15.08					
-87 XII2 8	1812	0602	beg	1916	moon	104.63	-3.83	4.94	2 1/2c	2.50	1.98	bhd	-4.94
					δ Cnc	99.69	-0.01	3.82					
-87 XII2 10	1813	0559	beg	1917	moon	133.24	-1.58	1.15	n/a	n/a	n/a	ifo	1.15
					θ Leo	134.39	9.65	11.23					
-87 XII2 14	1816	0554	last	0450	moon	198.13	3.21	2.68	1 1/2c	1.50	1.75	abv	2.62
					α Lib	195.45	0.59	2.62					
-87 XII2 15	1816	0552	last	0448	moon	213.38	3.93	0.21	1c	1.00	2.67	abv	2.67
					β Sco	213.59	1.26	2.67					
-87 XII2 20	1819	0545	last	0441	moon	282.67	2.94	7.58	3c	3.00	2.53	bhd	-7.58
					β Cap	275.09	4.83	1.89					
-77 IV 3	1908	0451	none	1956	moon	136.56	0.09	2.05	4 1/2c	4.50	2.12	blw	-9.56
					α Leo	134.51	9.65	9.56					
-77 IV 3	1908	0451	last	0403	Venus	81.73	-0.05	0.28	4c	4.00	2.50	blw	-9.99
					α Gem	81.45	9.94	9.99					
-77 IV 4	1908	0451	beg	1956	moon	150.68	-1.18	2.85	1c	1.00	2.85	bhd	-2.85
					β Vir	147.83	0.65	1.83					

Date	Sunset	Sunrise	Watch	Selected Time of Entry	1st Body 2nd Body	Ecl Long Decimal λ	Ecl Lat Decimal β	Ang Dist λ β	Cubits(c) Fingers(f)	Dec Dist in Cubits (24f/c)	Ang Deg/ Cubit	Topo Rel	+ Abv/Ifo - Blw/Bhd
-77 IV 5	1908	0452	beg	1956	moon	164.93	-2.43	3.68	1c	1.00	3.68	bhd	-3.68
					γ Vir	161.25	2.84	5.27					
-77 IV 6	1908	0452	beg	1956	moon	178.41	-3.61	3.42	1 1/2c	1.50	2.28	bhd	-3.42
					α Vir	174.99	-1.92	1.69					
-77 IV 7	1908	0453	beg	1956	moon	193.04	-4.59	2.50	1 1/2c	1.50	1.67	ifo	2.50
					α Lib	195.54	0.58	5.17					
-77 IV 7	1908	0453	last	0405	Venus	86.62	0.12	1.94	4c	4.00	1.60	blw	-6.40
					β Gem	84.68	6.52	6.40					
-77 IV 8	1908	0453	beg	1956	moon	207.27	-5.34	6.16	3c	3.00	2.05	ifo	6.16
					π Sco	213.43	-5.23	0.11					
-77 IV 8	1908	0453	beg	1956	moon	207.27	-5.34	5.88	2 1/2c	2.50	2.35	bhd	-5.88
					Saturn	201.39	2.42	7.76					
-77 IV 9	1907	0454	beg	1955	moon	222.04	-5.79	1.35	2/3c	0.67	2.01	bhd	-1.35
					α Sco	220.69	-4.30	1.49					
-77 IV 10	1907	0454	beg	1955	moon	236.17	-5.94	3.71	2 1/2c	2.50	1.48	bhd	-3.71
					θ Oph	232.46	-1.57	4.37					
-77 IV 13	1907	0456	beg	1955	moon	277.79	-4.61	2.56	5c	5.00	1.89	blw	-9.43
					β Cap	275.23	4.82	9.43					

Date	Sunset	Sunrise	Watch	Selected Time of Entry	1st Body 2nd Body	Ecl Long Decimal λ	Ecl Lat Decimal β	Ang Dist λ β	Cubits(c) Fingers(f)	Dec Dist in Cubits (24f/c)	Ang Deg/ Cubit	Topo Rel	+ Abv/Ifo - Blw/Bhd
-77 IV 19	1905	0500	last	0412	moon η Psc	356.54 357.96	2.31 5.26	1.42 2.95	1c 8f	1.33	2.22	blw	-2.95
-77 IV 19	1905	0500	last	0412	moon Jupiter	356.54 0.28	2.31 -1.58	3.76 3.89	2c	2.00	1.88	ifo	3.76
-77 IV 20	1904	0501	last	0413	moon α Ari	8.55 8.83	3.19 9.80	0.28 6.61	3c	3.00	2.20	blw	-6.61
-77 IV 21	1904	0501	last	0413	Mars η Tau	28.75 31.13	-1.98 3.81	2.38 5.79	2c	2.00	2.90	blw	-5.79
-77 IV 22	1903	0502	last	0414	moon Mars	32.63 29.31	4.45 -1.97	3.32 6.42	1 2/3c	1.67	1.99	bhd	-3.32
-77 IV 23	1903	0503	last	0415	moon α Tau	44.86 40.89	4.77 -5.61	3.97 10.38	1c	1.00	3.97	bhd	-3.97
-77 IV 23	1903	0503	last	0415	Jupiter η Psc	0.29 357.96	-1.60 5.26	2.33 6.86	1c 8f	1.33	1.75	bhd	-2.33
-77 IV 24	1902	0503	last	0415	moon β Tau	57.30 53.70	4.86 5.21	3.60 0.35	1c	1.00	3.60	bhd	-3.60
-77 IV 25	1902	0504	last	0416	moon γ Gem	70.03 70.23	4.70 -6.97	0.20 11.67	5c	5.00	2.33	abv	11.67

Date	Sunset	Sunrise	Watch	Selected Time of Entry	1st Body 2nd Body	Ecl Long Decimal λ	Ecl Lat Decimal β	Ang Dist λ β	Cubits(c) Fingers(f)	Dec Dist in Cubits (24f/c)	Ang Deg/ Cubit	Topo Rel	+ Abv/Ifo - Blw/Bhd
-77 IV 26	1901	0505	last	0417	moon	83.07	4.28	1.61	2c	2.00	0.81	ifo	1.61
					β Gem	84.68	6.52	2.24					
-77 IV 27	1901	0506	last	0418	moon	96.44	3.59	0.11	1c	1.00	2.21	abv	2.21
					η Cnc	96.55	1.38	2.21					
-77 IV 28	1900	0506	last	0418	moon	110.13	2.67	2.34	1c	1.00	2.34	ifo	2.34
					Venus	112.47	0.90	1.77					

Appendix 2

Charts

This section contains computer-generated star-charts that I have created for each selected diary entry. These depict celestial bodies as they appeared in Mesopotamia at the corresponding date and time. In certain instances I created multiple charts, such as enlarged views or differing hours, to further illustrate a point. The analyses in Chapter 10 direct the reader to these charts by reference date and page number.

Each star-chart is captioned with the reference date given by Sachs and Hunger (e.g., -567 I 9).

Horizon coordinates and grid lines run from top to bottom. In the horizon system celestial bodies are referenced to the number of degrees currently above the horizon and the number of degrees measured in a clockwise circle beginning at north. The zero degree horizontal grid line represents the horizon, below which any body is no longer in the observer's field of view. Also depicted is the celestial equator and its associated hours of right ascension. In this equatorial system the earth's equator and poles are projected on to the celestial sphere. Right ascension begins at the vernal equinox and declination is measured north and south of the celestial equator. Additional gridlines represent the ecliptic coordinate system. In the ecliptic system, coordinates refer to the apparent path of the sun. Celestial longitude begins at the vernal equinox and is measured to the east. Celestial latitude is measured north and south of the ecliptic.

The first specified body is centered in the middle of each chart. The second body is normally found near the first. The moon, when utilized, will be centered on the chart and represented by an unlabeled circle. The solid versus dashed portions of the circle represent the current moon phase. The planets are labeled with their modern names. Stars are labeled with their Bayer Letter captions (from the Greek alphabet). Constellations use three-letter abbreviations and have representative lines drawn between their component stars. A solid circle, similar in size to the full moon, depicts the sun.

The bar at the bottom of the chart lists time and day in both local time and UT. The geographic location of the observer is listed, as is Sidereal Time and the Julian Day. The equatorial coordinates described are for the body that has been centered at the middle of the chart. Except when magnified, the charted field of view is always 90 degrees.

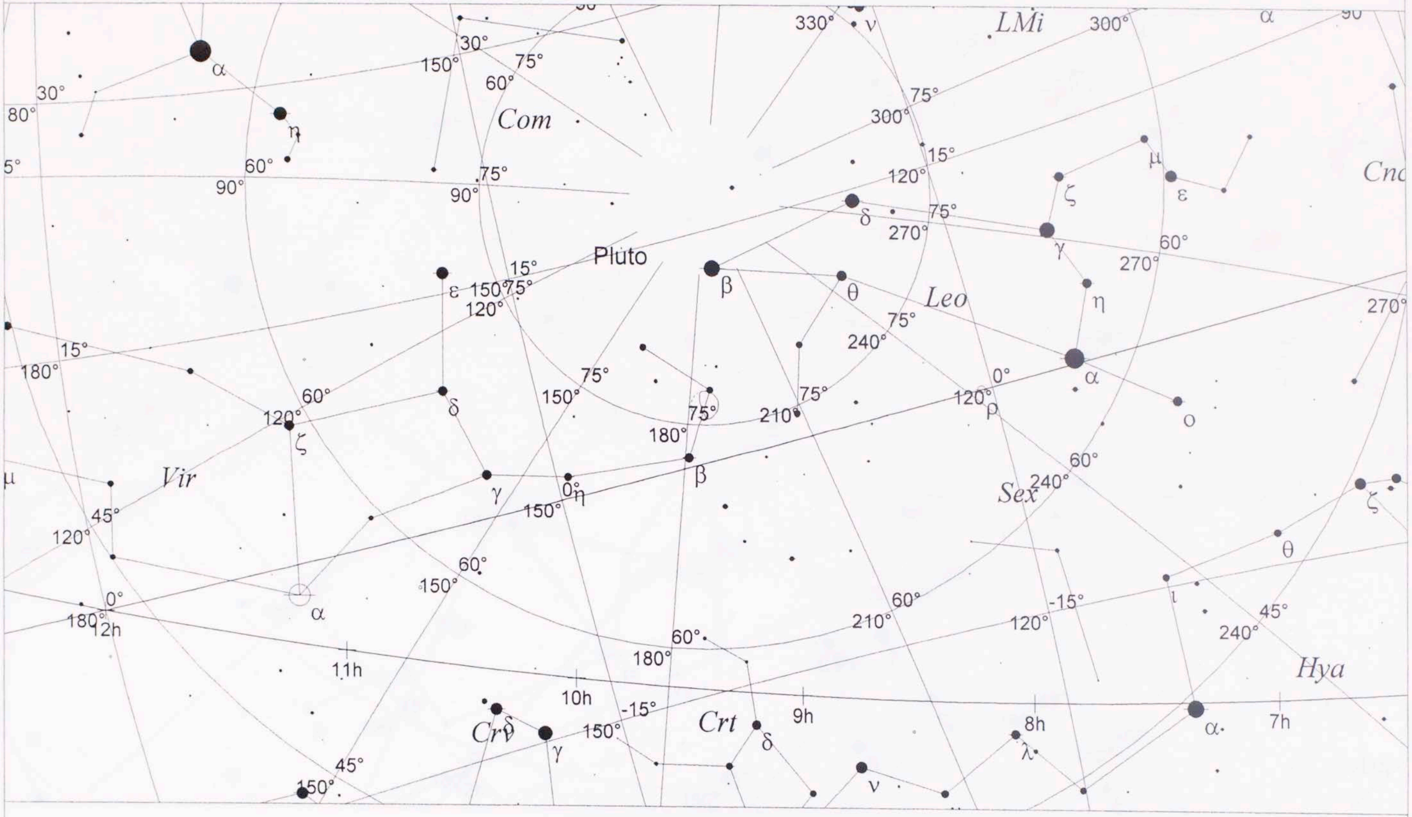
The ecliptic is represented on the charts as a slightly heavier black line in the same part of the sky as the first and second bodies. It is labeled with degrees of celestial longitude that increase from west to east, normally in 30-degree increments. The ecliptic grid system also includes lines of celestial latitude, with zero degrees at the ecliptic and +/- 15 degrees as the next lines above and below in the standard size depiction.

The horizon grid system runs from top to bottom on the charts. The celestial north pole is at 90 degrees and the horizon is a slightly heavier black line at zero degrees. Intermediate lines of altitude are given every 15 degrees in the normal depiction. Azimuth is measured from north and is given in 30-degree increments, increasing from left to right.

The celestial equator is shown as a heavier black line labeled with hours of right ascension. These increase from west to east and are denoted with a cross and the corresponding hour. I chose not to include grids for declination so as to reduce clutter on the charts.

If not otherwise stated, chart references in the analyses are made with respect to the ecliptic.

-567 / 8

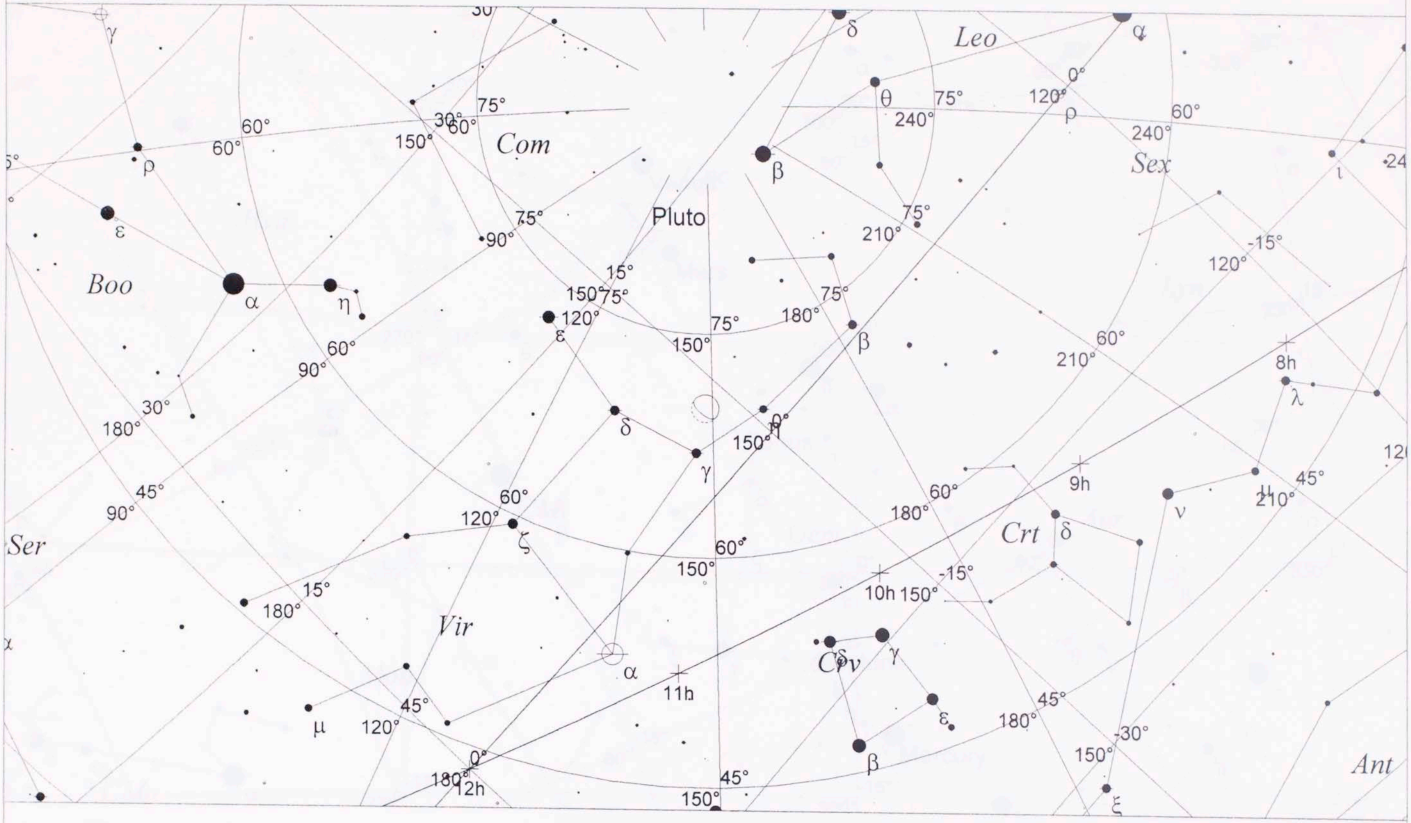


Local Time: 19:32:00 29-Apr-568BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 16:34:00 29-Apr-568BC
RA: 9h31m08s Dec: +18° 55' Field: 90.0°

Sidereal Time: 09:35:33
Julian Day: 1514080.1903

-567 / 9

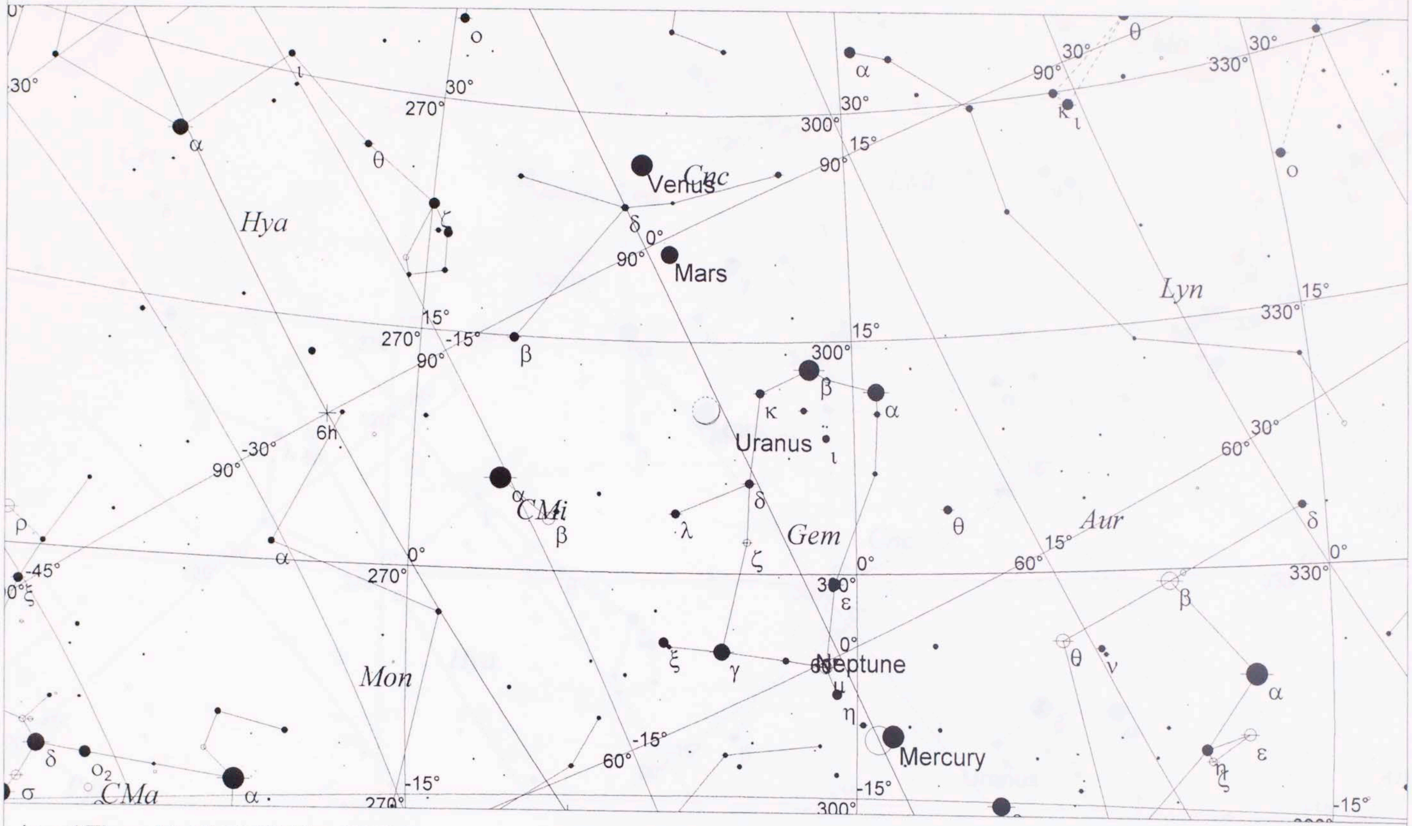


Local Time: 19:32:00 30-Apr-568BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:34:00 30-Apr-568BC
RA: 10h22m03s Dec: +15° 03' Field: 90.0°

Sidereal Time: 09:39:30
Julian Day: 1514081.1903

-567 II 1

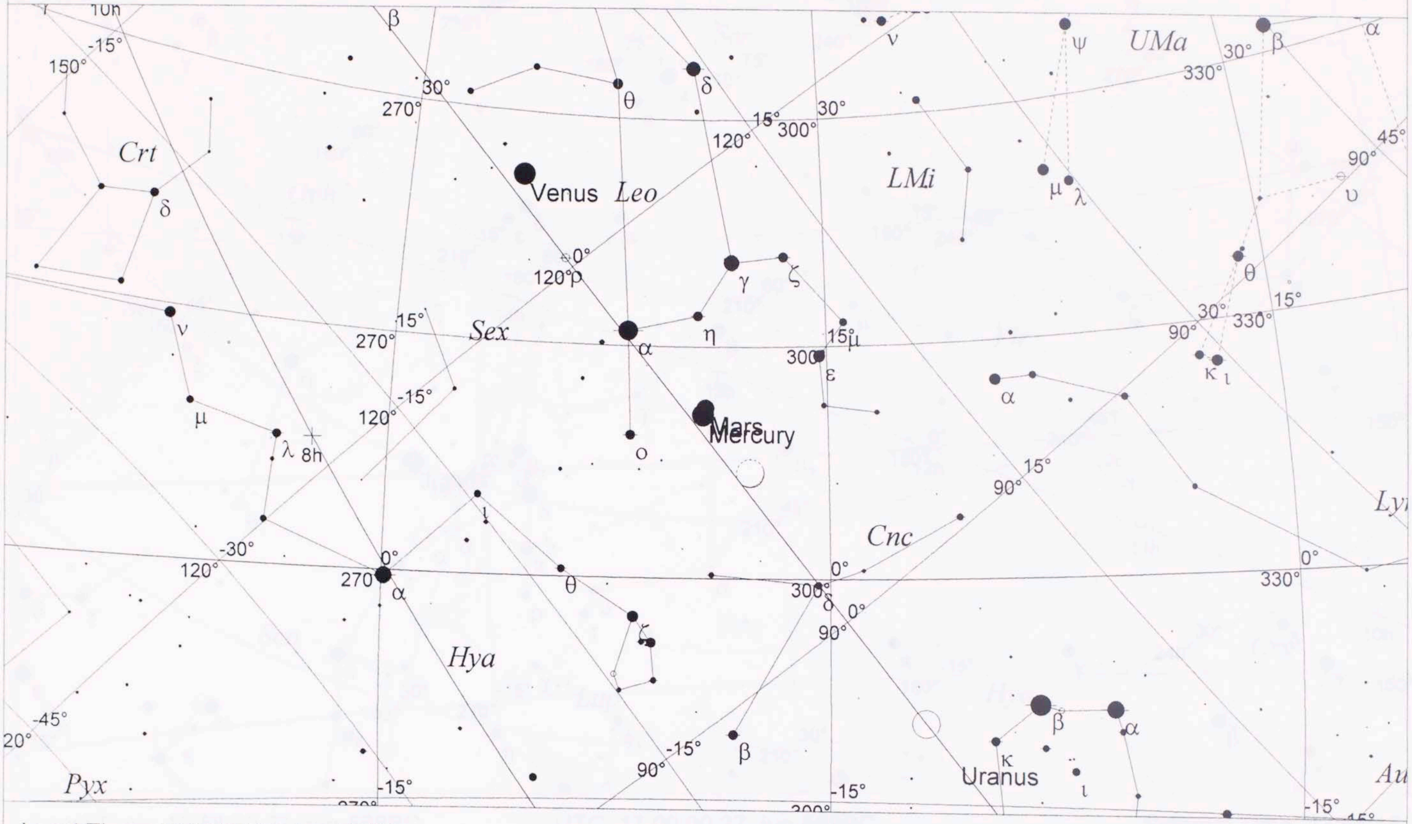


Local Time: 19:43:00 22-May-568BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:45:00 22-May-568BC
RA: 5h10m36s Dec: +22° 14' Field: 90.0°

Sidereal Time: 11:17:16
Julian Day: 1514103.1979

-567 III 1

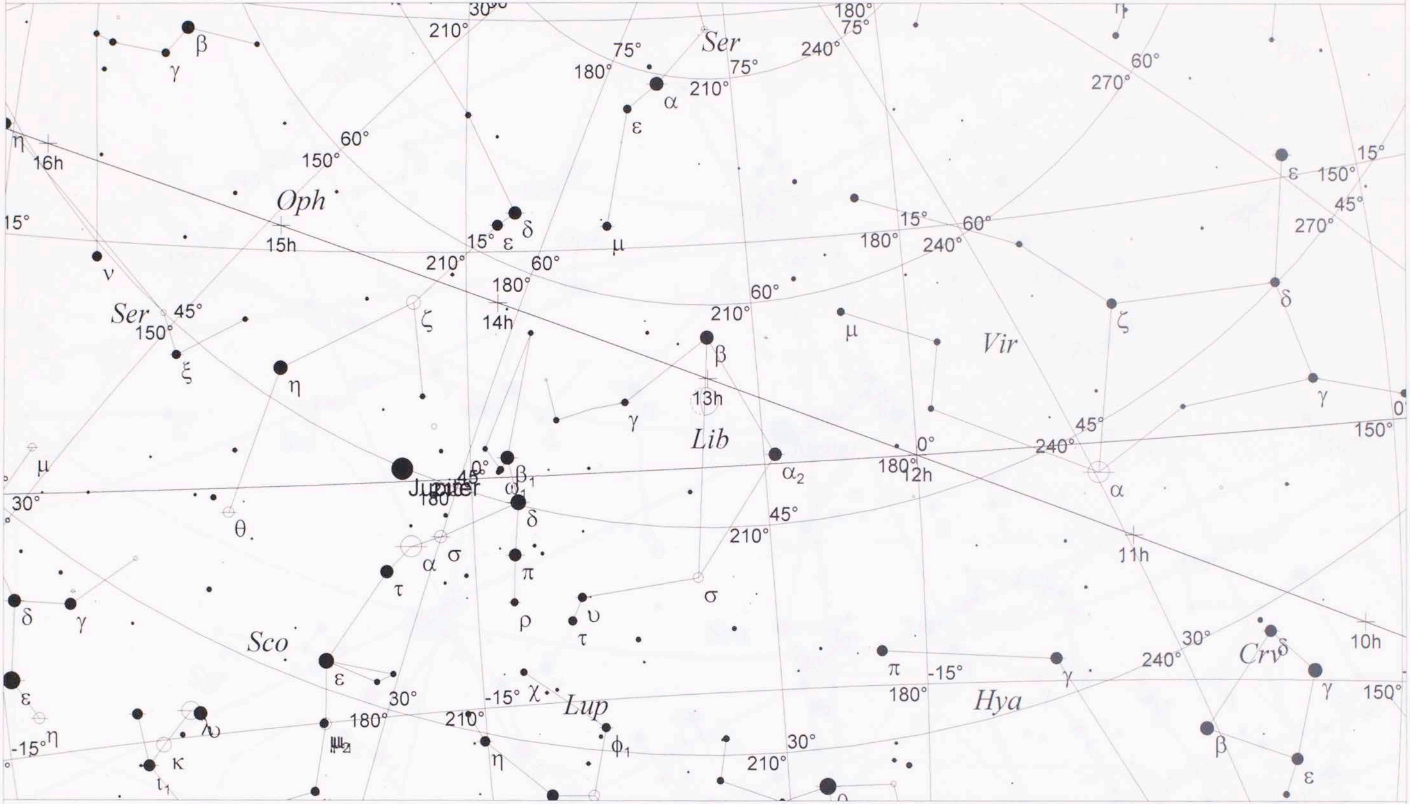


Local Time: 19:55:00 20-Jun-568BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:57:00 20-Jun-568BC
RA: 7h14m28s Dec: +23° 53' Field: 90.0°

Sidereal Time: 13:23:38
Julian Day: 1514132.2062

-567 III 8

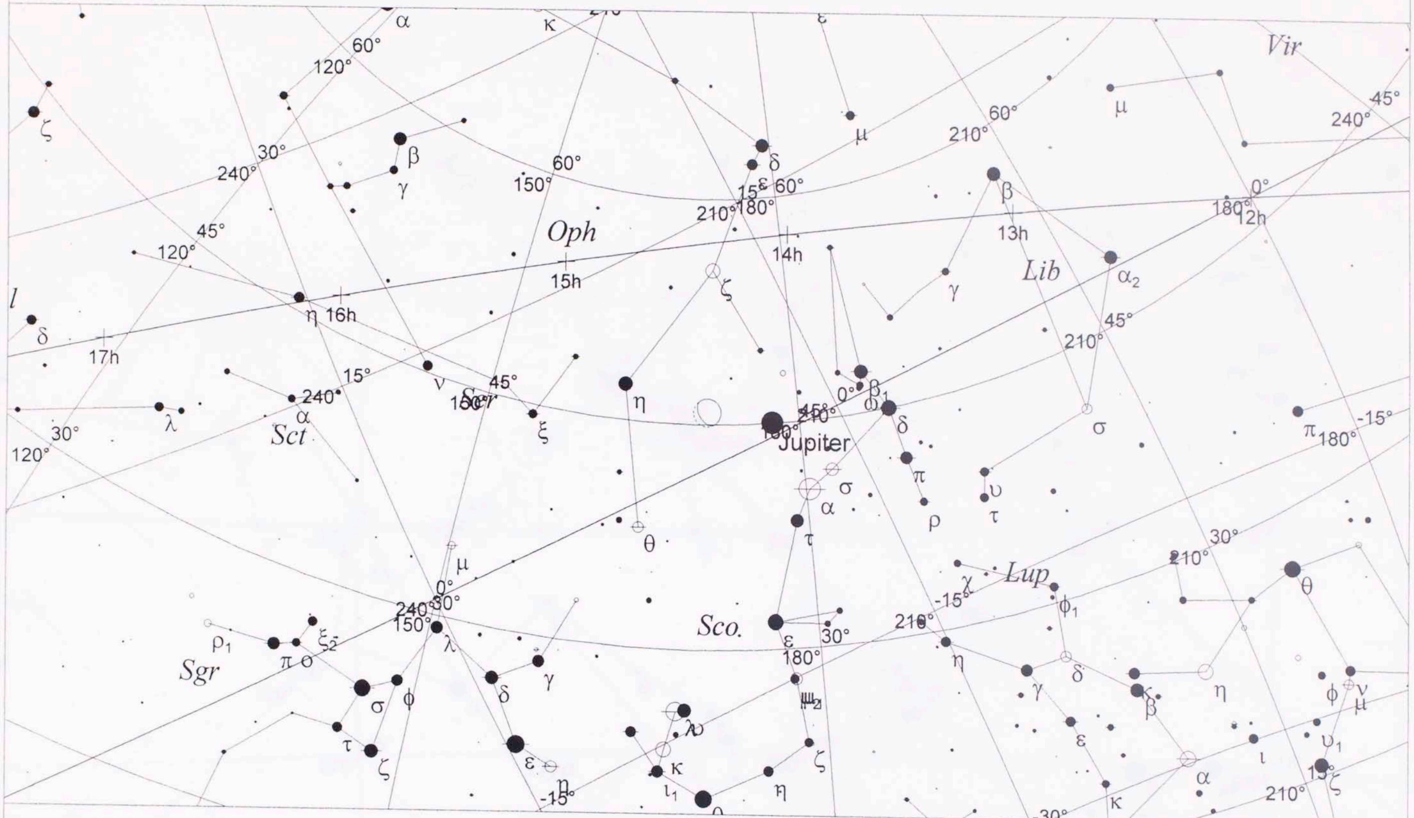


Local Time: 19:58:00 27-Jun-568BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 17:00:00 27-Jun-568BC
RA: 12h58m48s Dec: -1° 30' Field: 90.0°

Sidereal Time: 13:54:15
Julian Day: 1514139.2083

-567 III 10



Local Time: 19:58:00 29-Jun-568BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 17:00:00 29-Jun-568BC
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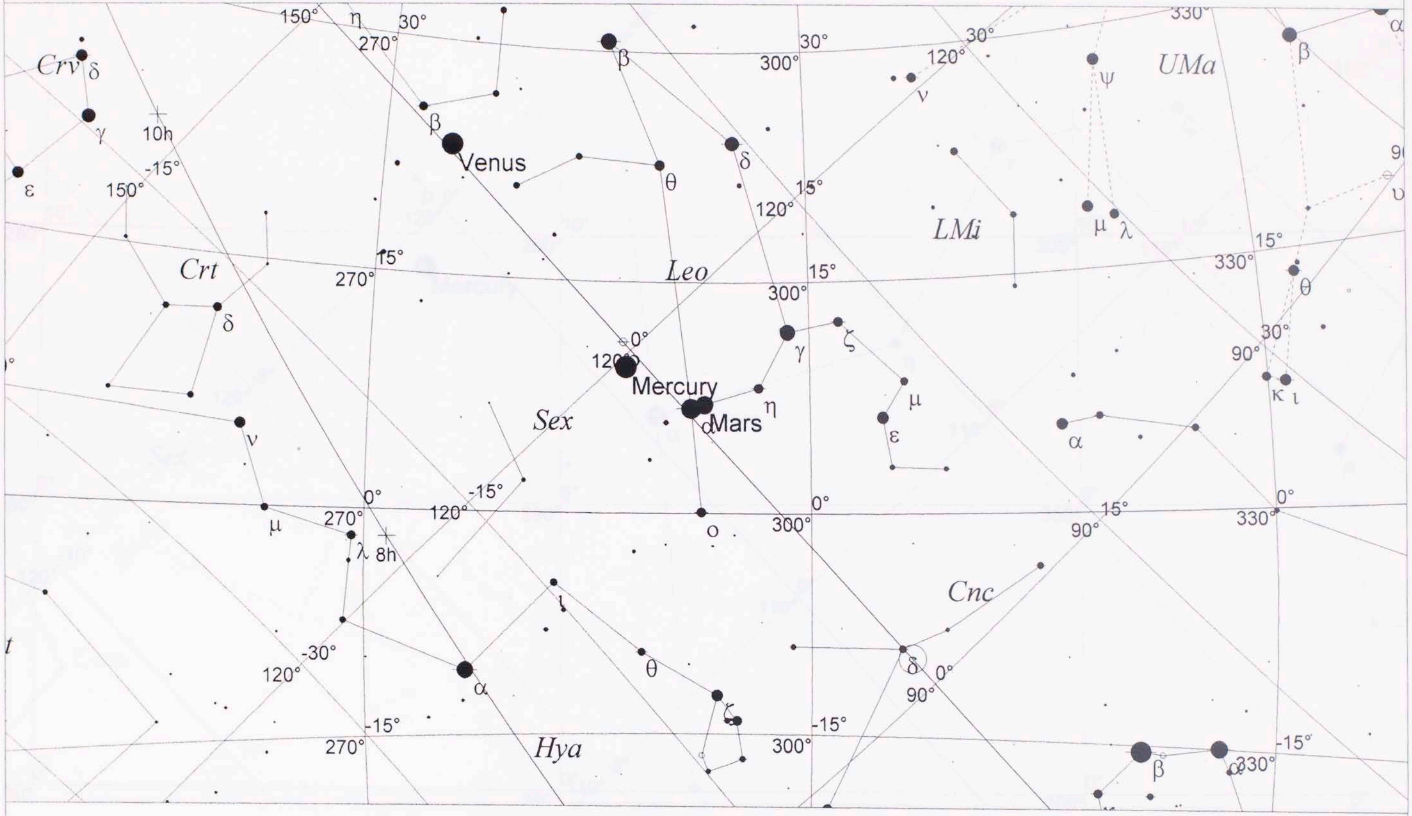
Sidereal Time: 14:02:08
Julian Day: 1514141.2083

-567 III 12



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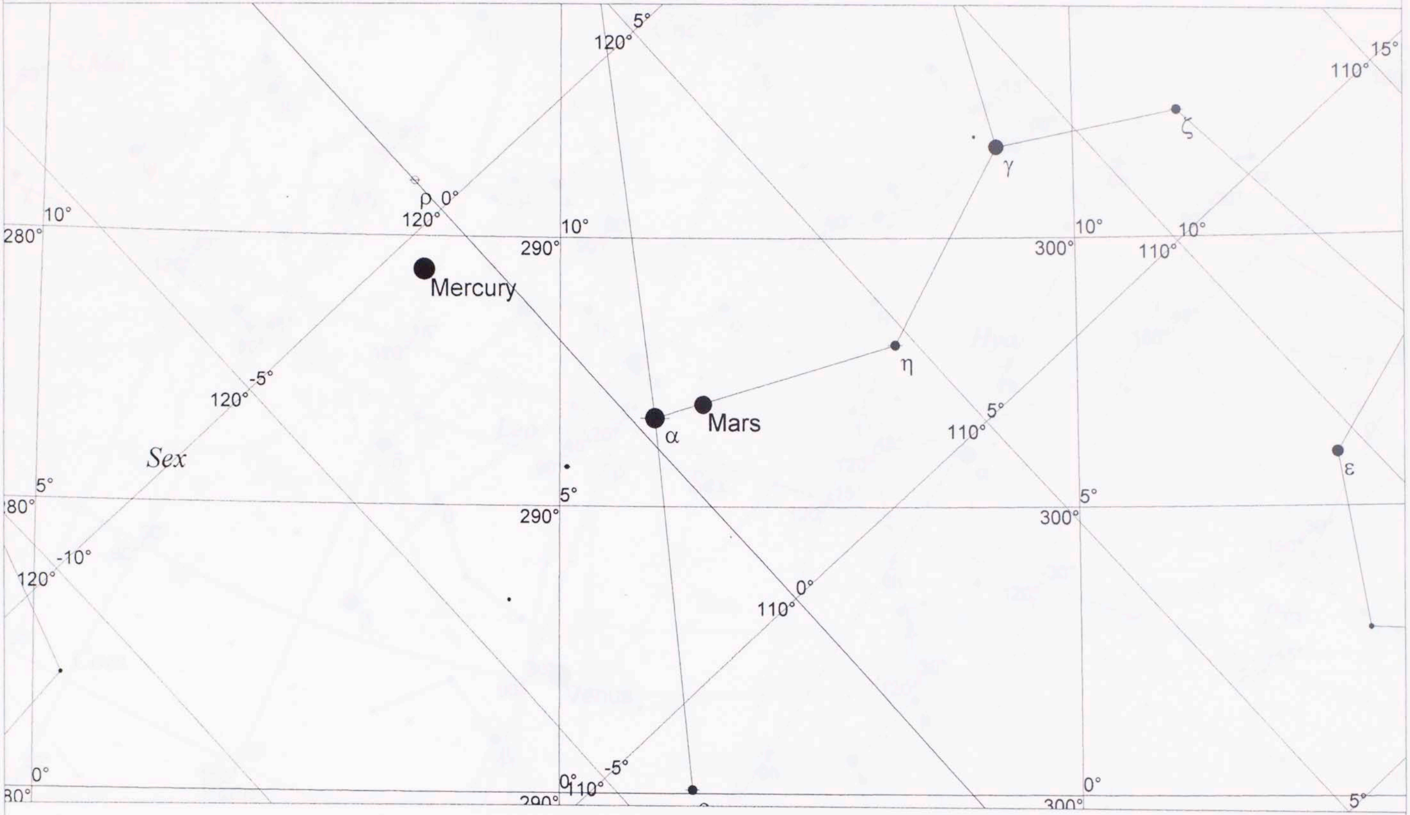
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 17:01:00 1-Jul-568BC
RA: 7h44m17s Dec: +22° 48' Field: 90.0°

Sidereal Time: 14:11:01
Julian Day: 1514143.2090

-567 III 12



Local Time: 19:59:00 1-Jul-568BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 17:01:00 1-Jul-568BC
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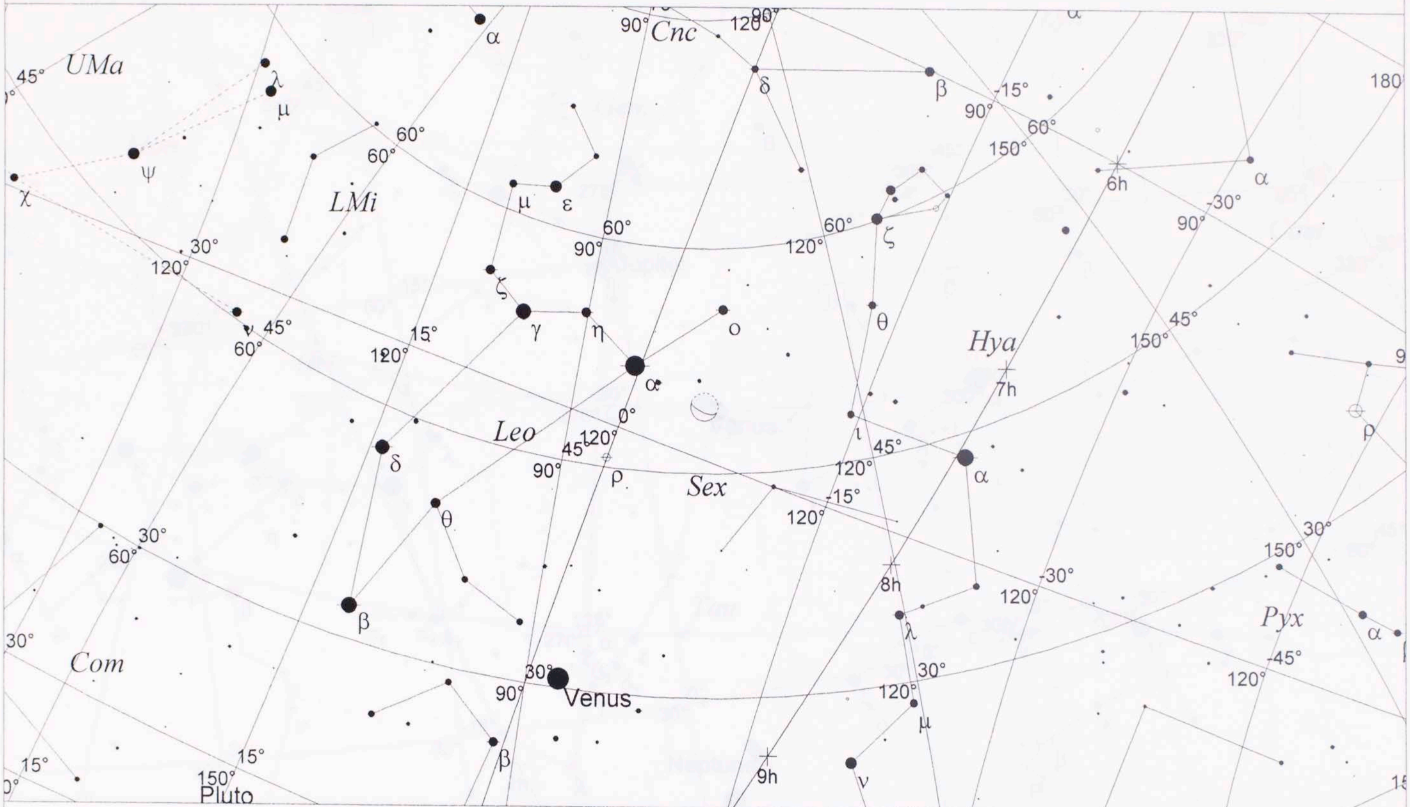
Sidereal Time: 14:11:01
Julian Day: 1514143.2090

-463 VI 22

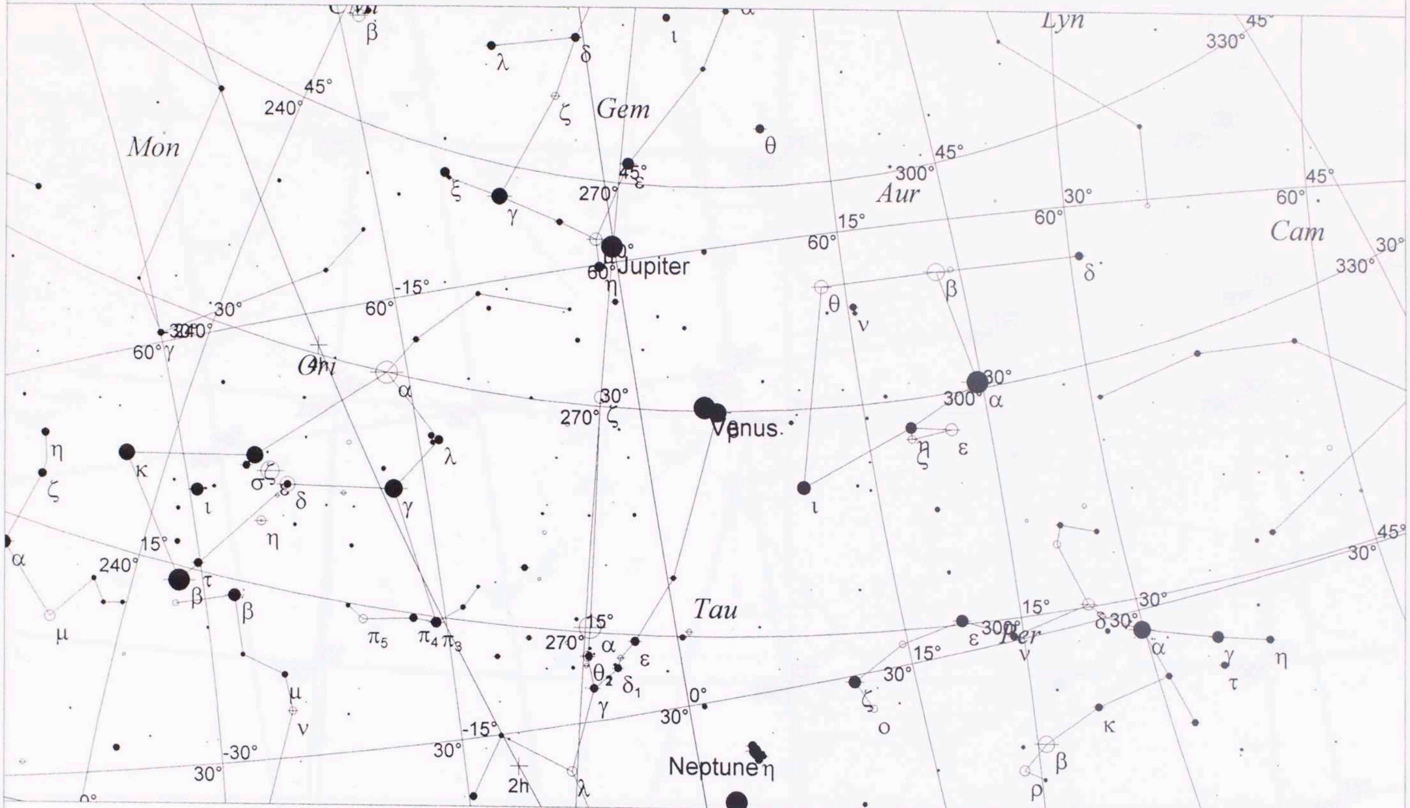


Local Time: 04:55:00 30-Sep-464BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 01:57:00 30-Sep-464BC
RA: 7h50m54s Dec: +16° 12' Field: 90.0°

Sidereal Time: 05:06:28
Julian Day: 1552219.5812

-418 / 7



Local Time: 19:15:00 1-Apr-419BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:17:00 1-Apr-419BC
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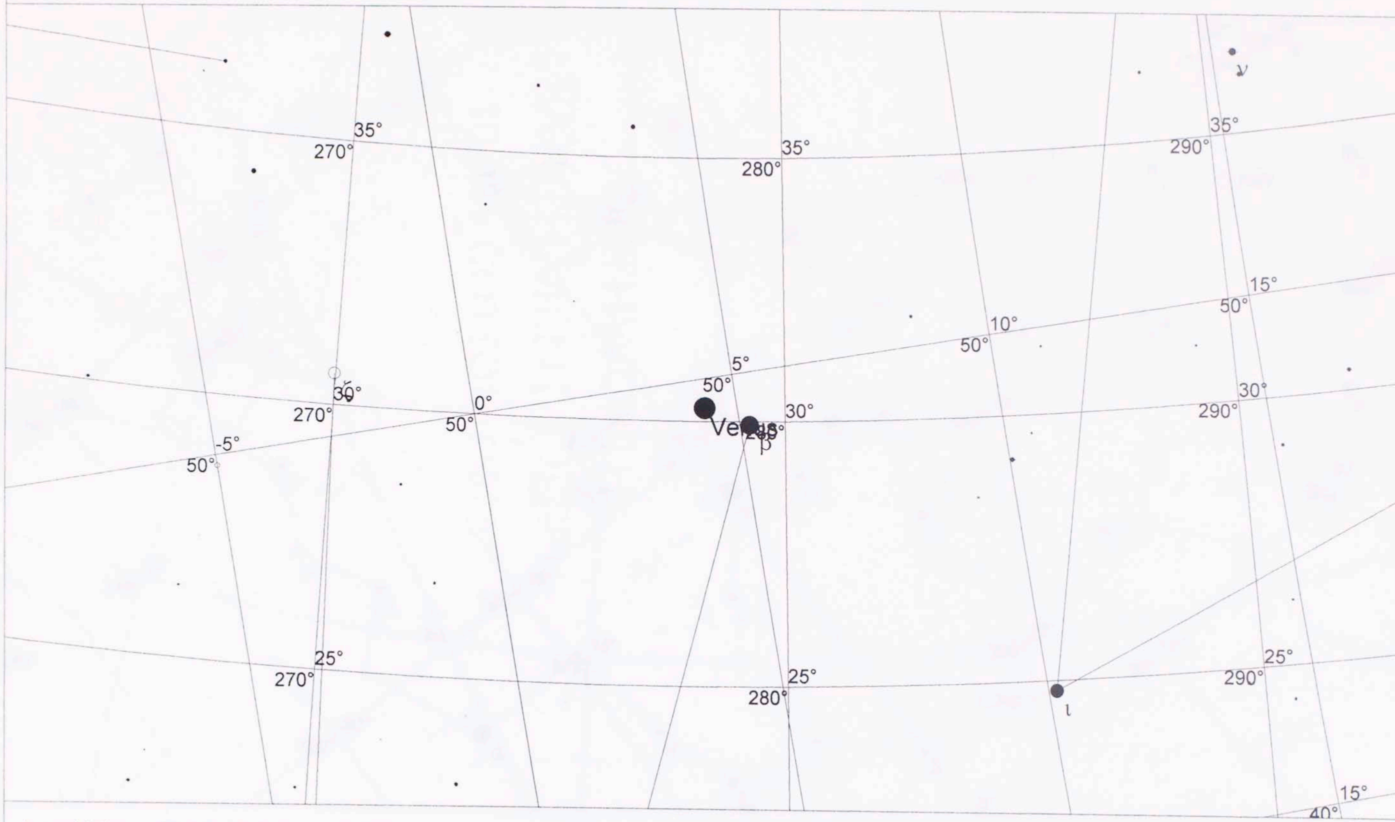
Sidereal Time: 07:31:36
Julian Day: 1568474.1785

-418 / 7

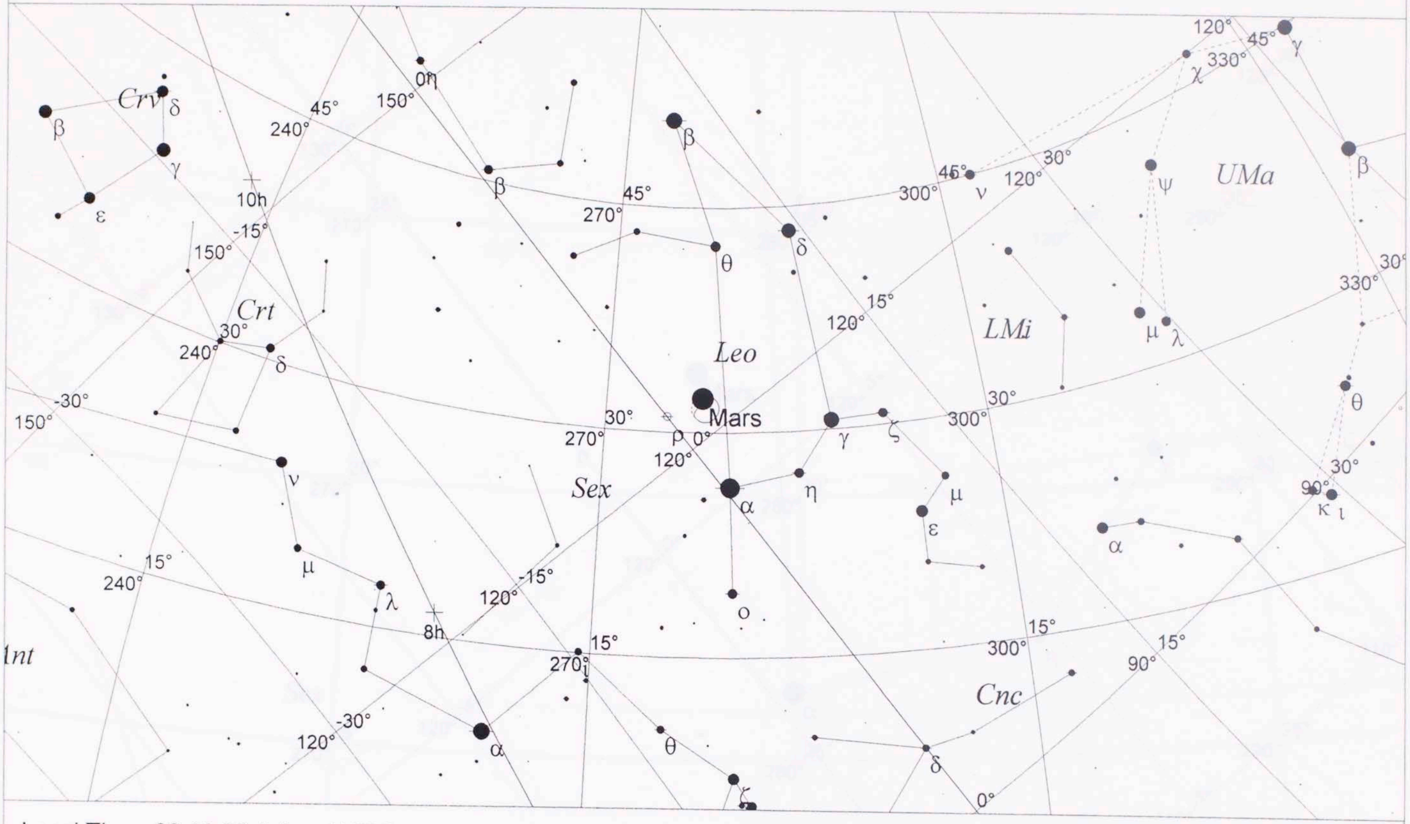


Local Time: 19:15:00 1-Apr-419BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:17:00 1-Apr-419BC
RA: 3h02m28s Dec: +22° 01' Field: 26.7°

Sidereal Time: 07:31:36
Julian Day: 1568474.1785

-418 / 9

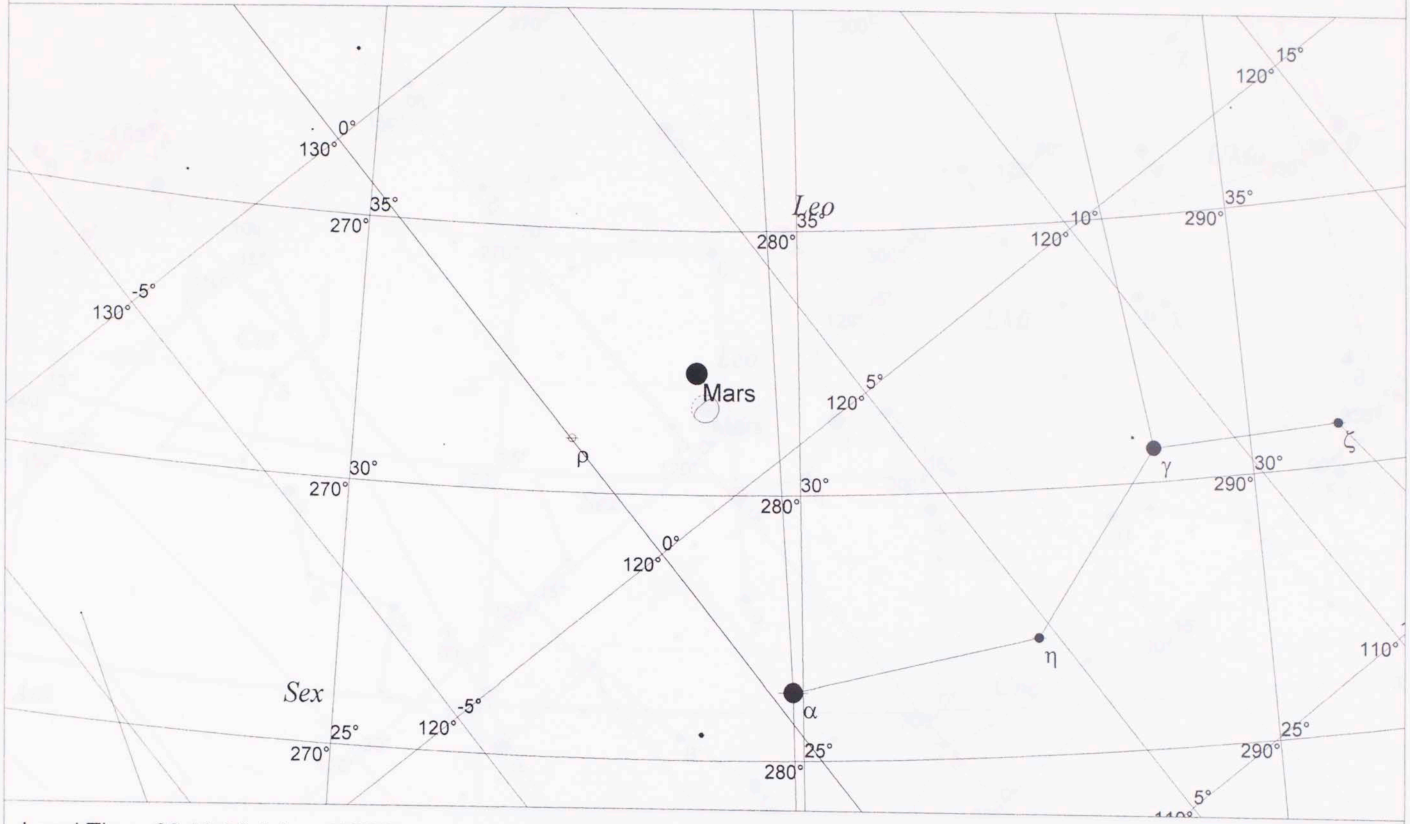


Local Time: 00:16:00 4-Apr-419BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 21:18:00 3-Apr-419BC
RA: 8h18m11s Dec: +22° 21' Field: 90.0°

Sidereal Time: 12:41:19
Julian Day: 1568476.3875

-418 / 9

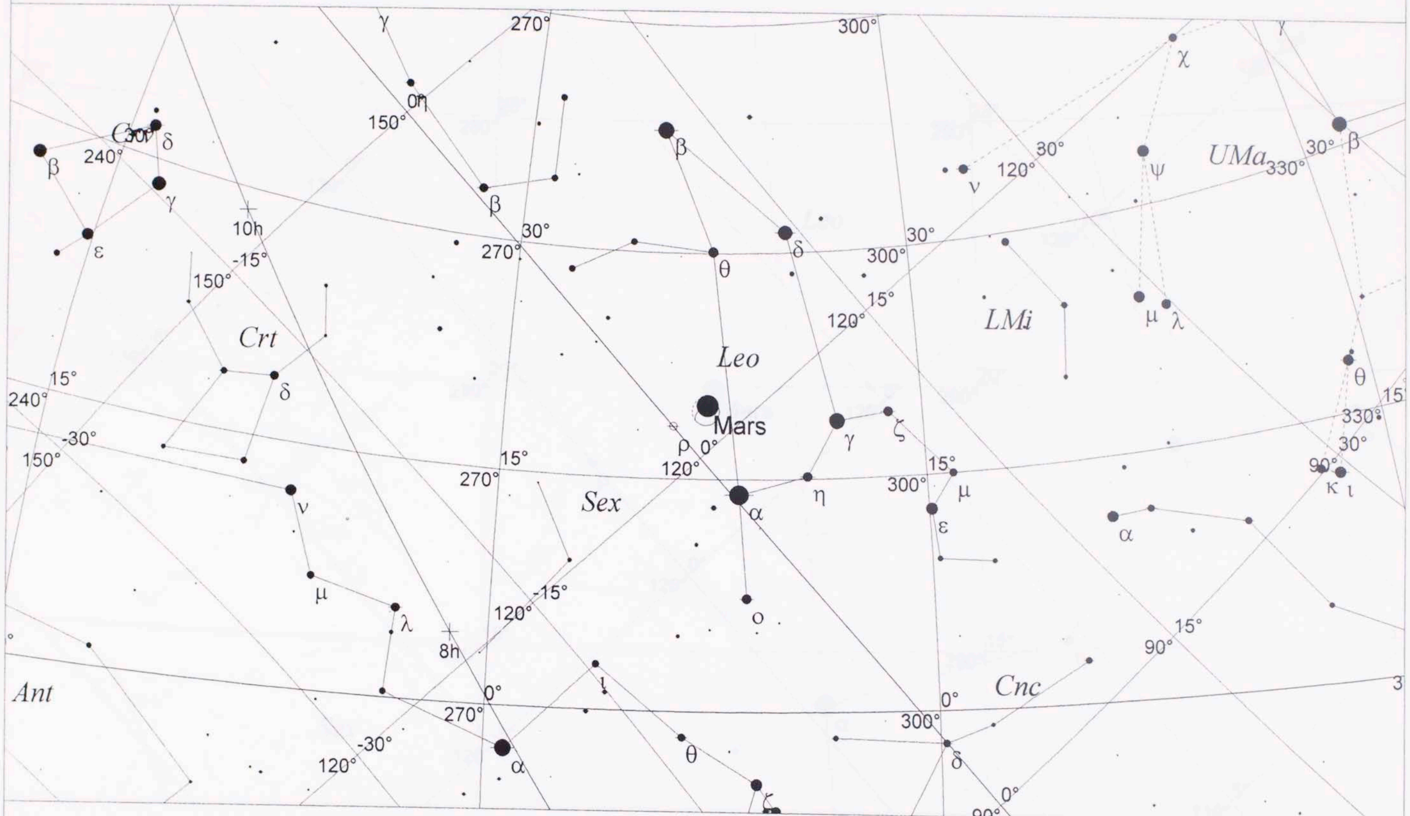


Local Time: 00:16:00 4-Apr-419BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 21:18:00 3-Apr-419BC
RA: 8h18m11s Dec: +22° 21' Field: 26.7°

Sidereal Time: 12:41:19
Julian Day: 1568476.3875

-418 / 9

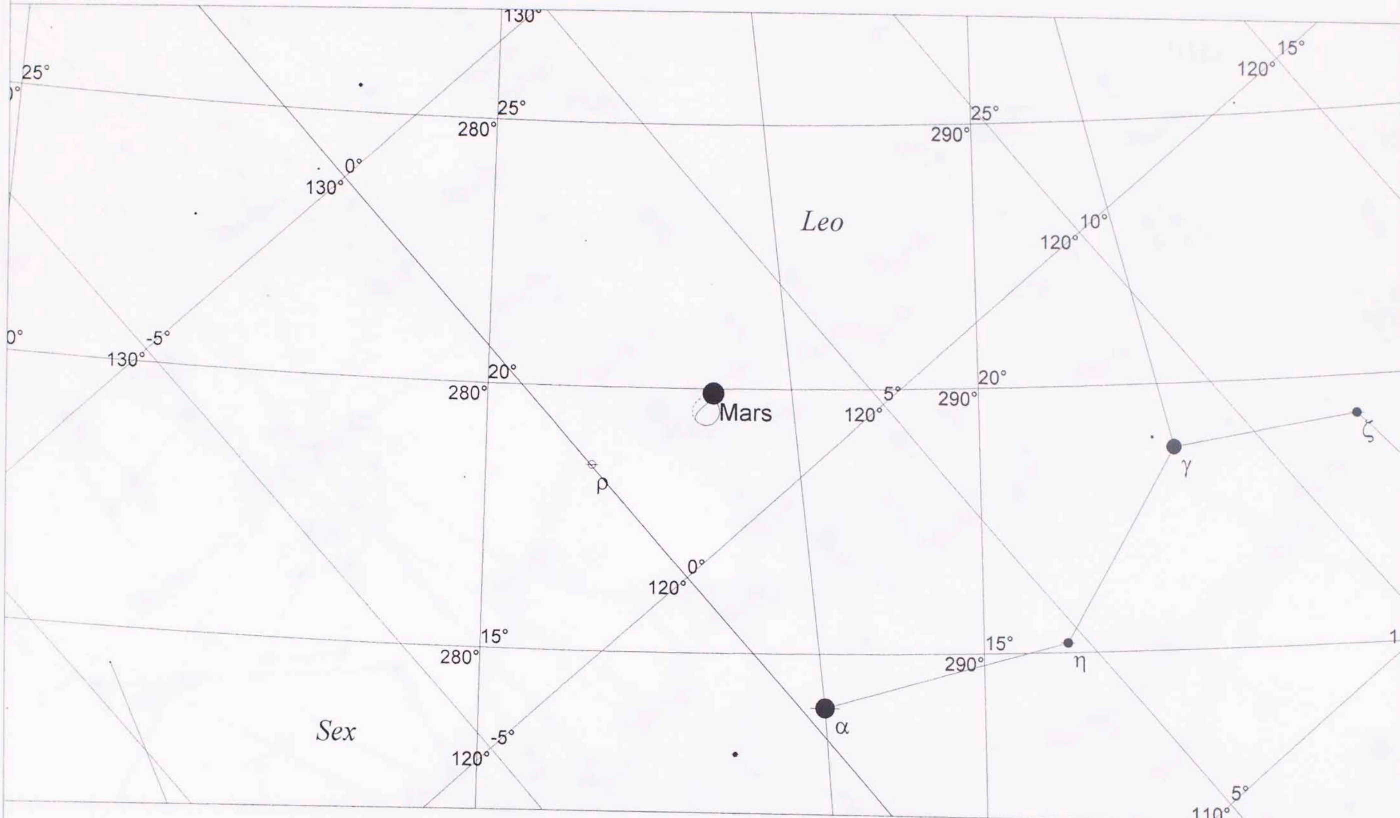


Local Time: 01:16:00 4-Apr-419BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 22:18:00 3-Apr-419BC
RA: 8h20m05s Dec: +22° 12' Field: 90.0°

Sidereal Time: 13:41:29
Julian Day: 1568476.4292

-418 / 9

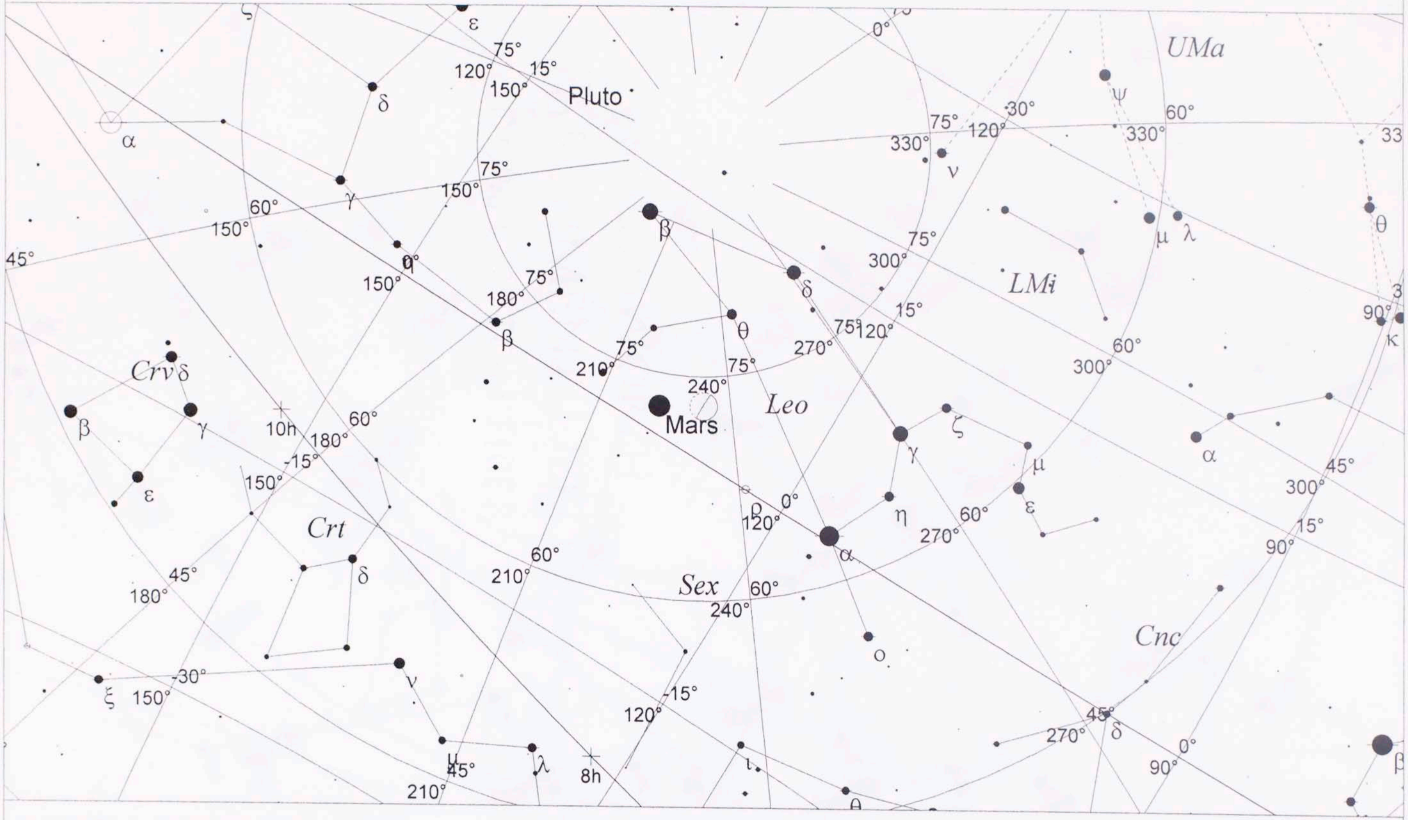


Local Time: 01:16:00 4-Apr-419BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 22:18:00 3-Apr-419BC
RA: 8h20m05s Dec: +22° 12' Field: 26.7°

Sidereal Time: 13:41:29
Julian Day: 1568476.4292

-418 II 7

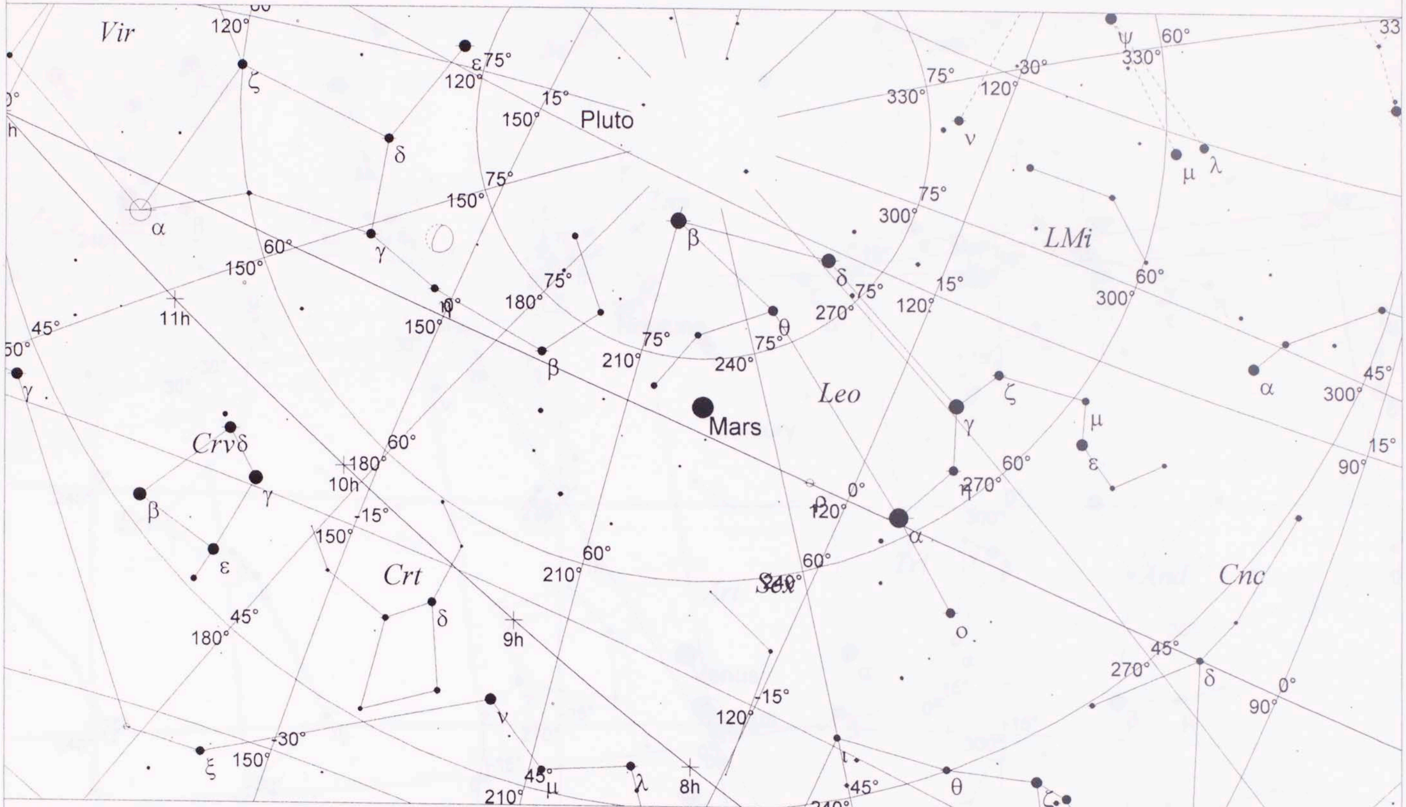


Local Time: 19:30:00 1-May-419BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:32:00 1-May-419BC
RA: 8h46m14s Dec: +21° 37' Field: 90.0°

Sidereal Time: 09:44:56
Julian Day: 1568504.1889

-418 II 9

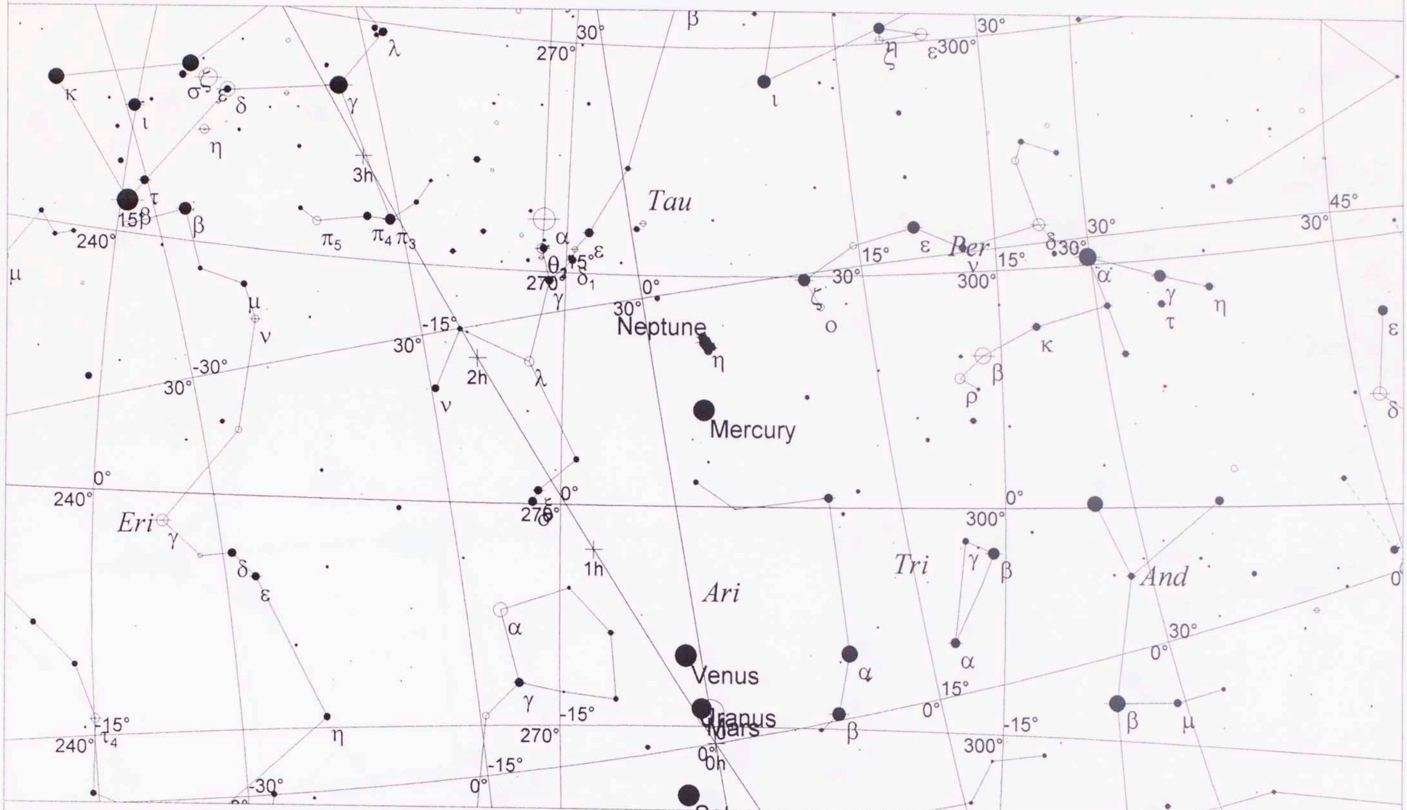


Local Time: 19:31:00 3-May-419BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 16:33:00 3-May-419BC
RA: 8h58m07s Dec: +19° 08' Field: 90.0°

Sidereal Time: 09:53:49
Julian Day: 1568506.1896

-418 XII2 13

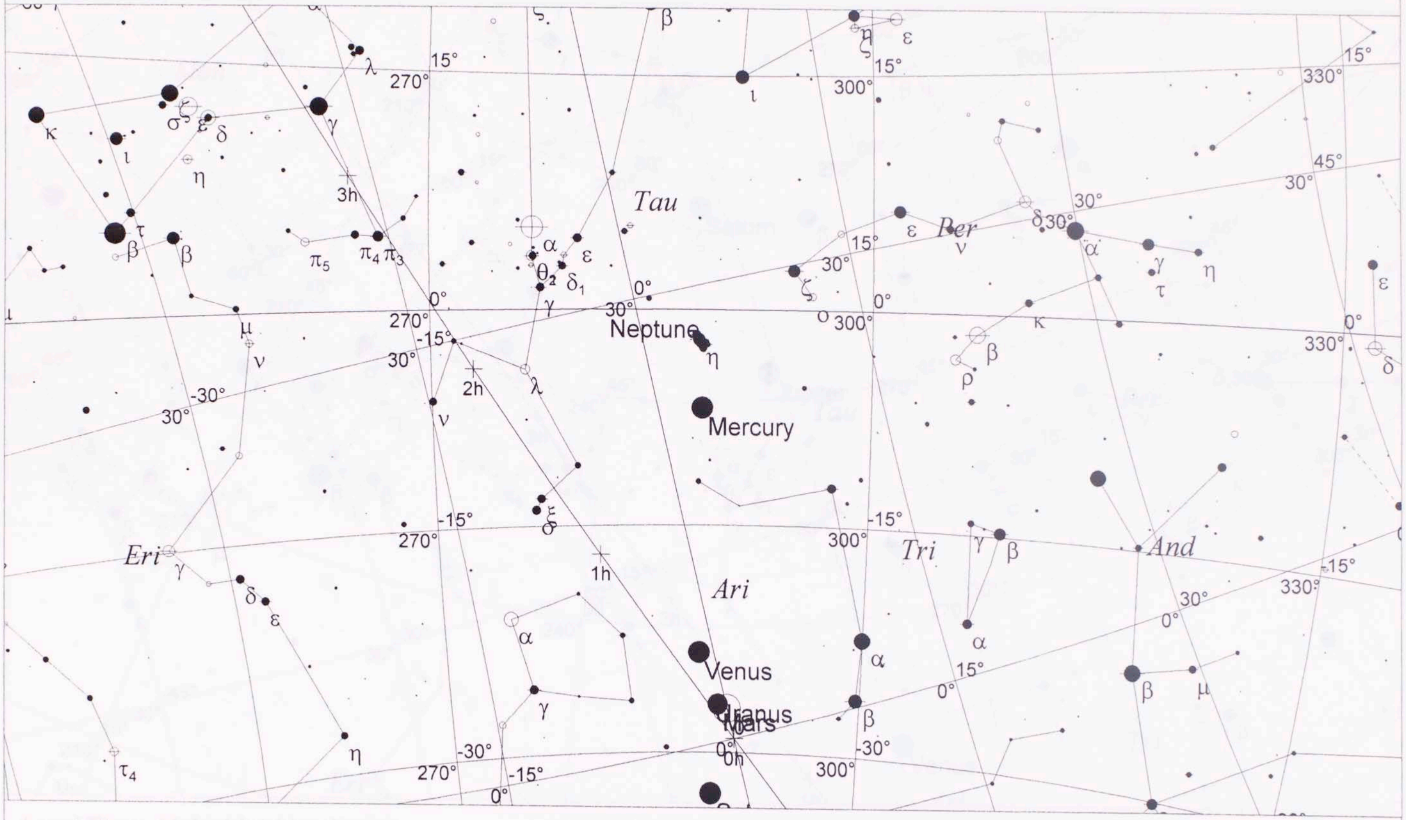


Local Time: 19:17:00 28-Mar-418BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:19:00 28-Mar-418BC
RA: 1h16m20s Dec: +11° 23' Field: 90.0°

Sidereal Time: 07:16:53
Julian Day: 1568835.1799

-418 XII2 13

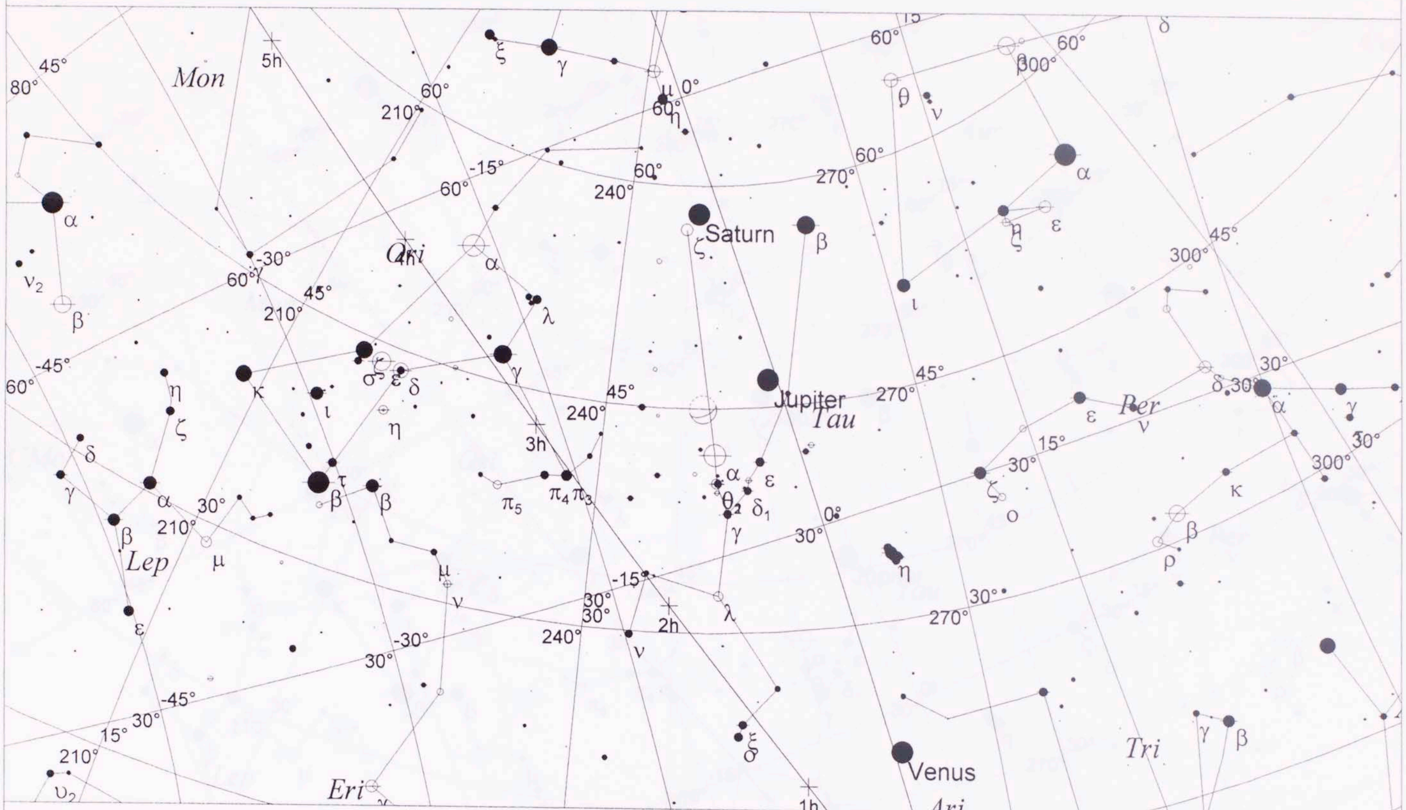


Local Time: 20:21:00 28-Mar-418BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 17:23:00 28-Mar-418BC
RA: 1h16m27s Dec: +11° 23' Field: 90.0°

Sidereal Time: 08:21:04
Julian Day: 1568835.2243

-384 XII 4

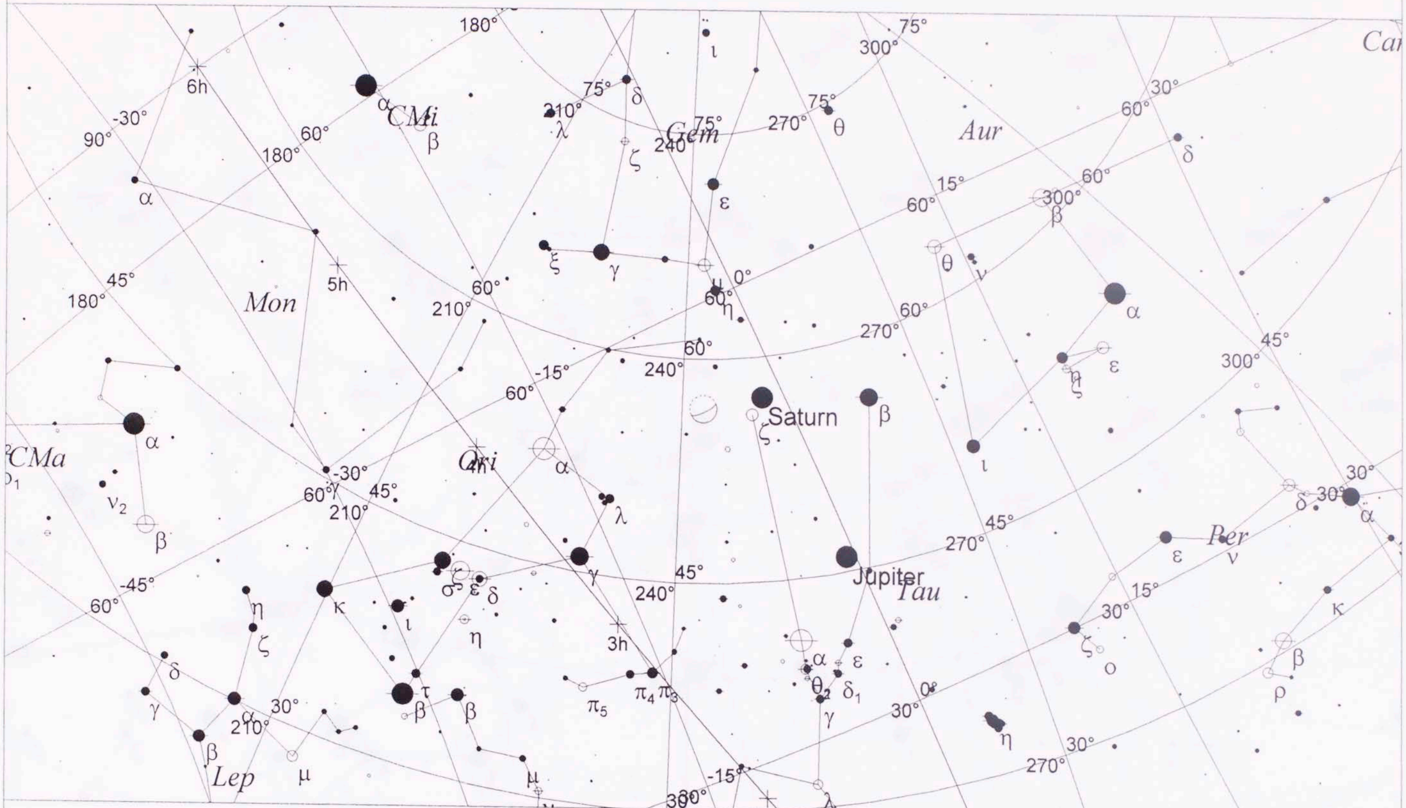


Local Time: 19:01:00 3-Mar-384BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:03:00 3-Mar-384BC
RA: 2h36m27s Dec: +9° 45' Field: 90.0°

Sidereal Time: 05:25:17
Julian Day: 1581229.1688

-384 XII 5

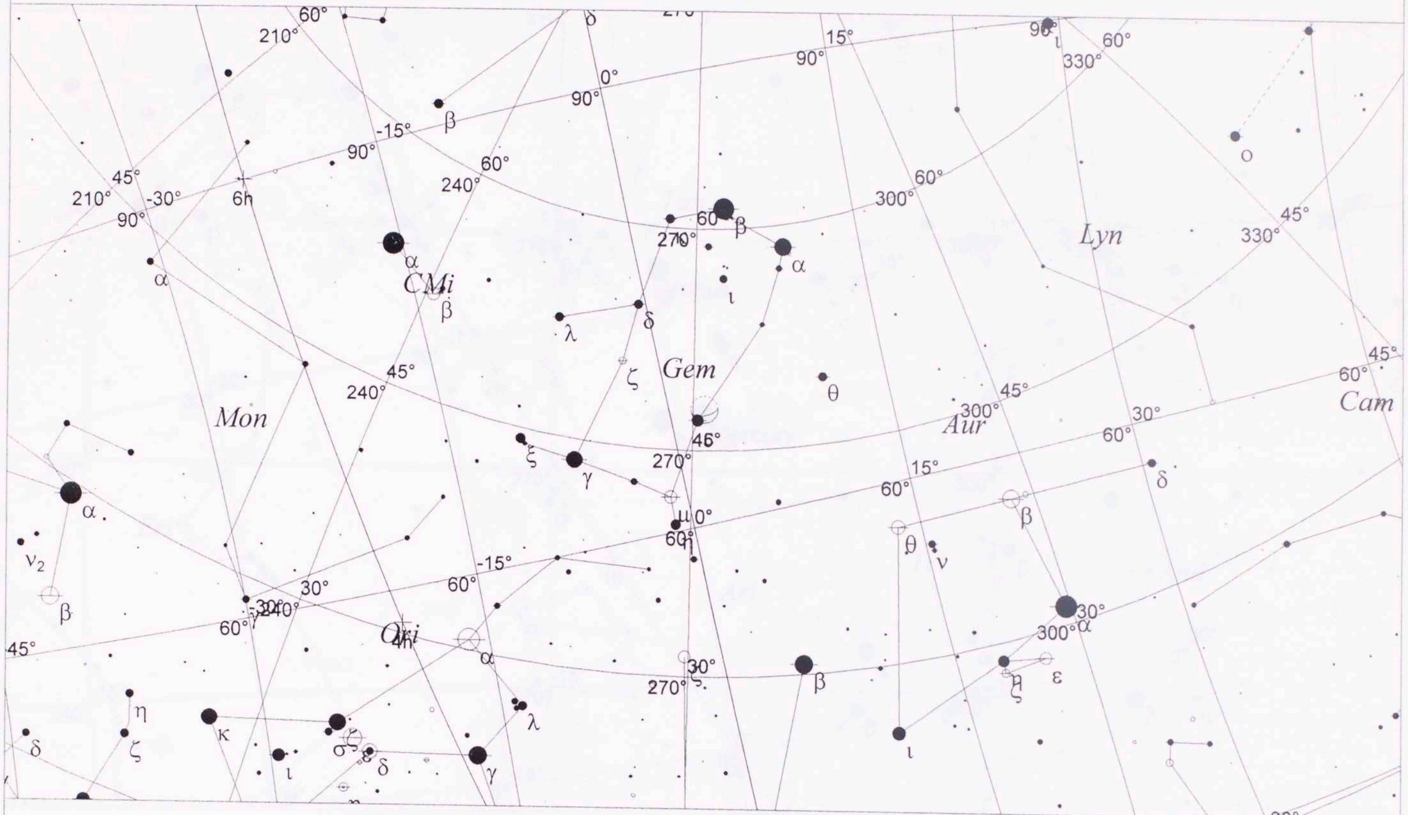


Local Time: 19:02:00 4-Mar-384BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:04:00 4-Mar-384BC
RA: 3h29m31s Dec: +13° 38' Field: 90.0°

Sidereal Time: 05:30:13
Julian Day: 1581230.1694

-372 / 4

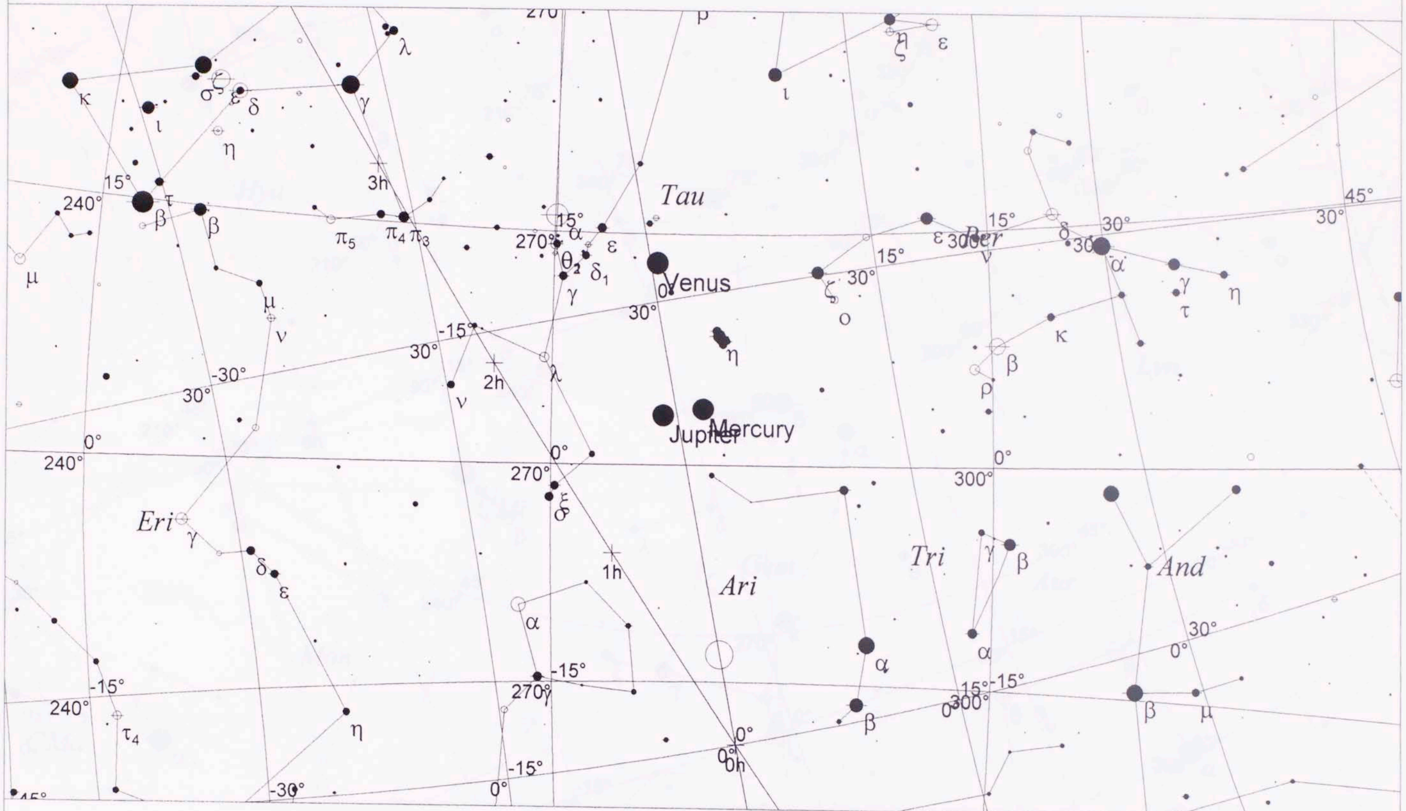


Local Time: 19:15:00 31-Mar-373BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:17:00 31-Mar-373BC
RA: 4h21m25s Dec: +24° 11' Field: 90.0°

Sidereal Time: 07:31:03
Julian Day: 1585275.1785

-372 / 4

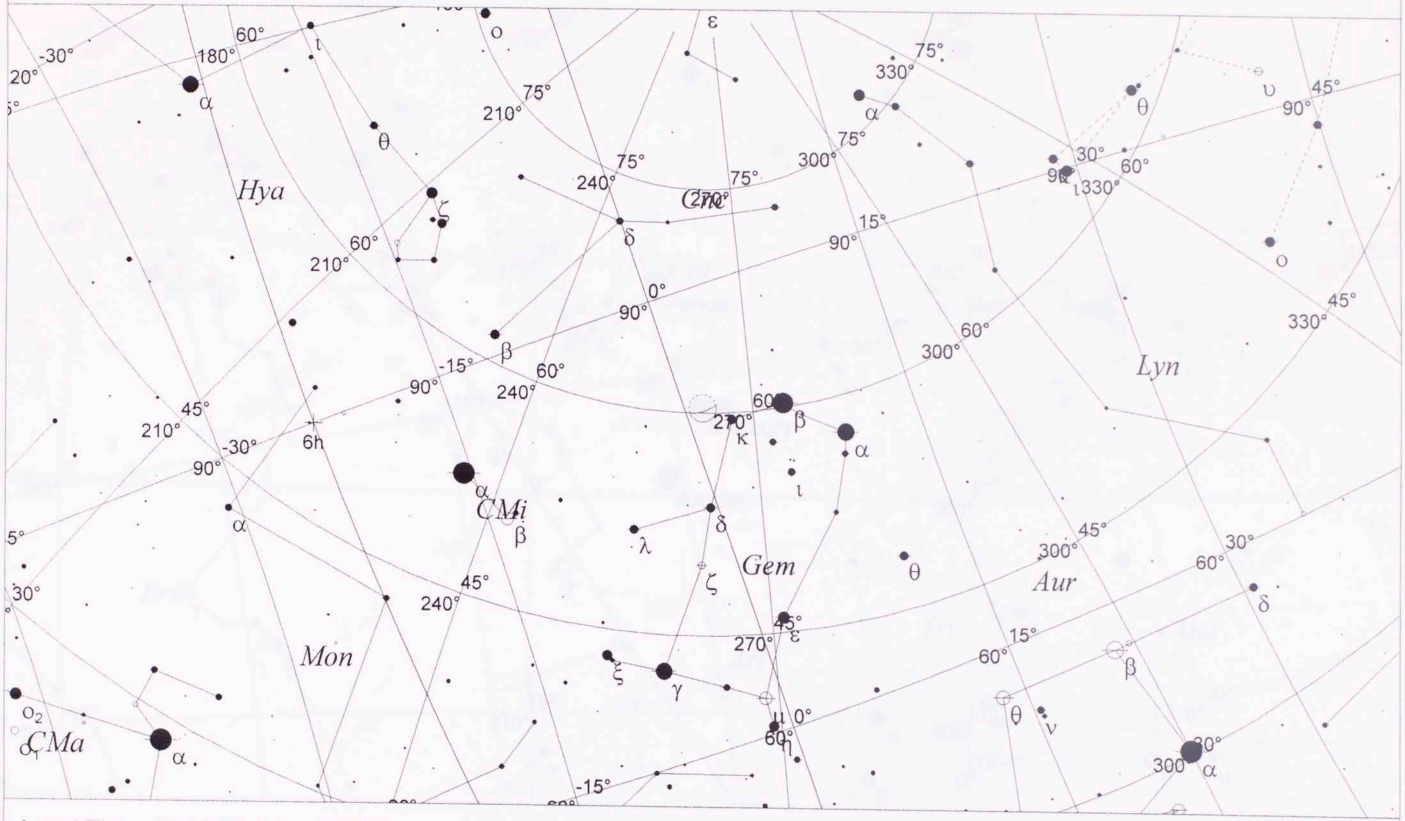


Local Time: 19:15:00 31-Mar-373BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:17:00 31-Mar-373BC
RA: 1h19m40s Dec: +10° 28' Field: 90.0°

Sidereal Time: 07:31:03
Julian Day: 1585275.1785

-372 / 5

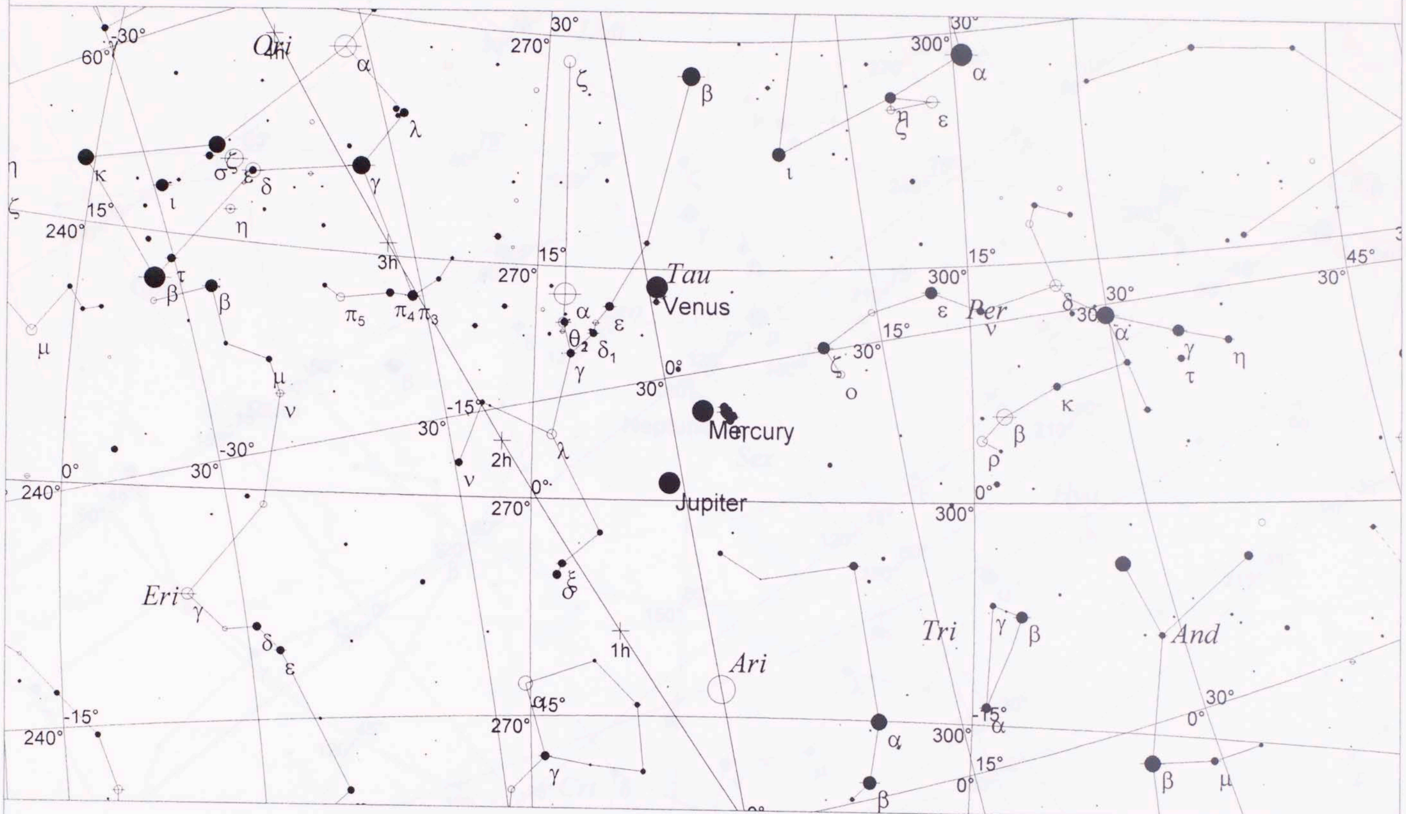


Local Time: 19:16:00 1-Apr-373BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:18:00 1-Apr-373BC
RA: 5h25m09s Dec: +24° 42' Field: 90.0°

Sidereal Time: 07:36:00
Julian Day: 1585276.1792

-372 / 7

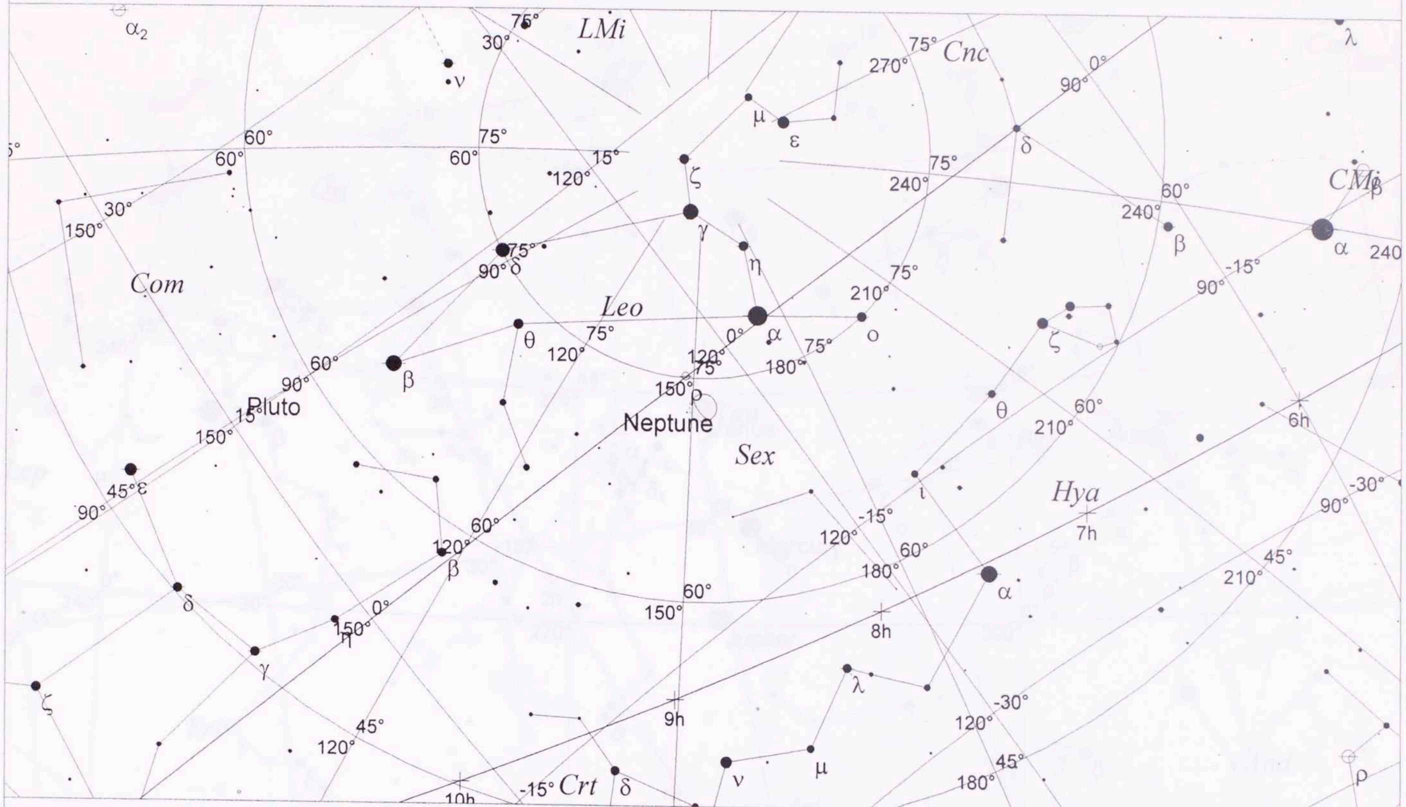


Local Time: 19:17:00 3-Apr-373BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 16:19:00 3-Apr-373BC
RA: 1h38m17s Dec: +12° 43' Field: 90.0°

Sidereal Time: 07:44:53
Julian Day: 1585278.1799

-372 / 8

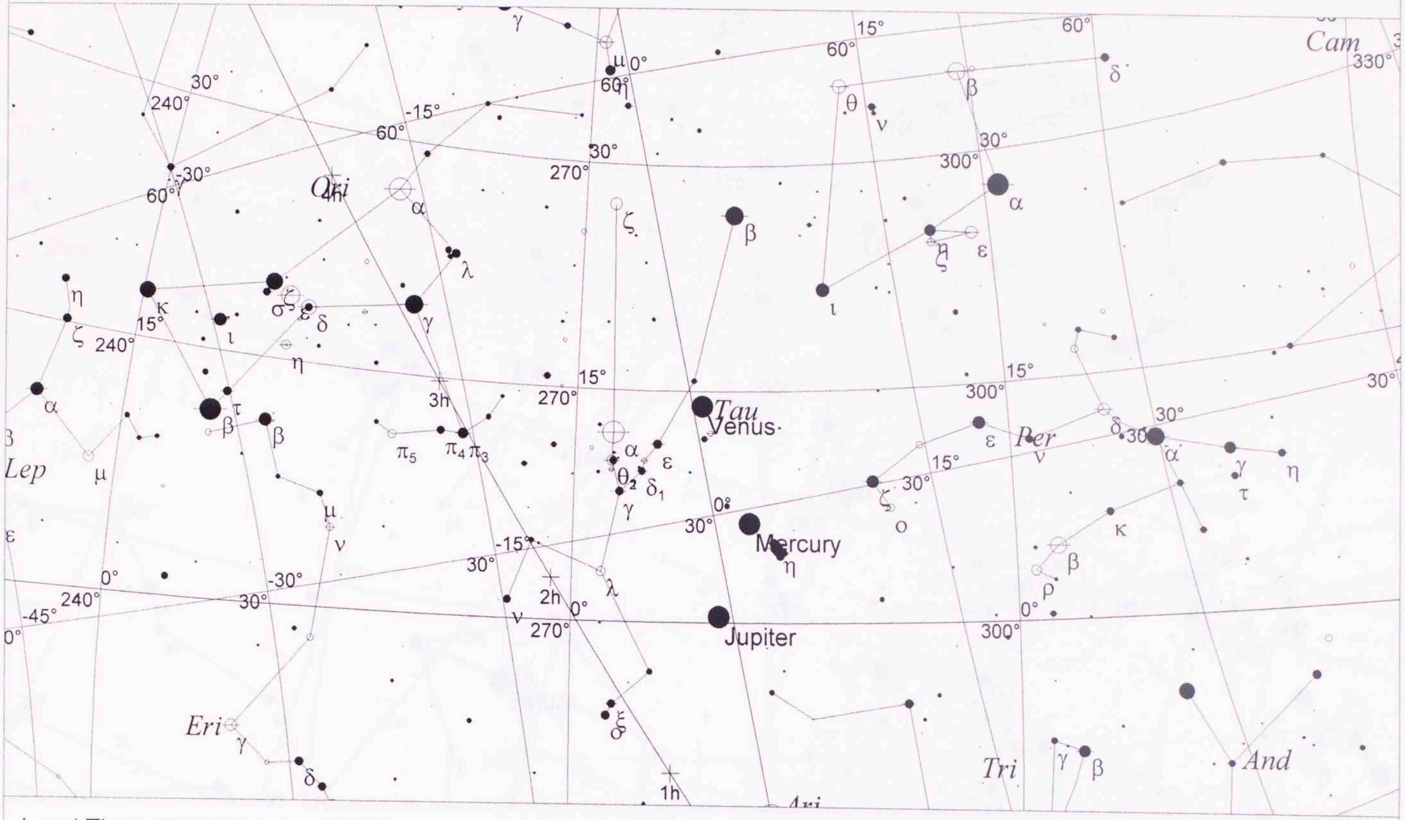


Local Time: 19:18:00 4-Apr-373BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:20:00 4-Apr-373BC
RA: 8h22m13s Dec: +17° 14' Field: 90.0°

Sidereal Time: 07:49:50
Julian Day: 1585279.1806

-372 / 8

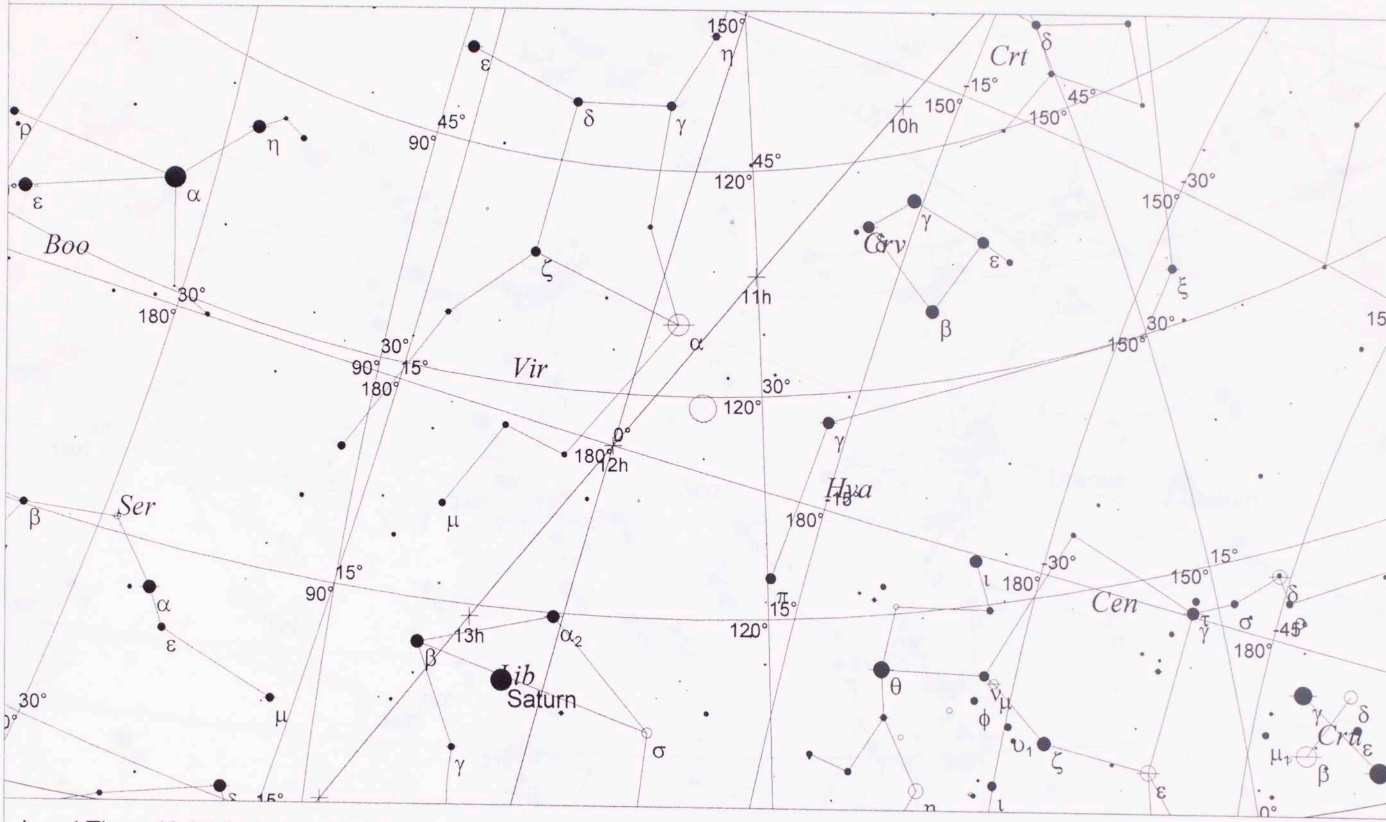


Local Time: 19:18:00 4-Apr-373BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:20:00 4-Apr-373BC
RA: 2h18m57s Dec: +14° 45' Field: 90.0°

Sidereal Time: 07:49:50
Julian Day: 1585279.1806

-372 / 12

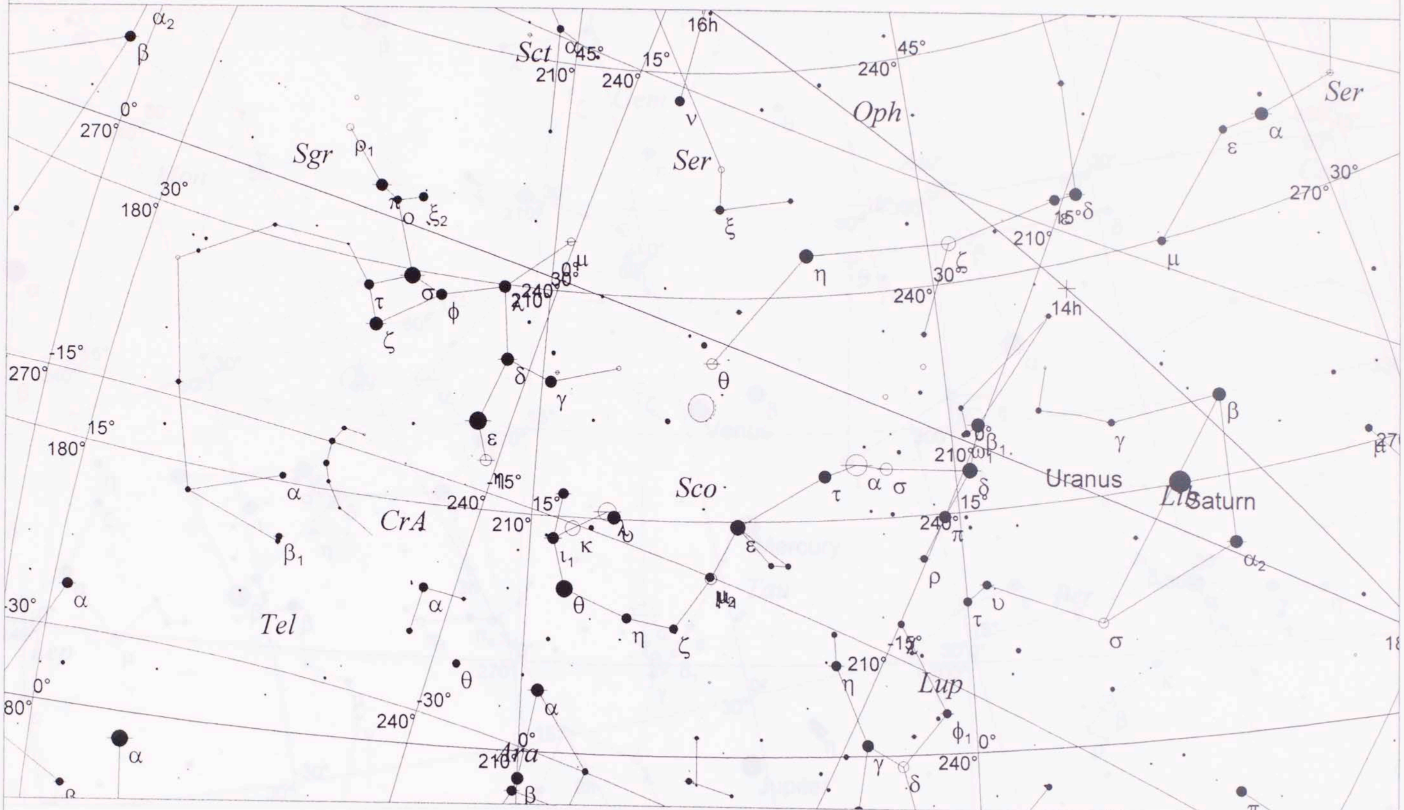


Local Time: 19:20:00 8-Apr-373BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:22:00 8-Apr-373BC
RA: 11h36m23s Dec: -2° 59' Field: 90.0°

Sidereal Time: 08:07:36
Julian Day: 1585283.1819

-372 / 16

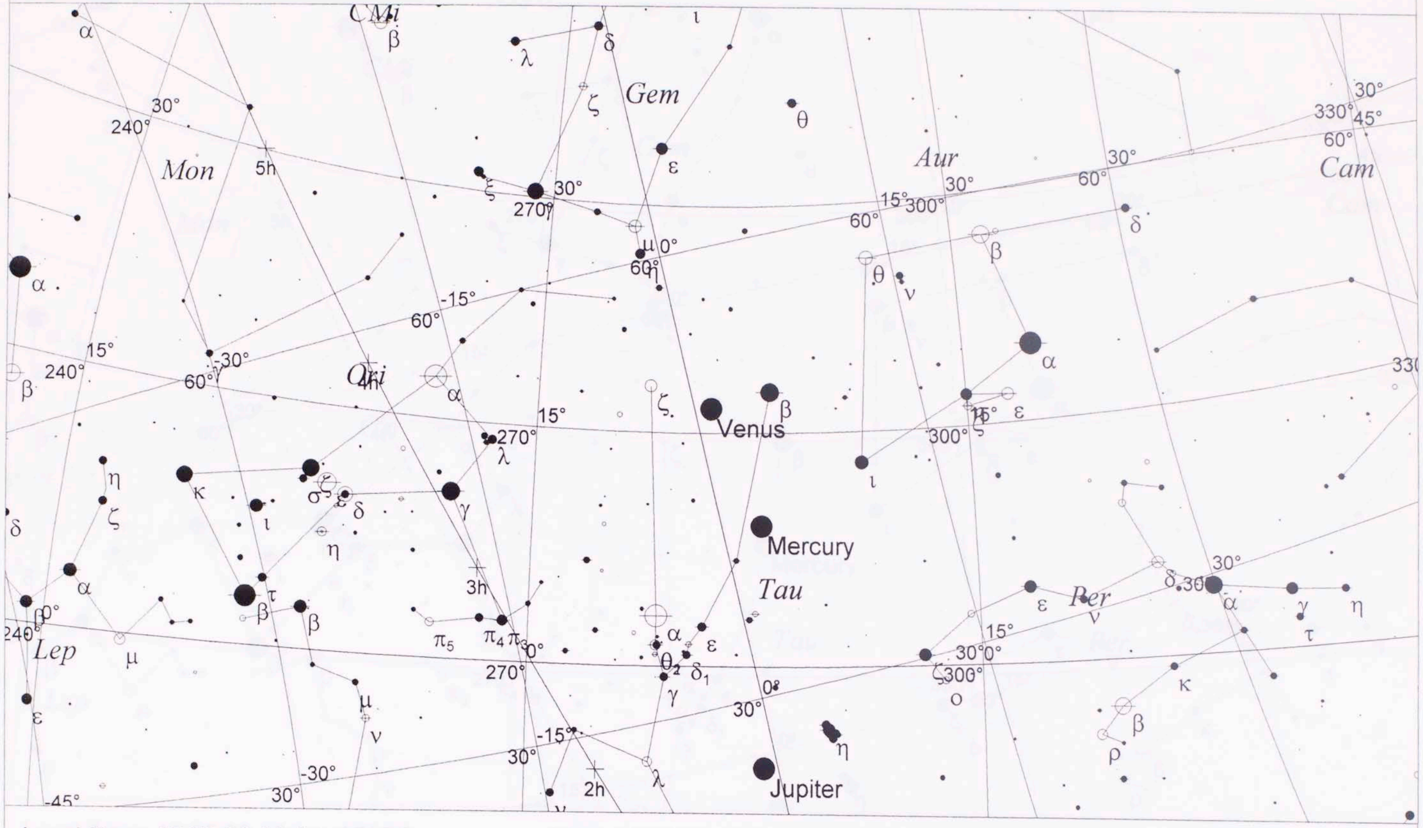


Local Time: 04:38:00 13-Apr-373BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:40:00 13-Apr-373BC
RA: 14h56m31s Dec: -21° 46' Field: 90.0°

Sidereal Time: 17:42:54
Julian Day: 1585287.5694

-372 / 18

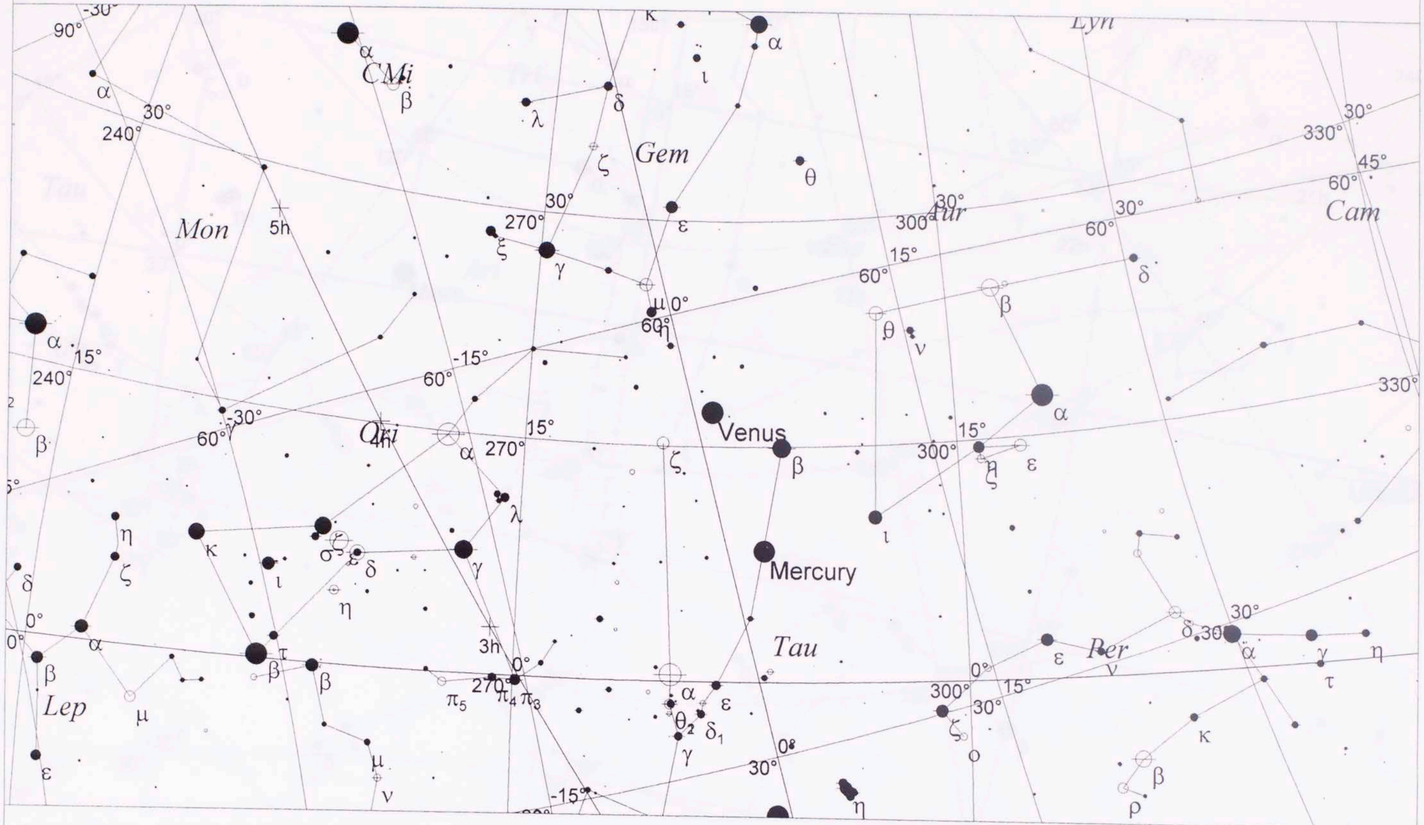


Local Time: 19:23:00 14-Apr-373BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:25:00 14-Apr-373BC
RA: 3h06m19s Dec: +18° 51' Field: 90.0°

Sidereal Time: 08:34:16
Julian Day: 1585289.1840

-372 I 21

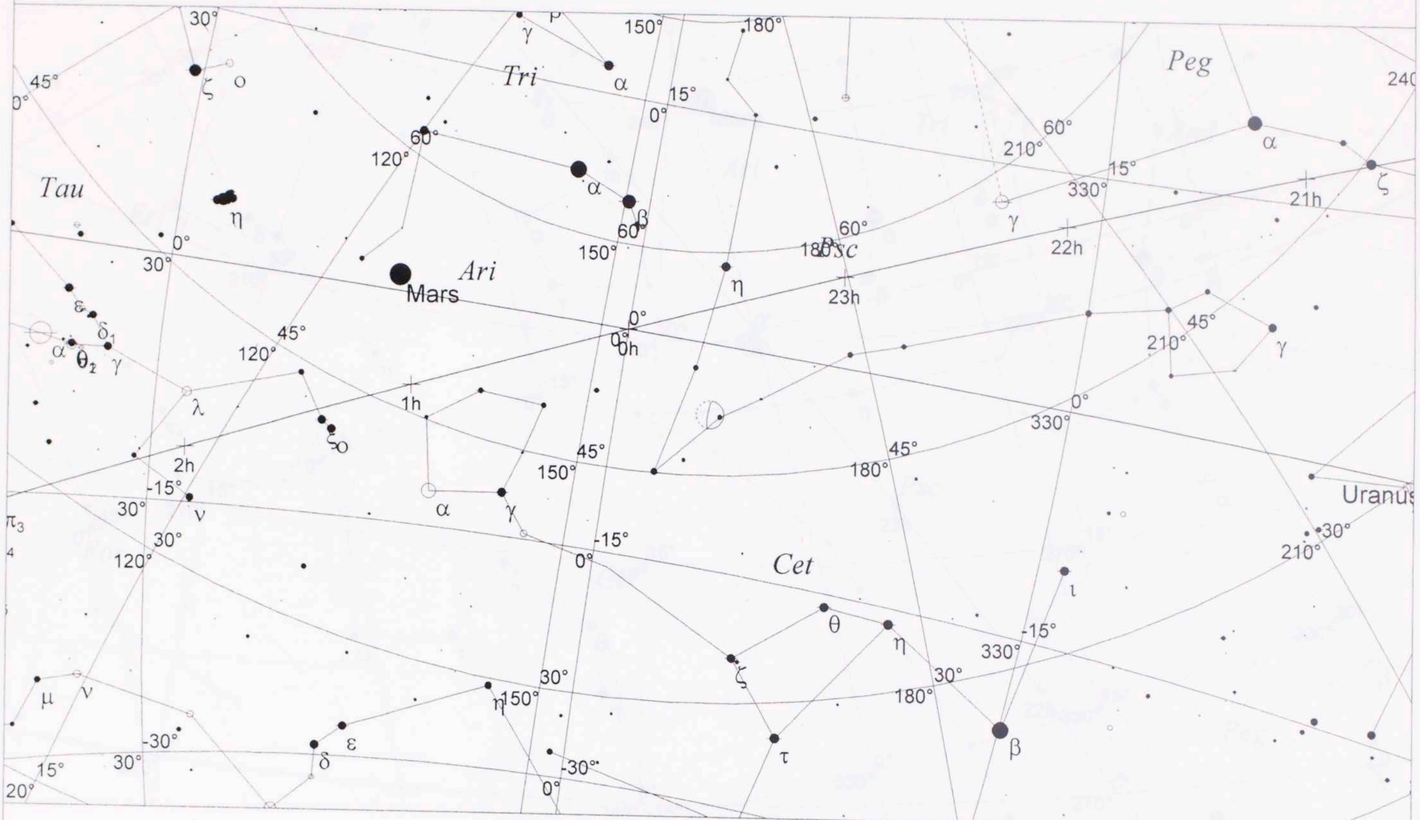


Local Time: 19:25:00 17-Apr-373BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:27:00 17-Apr-373BC
RA: 3h20m52s Dec: +19° 56' Field: 90.0°

Sidereal Time: 08:48:06
Julian Day: 1585292.1854

-346 IX 8

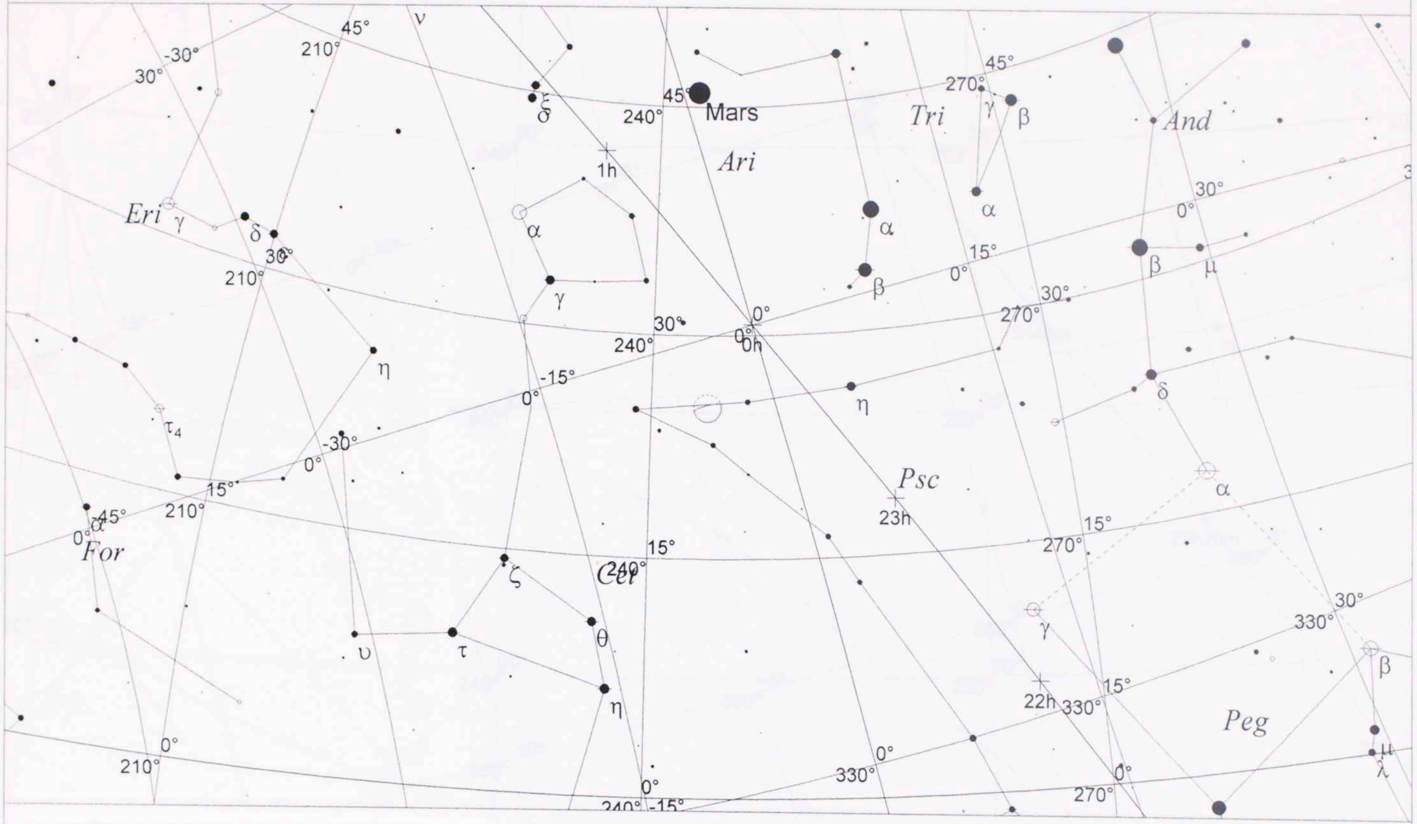


Local Time: 18:07:00 9-Dec-347BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 15:09:00 9-Dec-347BC
RA: 23h44m13s Dec: -6° 55' Field: 90.0°

Sidereal Time: 22:59:07
Julian Day: 1595024.1312

-346 IX 8

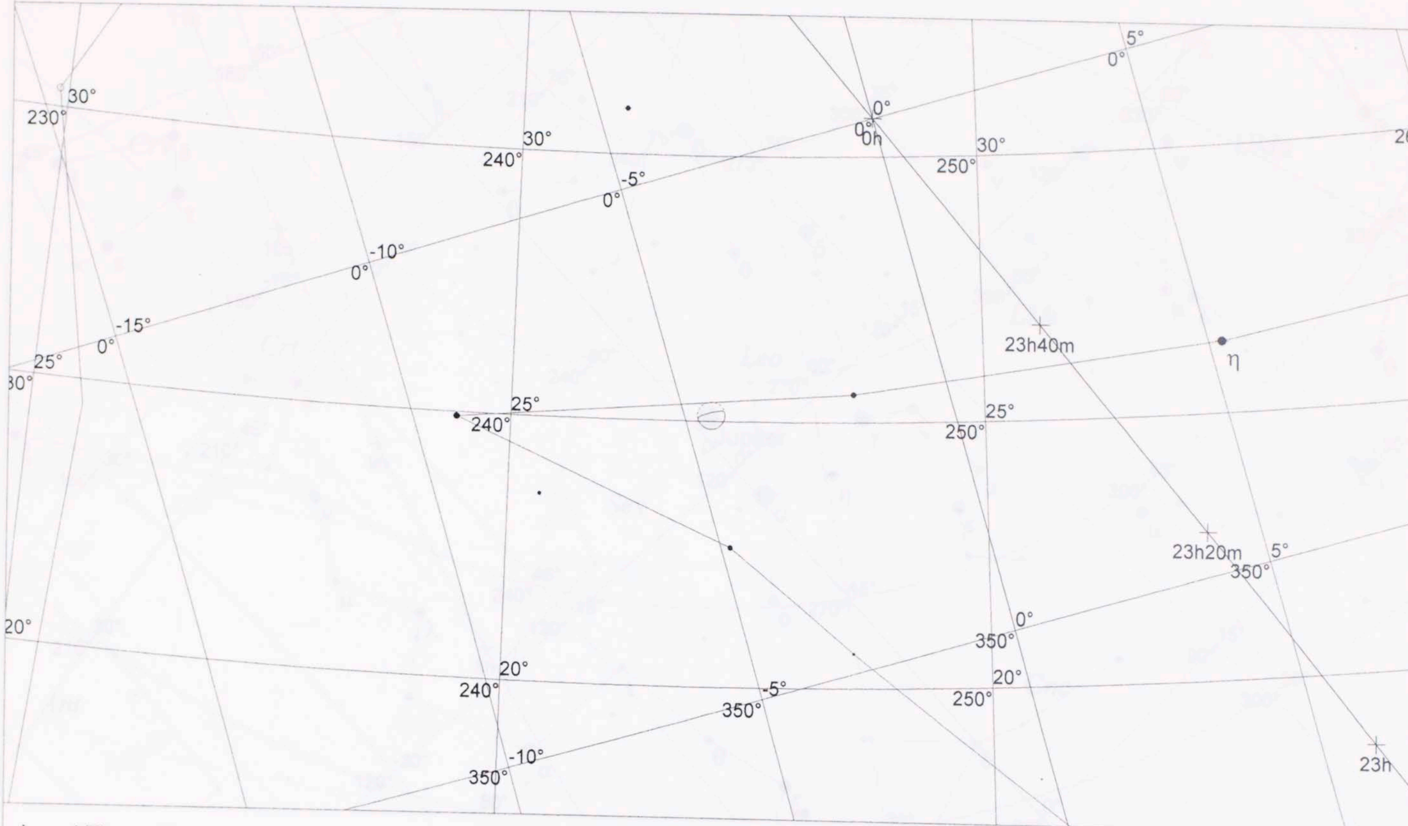


Local Time: 22:38:00 9-Dec-347BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 19:40:00 9-Dec-347BC
RA: 23h50m32s Dec: -5° 57' Field: 90.0°

Sidereal Time: 03:30:52
Julian Day: 1595024.3194

-346 IX 8

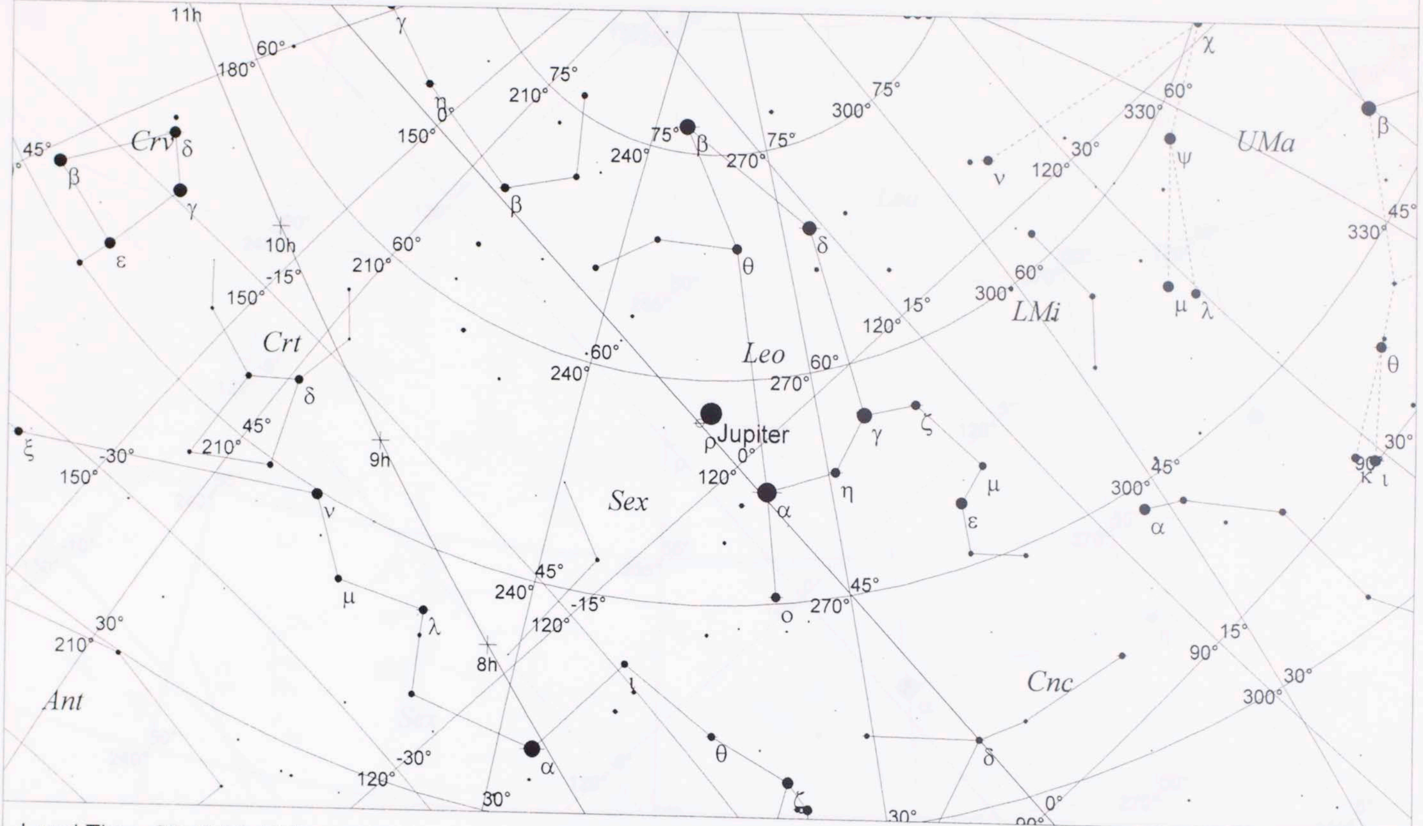


Local Time: 22:38:00 9-Dec-347BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 19:40:00 9-Dec-347BC
RA: 23h50m32s Dec: -5° 57' Field: 26.7°

Sidereal Time: 03:30:52
Julian Day: 1595024.3194

-346 IX 8

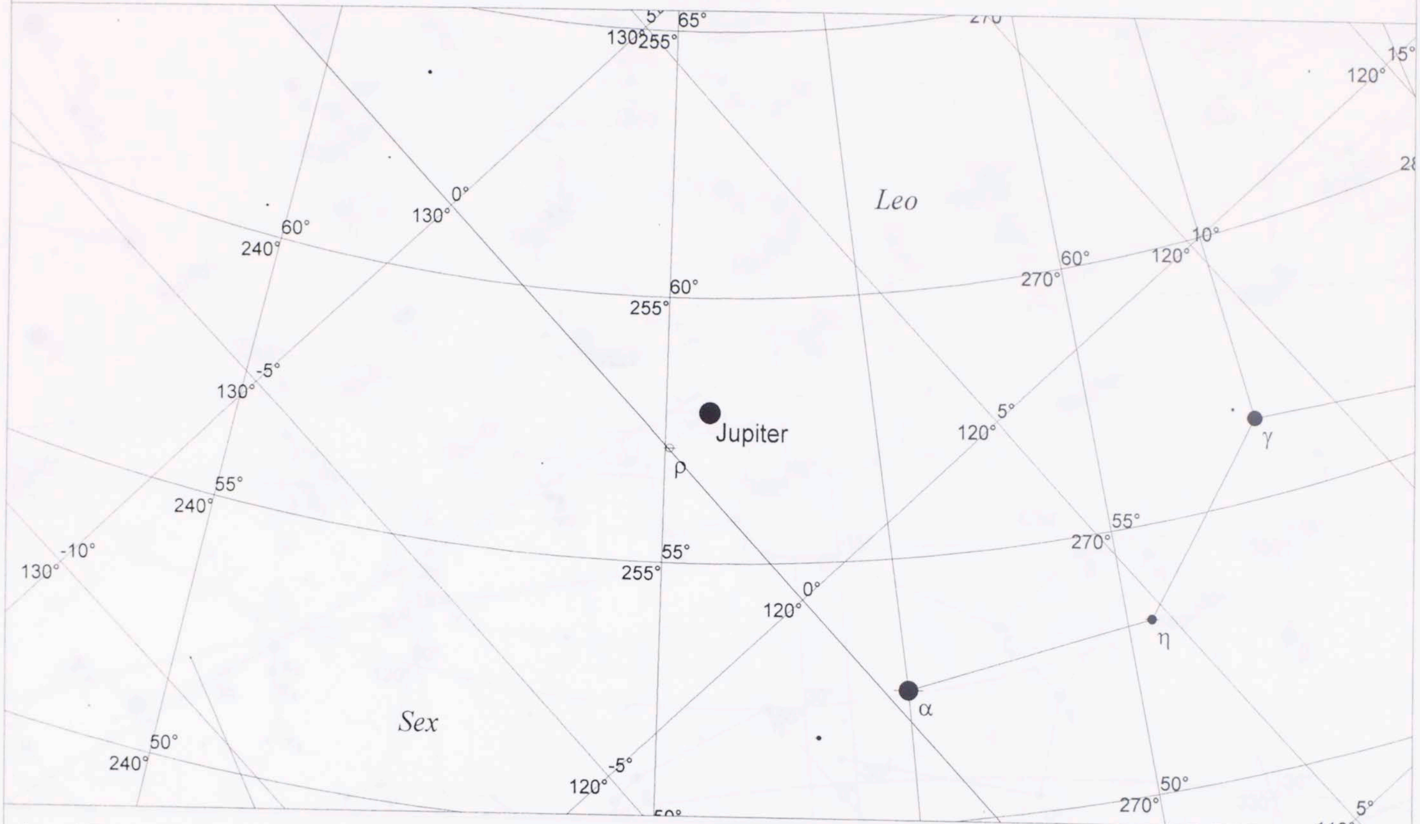


Local Time: 05:46:00 10-Dec-347BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:48:00 10-Dec-347BC
RA: 8h25m39s Dec: +20° 33' Field: 90.0°

Sidereal Time: 10:40:02
Julian Day: 1595024.6167

-346 IX 8

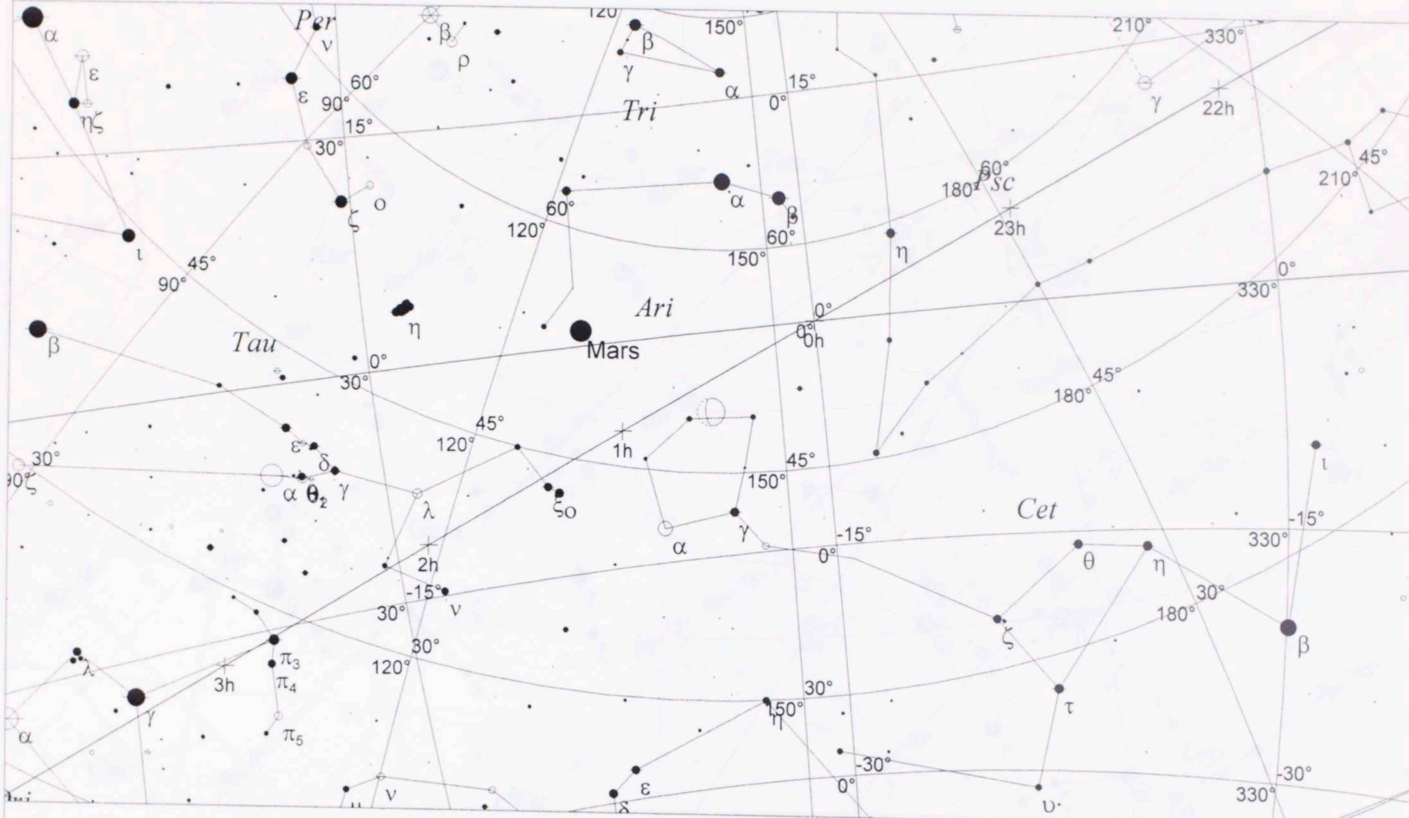


Local Time: 05:46:00 10-Dec-347BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 02:48:00 10-Dec-347BC
RA: 8h25m39s Dec: +20° 33' Field: 26.7°

Sidereal Time: 10:40:02
Julian Day: 1595024.6167

-346 IX 9

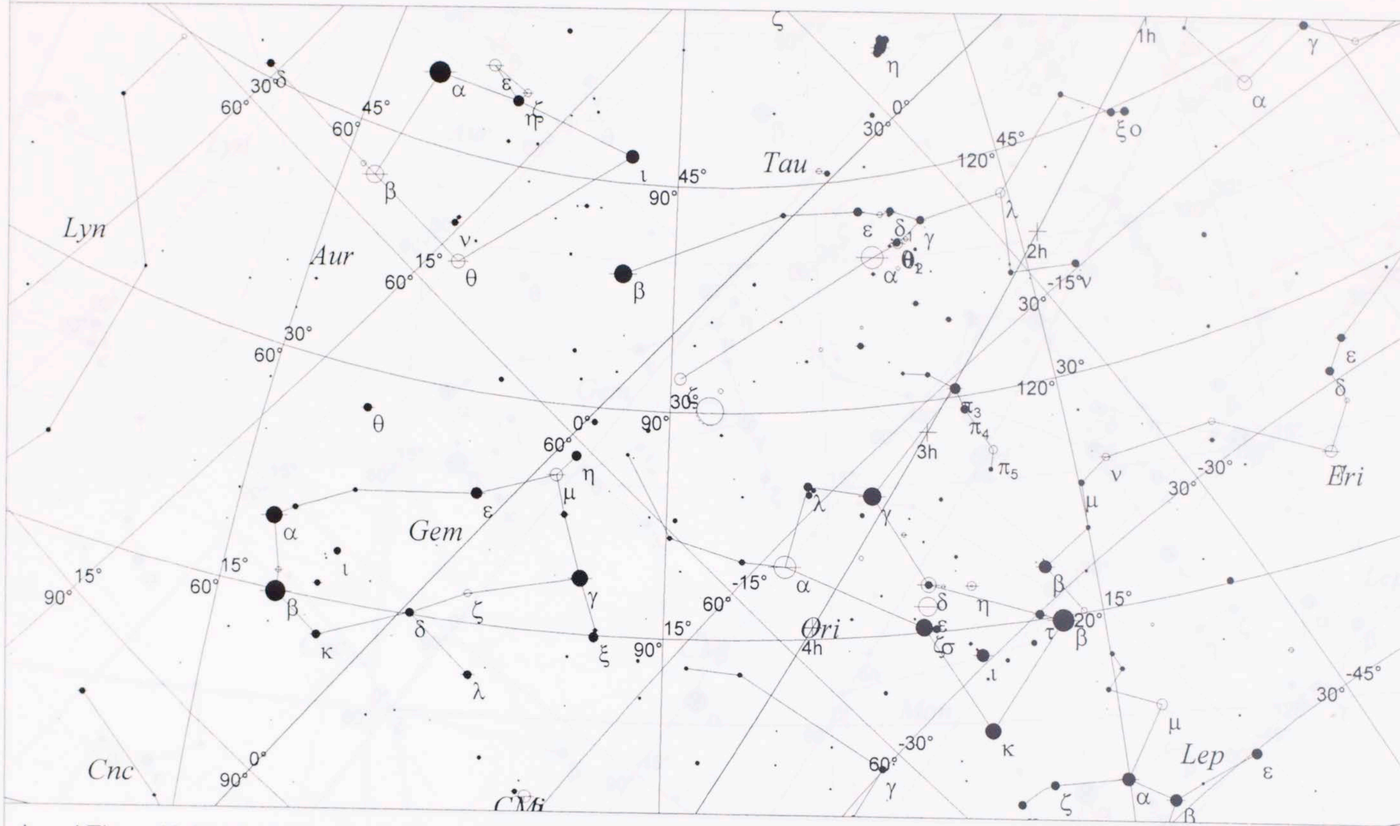


Local Time: 18:07:00 10-Dec-347BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 15:09:00 10-Dec-347BC
RA: 0h36m38s Dec: -1° 51' Field: 90.0°

Sidereal Time: 23:03:04
Julian Day: 1595025.1312

-346 IX 12

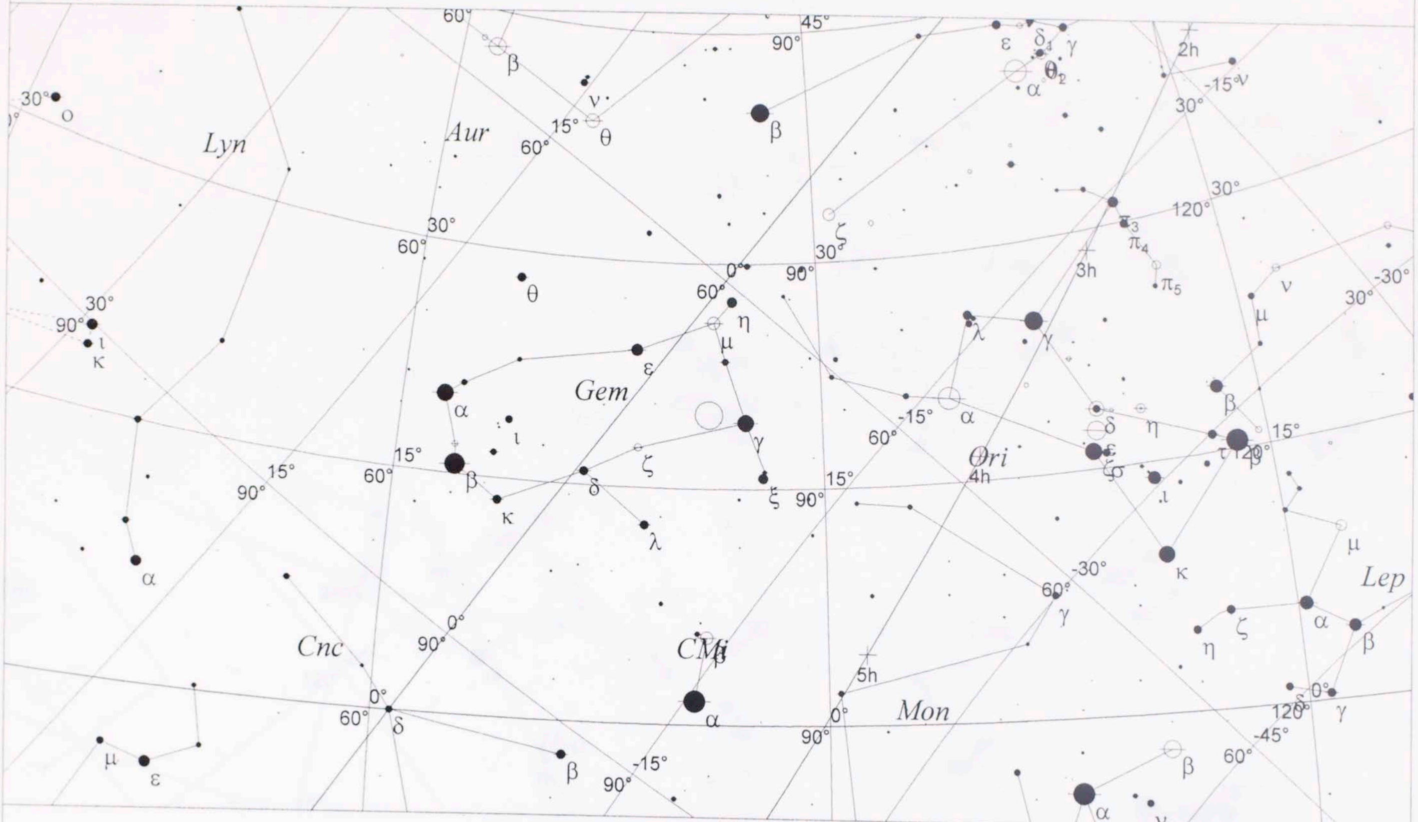


Local Time: 18:07:00 13-Dec-347BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 15:09:00 13-Dec-347BC
RA: 3h25m09s Dec: +13° 20' Field: 90.0°

Sidereal Time: 23:14:53
Julian Day: 1595028.1312

-346 IX 13

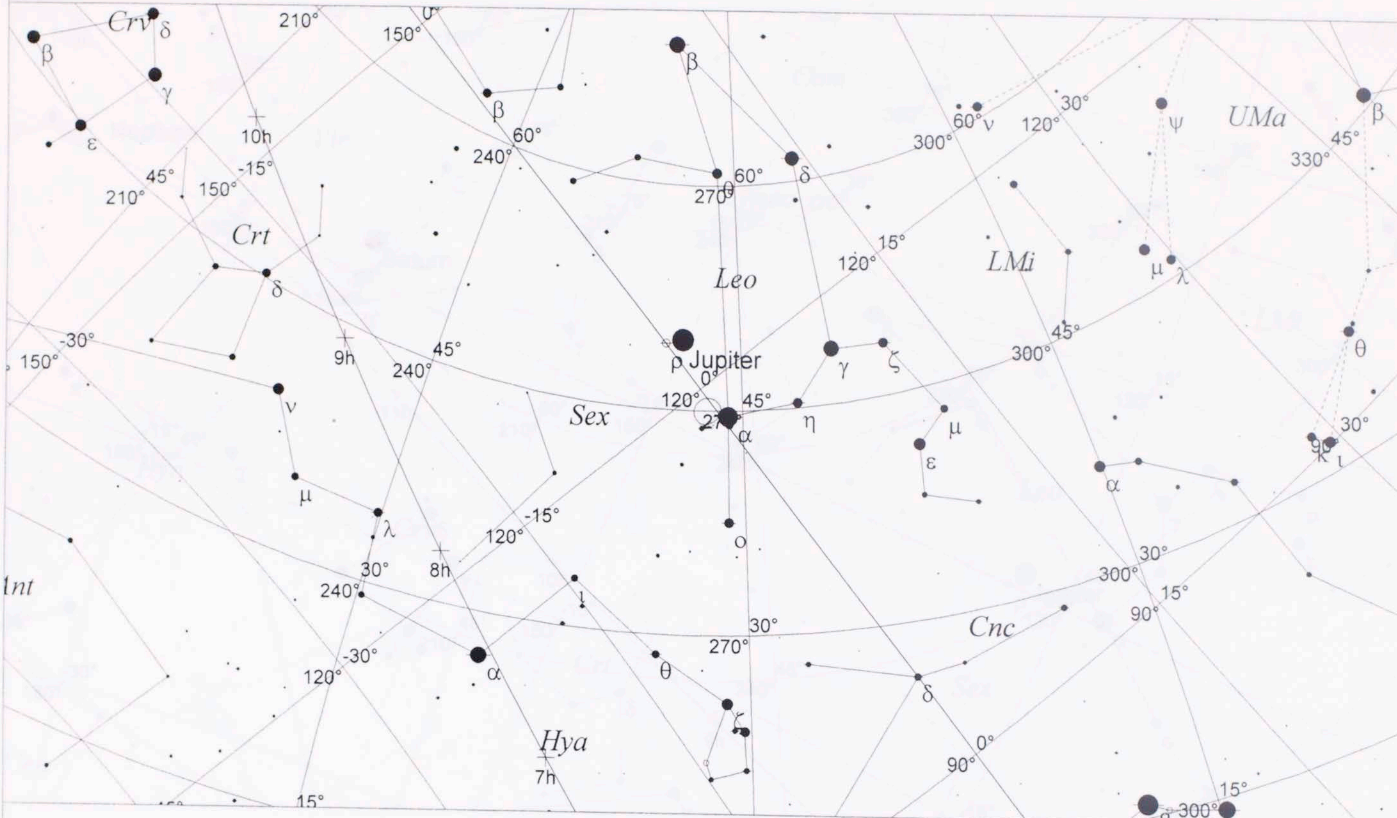


Local Time: 18:07:00 14-Dec-347BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 15:09:00 14-Dec-347BC
RA: 4h26m39s Dec: +17° 11' Field: 90.0°

Sidereal Time: 23:18:50
Julian Day: 1595029.1312

-346 IX 16

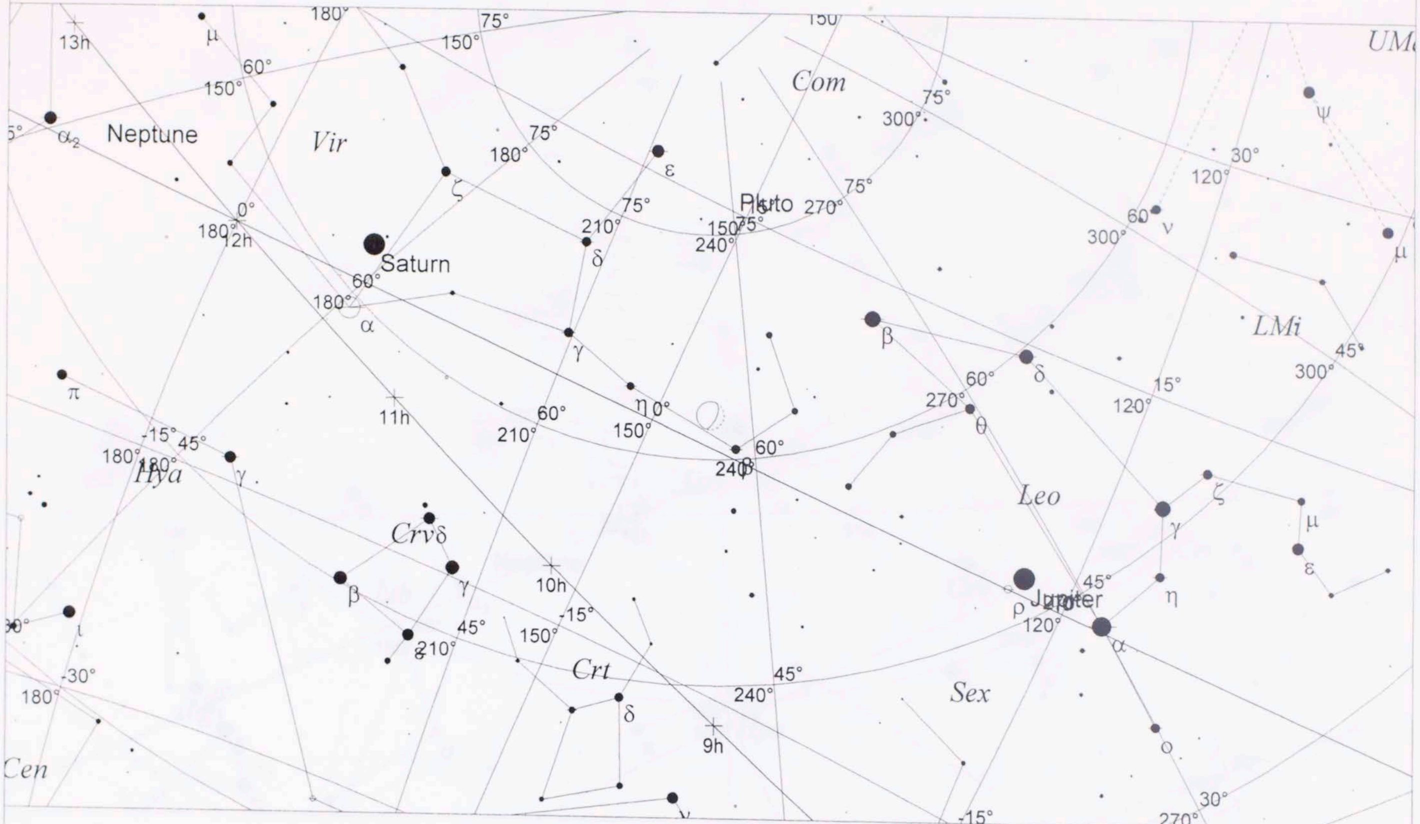


Local Time: 05:52:00 18-Dec-347BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:54:00 18-Dec-347BC
RA: 8h02m10s Dec: +20° 12' Field: 90.0°

Sidereal Time: 11:17:35
Julian Day: 1595032.6208

-346 IX 18

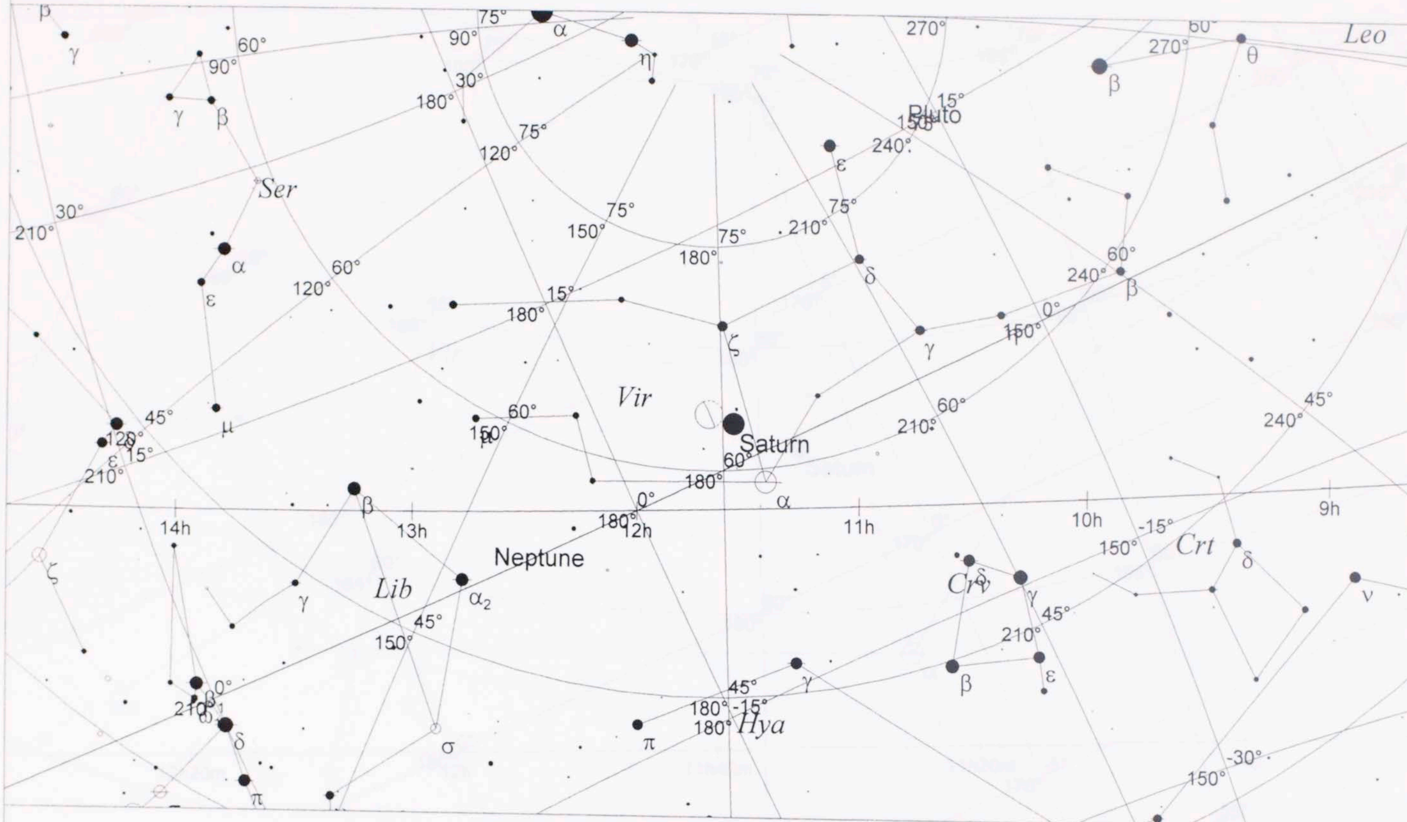


Local Time: 05:54:00 20-Dec-347BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:56:00 20-Dec-347BC
RA: 9h58m14s Dec: +14° 38' Field: 90.0°

Sidereal Time: 11:27:29
Julian Day: 1595034.6222

-346 IX 20

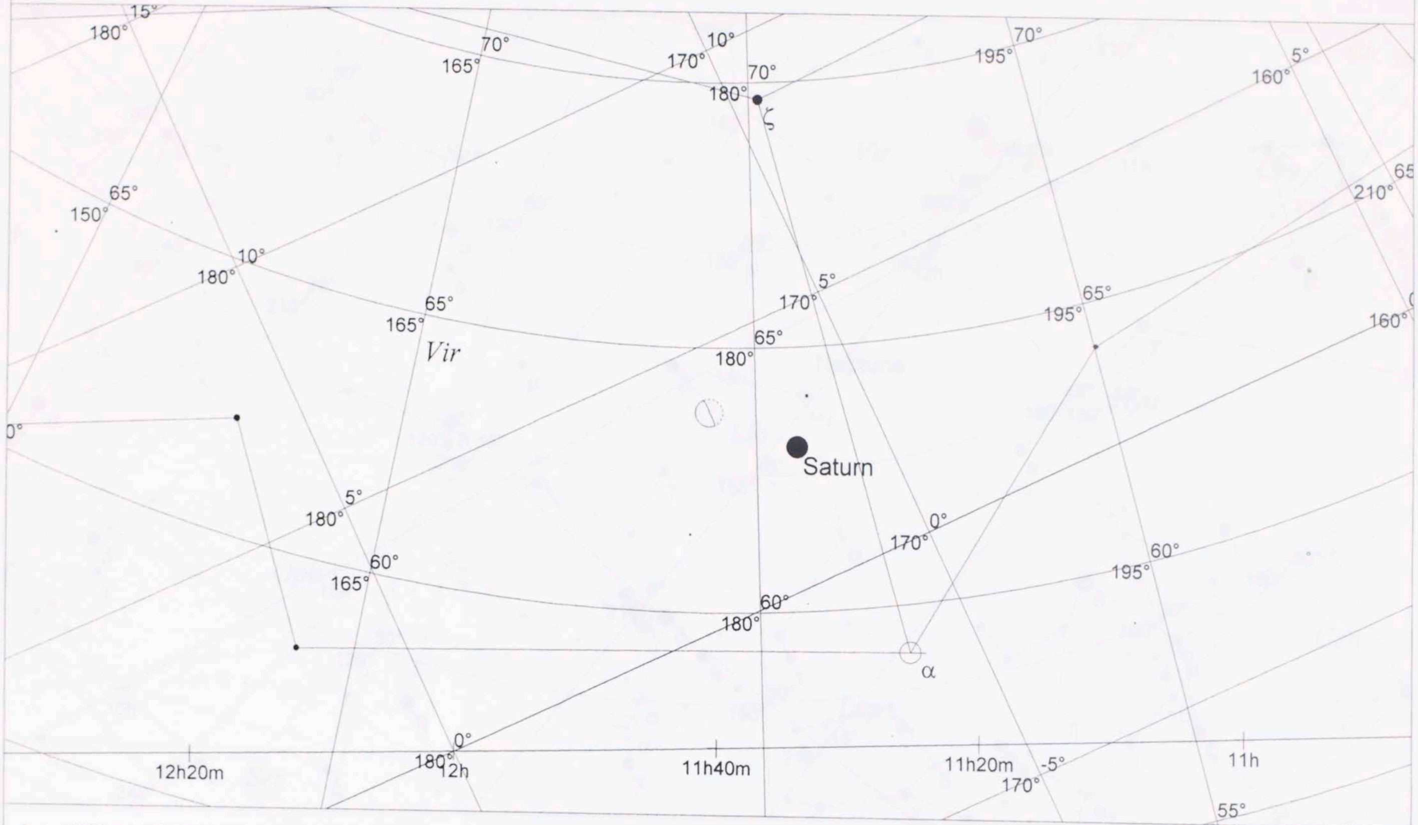


Local Time: 05:55:00 22-Dec-347BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:57:00 22-Dec-347BC
RA: 11h39m59s Dec: +6° 18' Field: 90.0°

Sidereal Time: 11:36:22
Julian Day: 1595036.6229

-346 IX 20

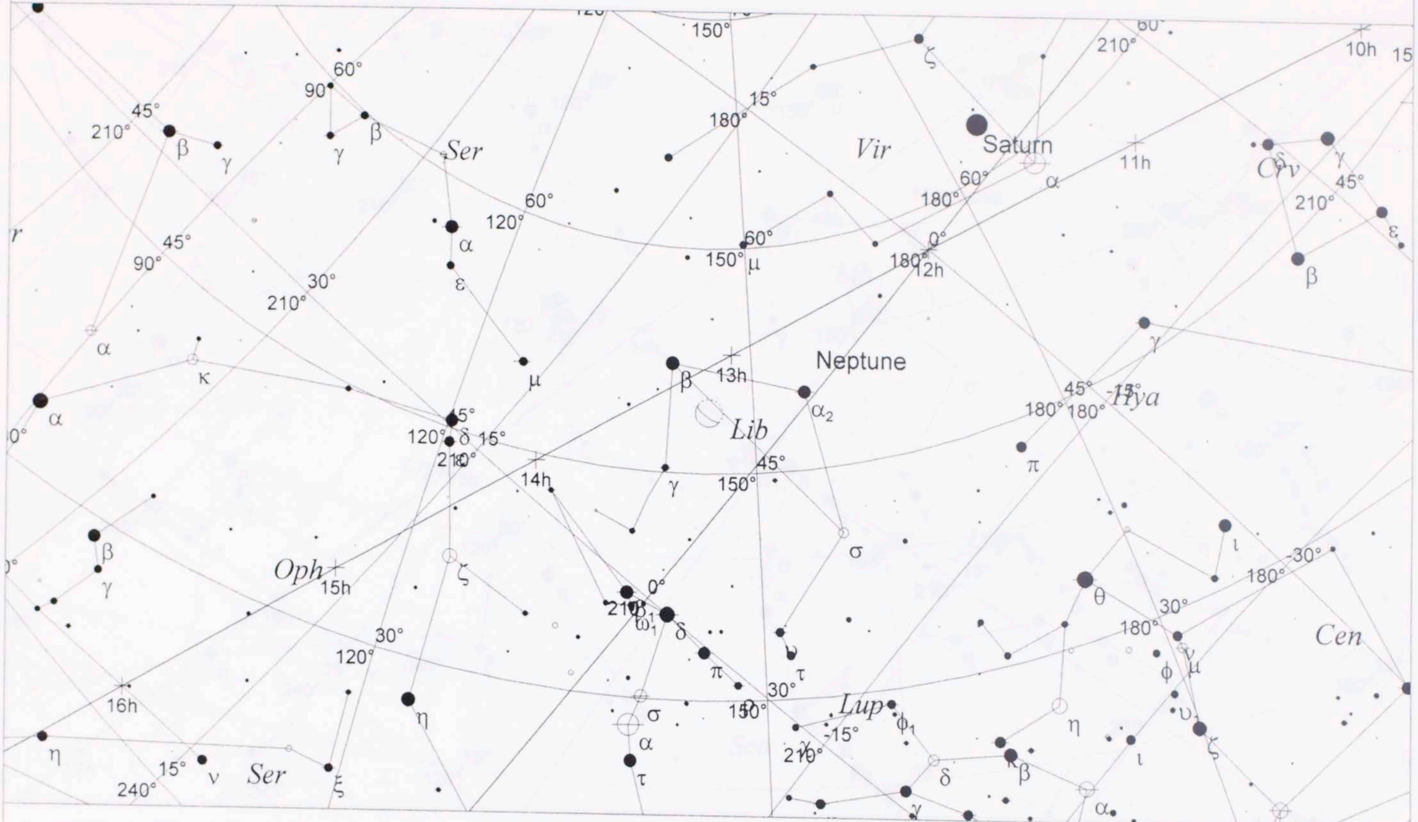


Local Time: 05:55:00 22-Dec-347BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:57:00 22-Dec-347BC
RA: 11h39m59s Dec: +6° 18' Field: 26.7°

Sidereal Time: 11:36:22
Julian Day: 1595036.6229

-346 IX 22

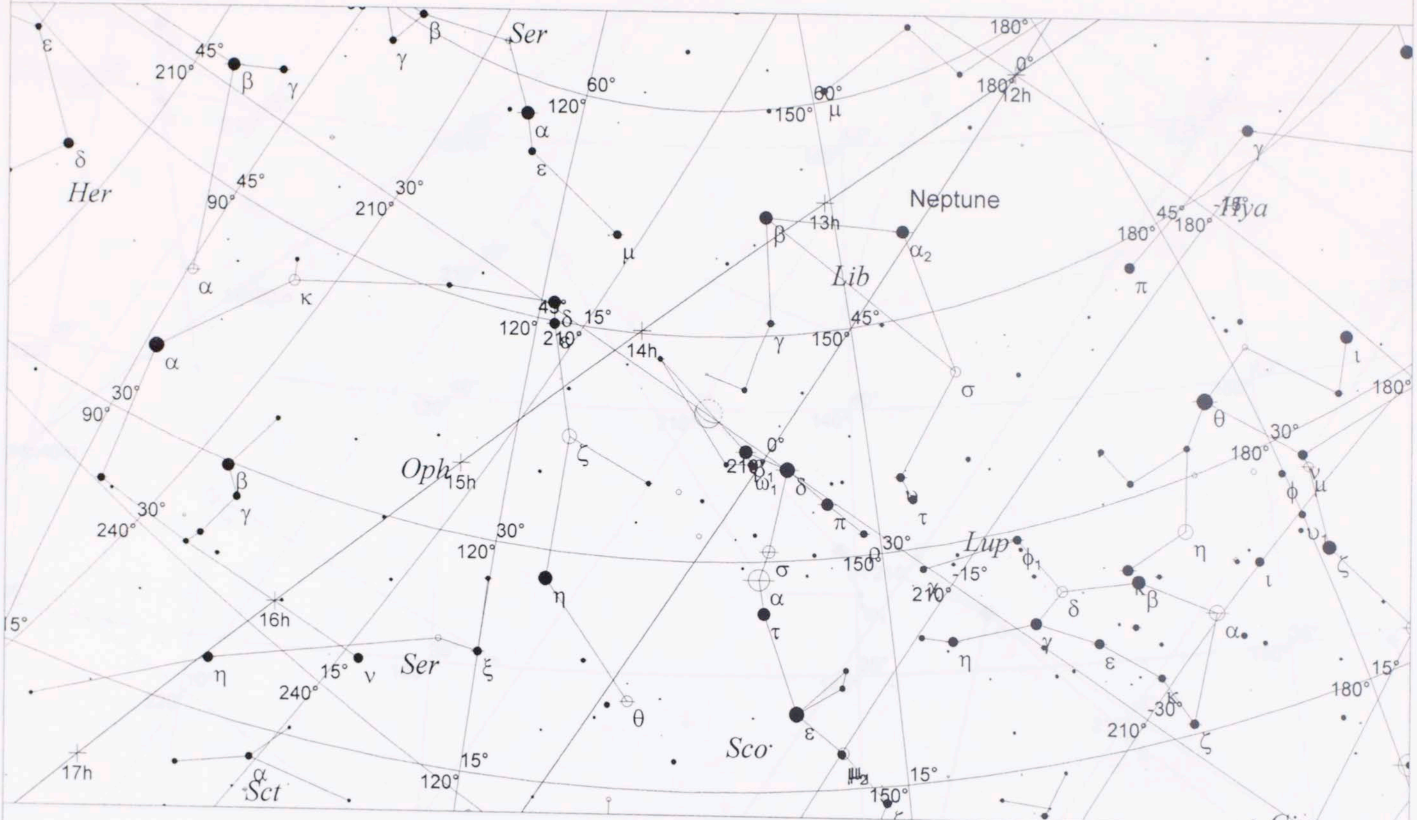


Local Time: 05:56:00 24-Dec-347BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 02:58:00 24-Dec-347BC
RA: 13h12m48s Dec: -2° 43' Field: 90.0°

Sidereal Time: 11:45:15
Julian Day: 1595038.6236

-346 IX 23

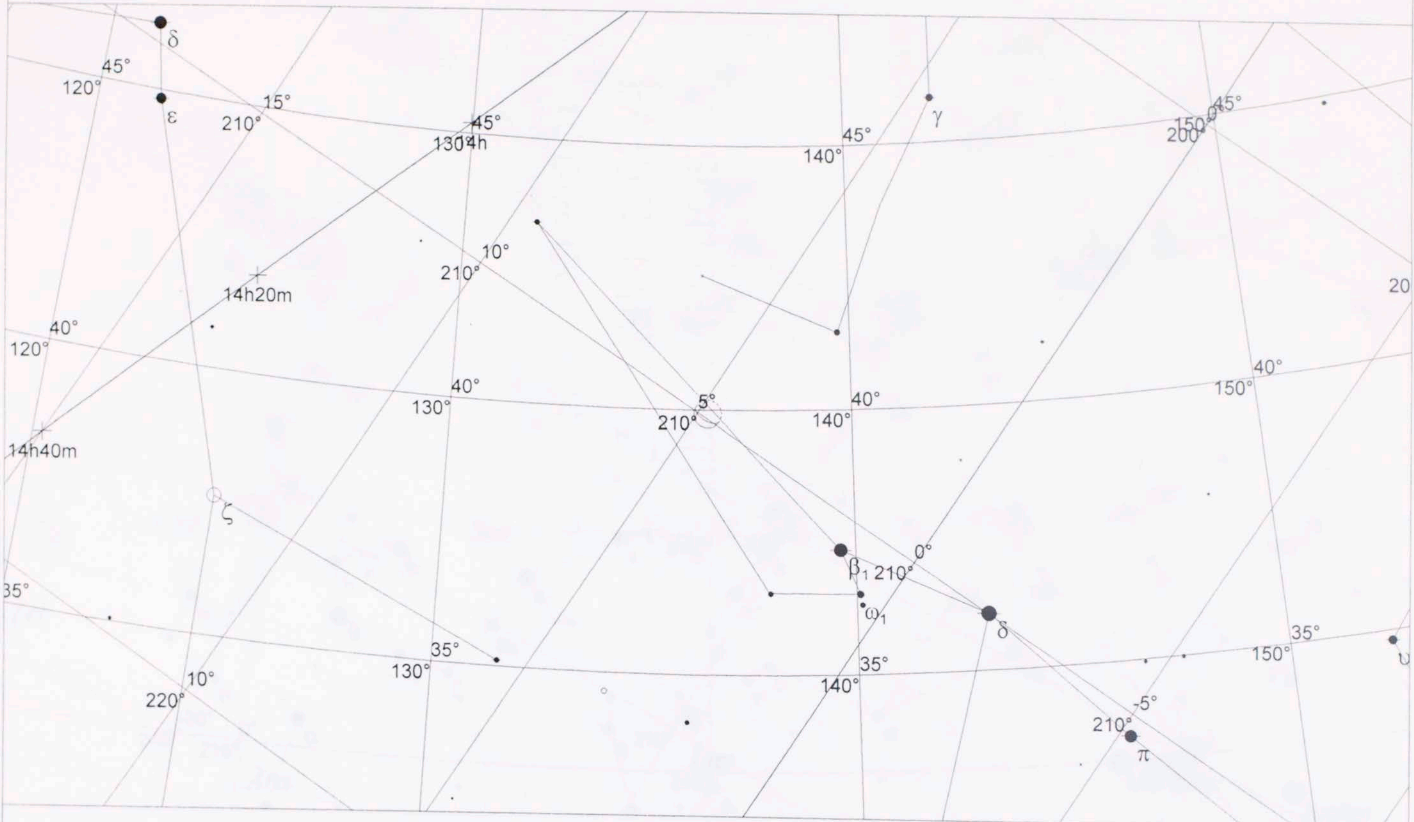


Local Time: 05:56:00 25-Dec-347BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:58:00 25-Dec-347BC
RA: 13h58m02s Dec: -7° 04' Field: 90.0°

Sidereal Time: 11:49:12
Julian Day: 1595039.6236

-346 IX 23

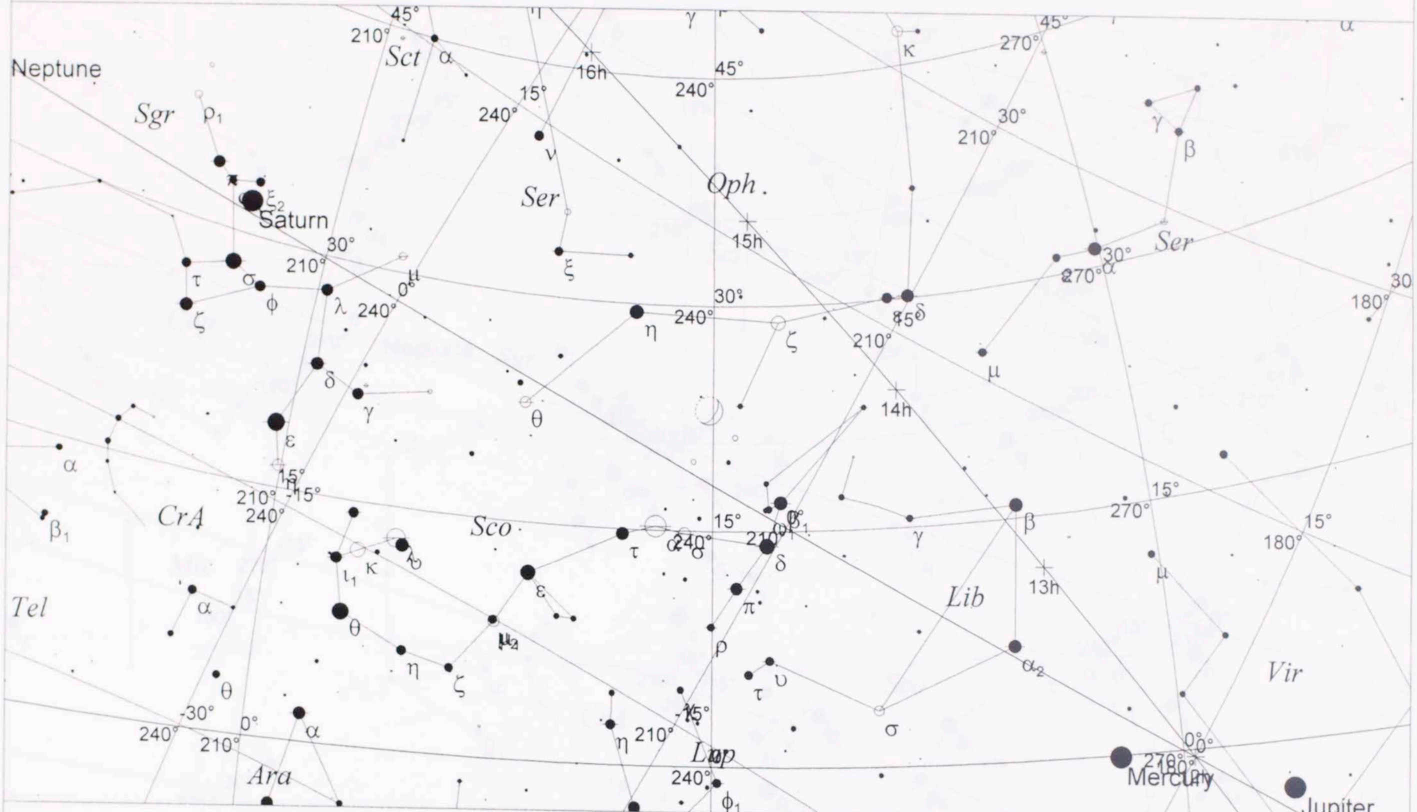


Local Time: 05:56:00 25-Dec-347BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:58:00 25-Dec-347BC
RA: 13h58m02s Dec: -7° 04' Field: 26.7°

Sidereal Time: 11:49:12
Julian Day: 1595039.6236

-308 VI 4

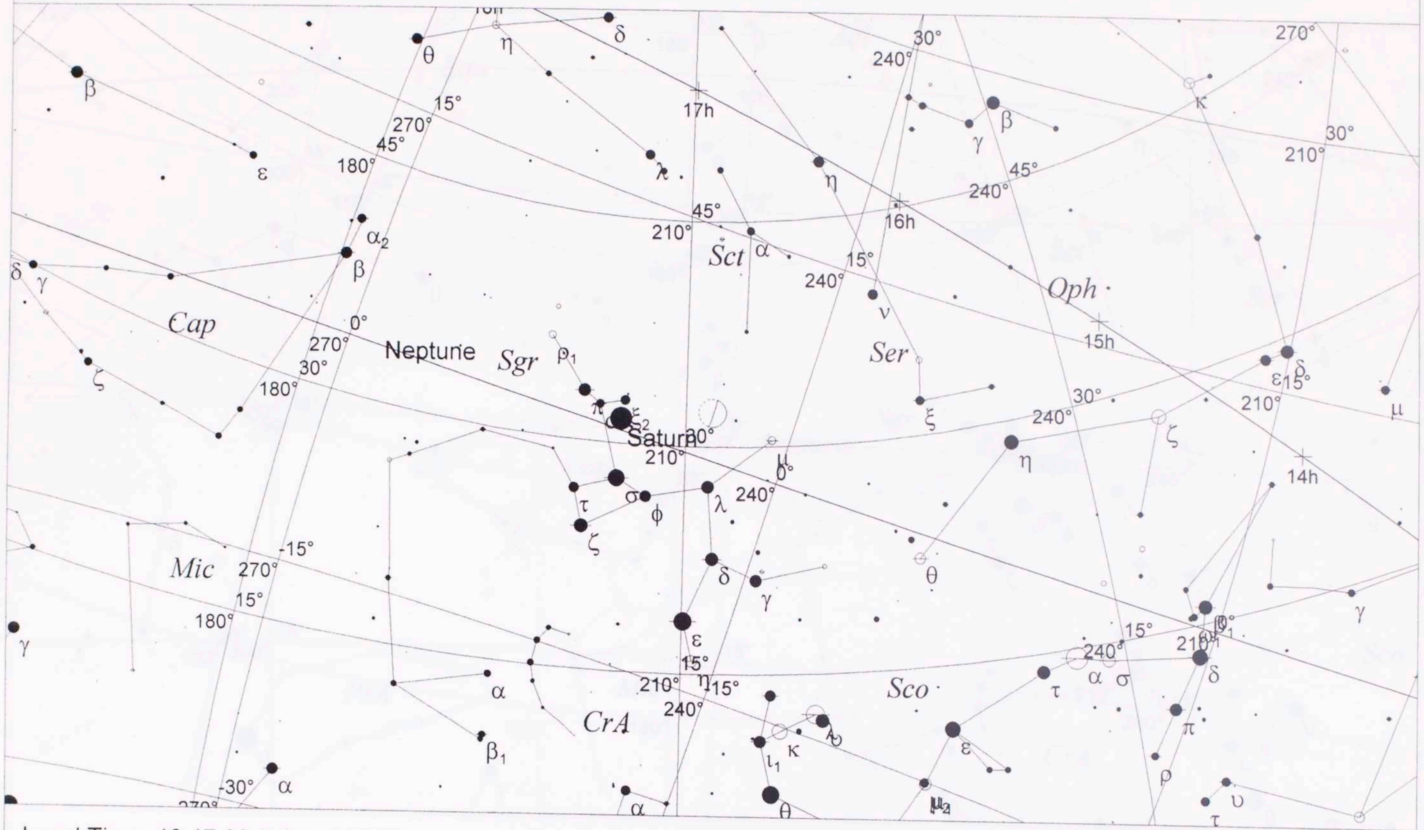


Local Time: 19:20:00 6-Sep-309BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:22:00 6-Sep-309BC
RA: 14h29m11s Dec: -10° 29' Field: 90.0°

Sidereal Time: 18:04:50
Julian Day: 1608810.1819

-308 VI 6

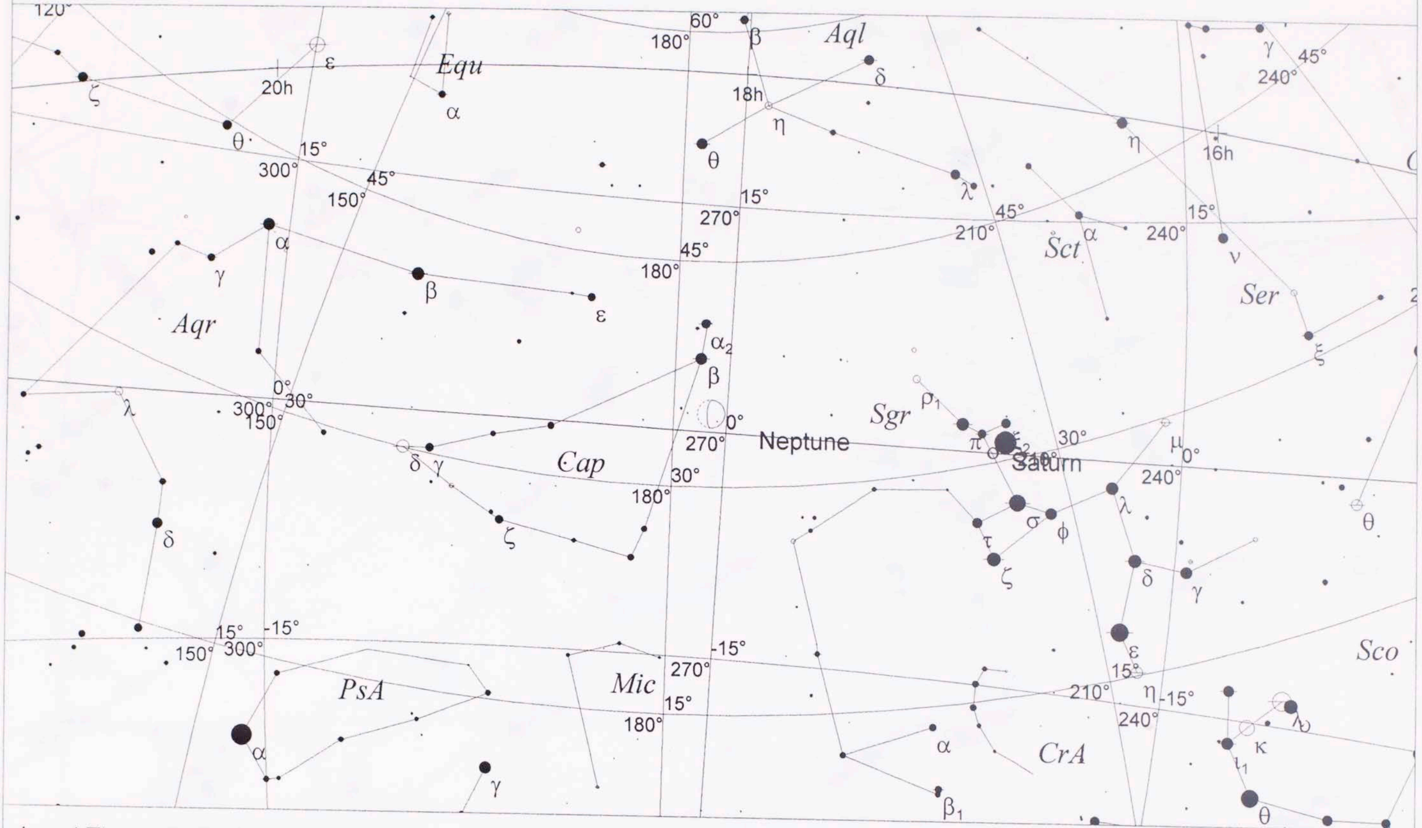


Local Time: 19:17:00 8-Sep-309BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:19:00 8-Sep-309BC
RA: 16h16m37s Dec: -18° 28' Field: 90.0°

Sidereal Time: 18:09:42
Julian Day: 1608812.1799

-308 VI 8

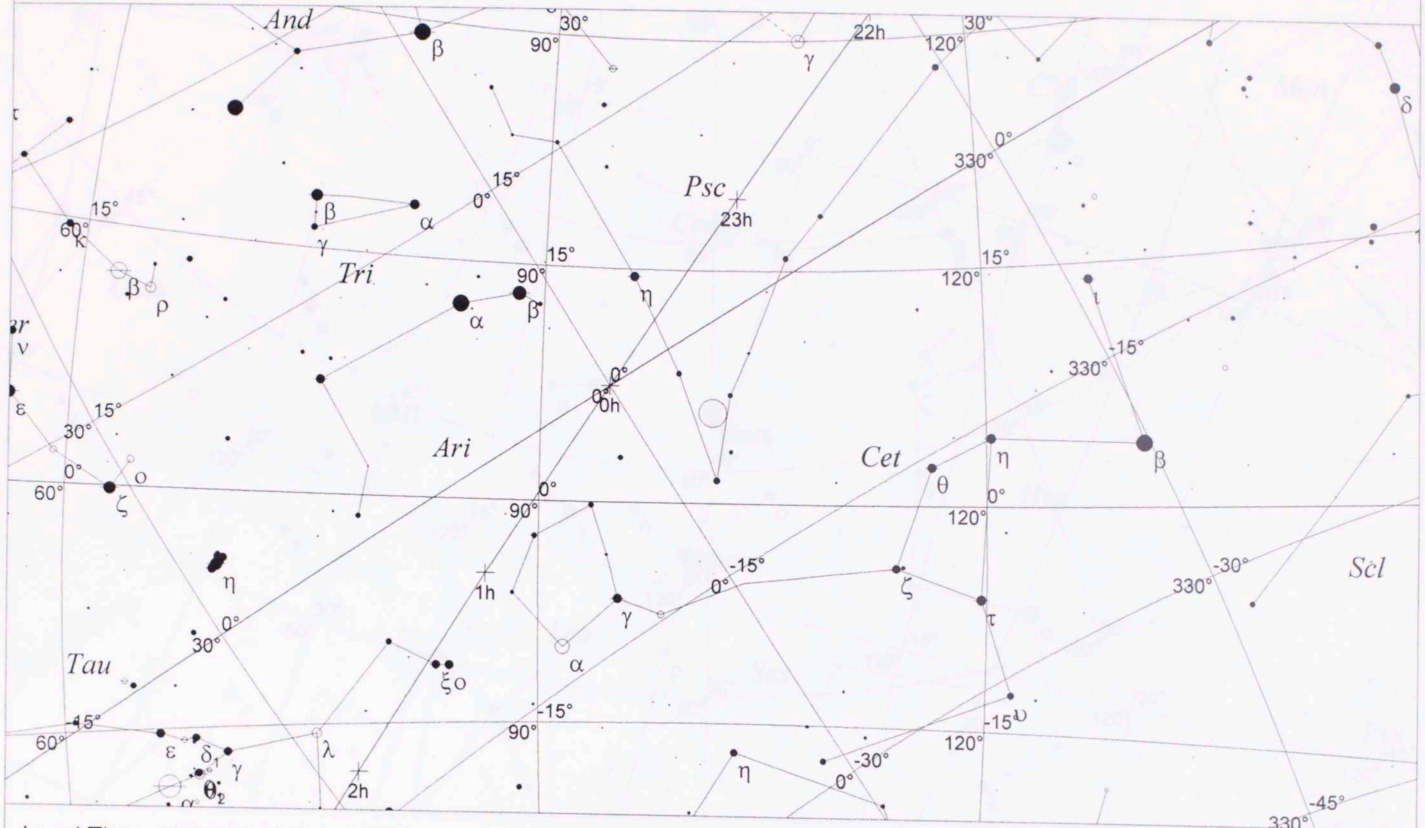


Local Time: 19:15:00 10-Sep-309BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:17:00 10-Sep-309BC
RA: 18h04m41s Dec: -22° 30' Field: 90.0°

Sidereal Time: 18:15:35
Julian Day: 1608814.1785

-308 VI 15

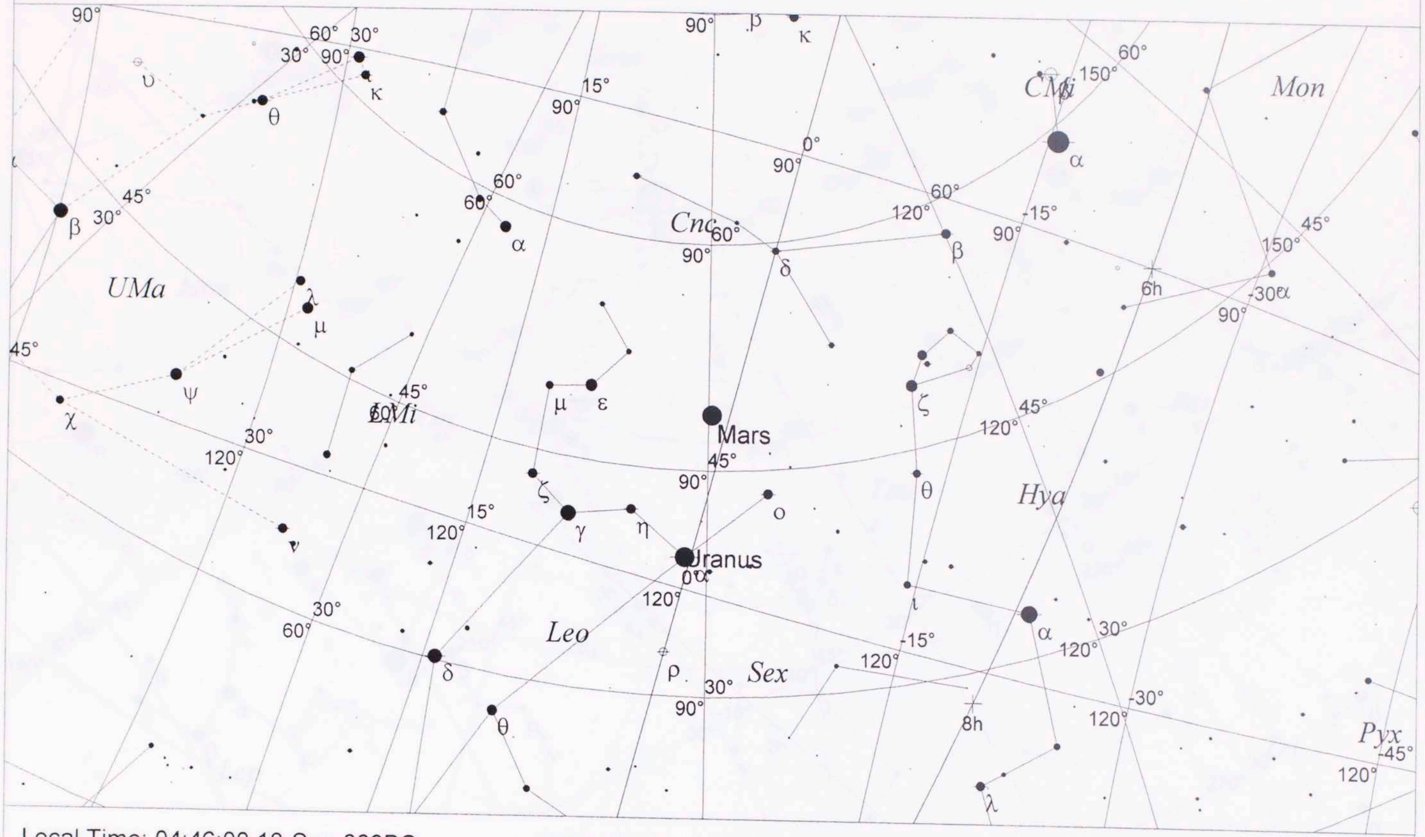


Local Time: 19:06:00 17-Sep-309BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:08:00 17-Sep-309BC
RA: 23h50m18s Dec: -6° 45' Field: 90.0°

Sidereal Time: 18:34:10
Julian Day: 1608821.1722

-308 VI 15

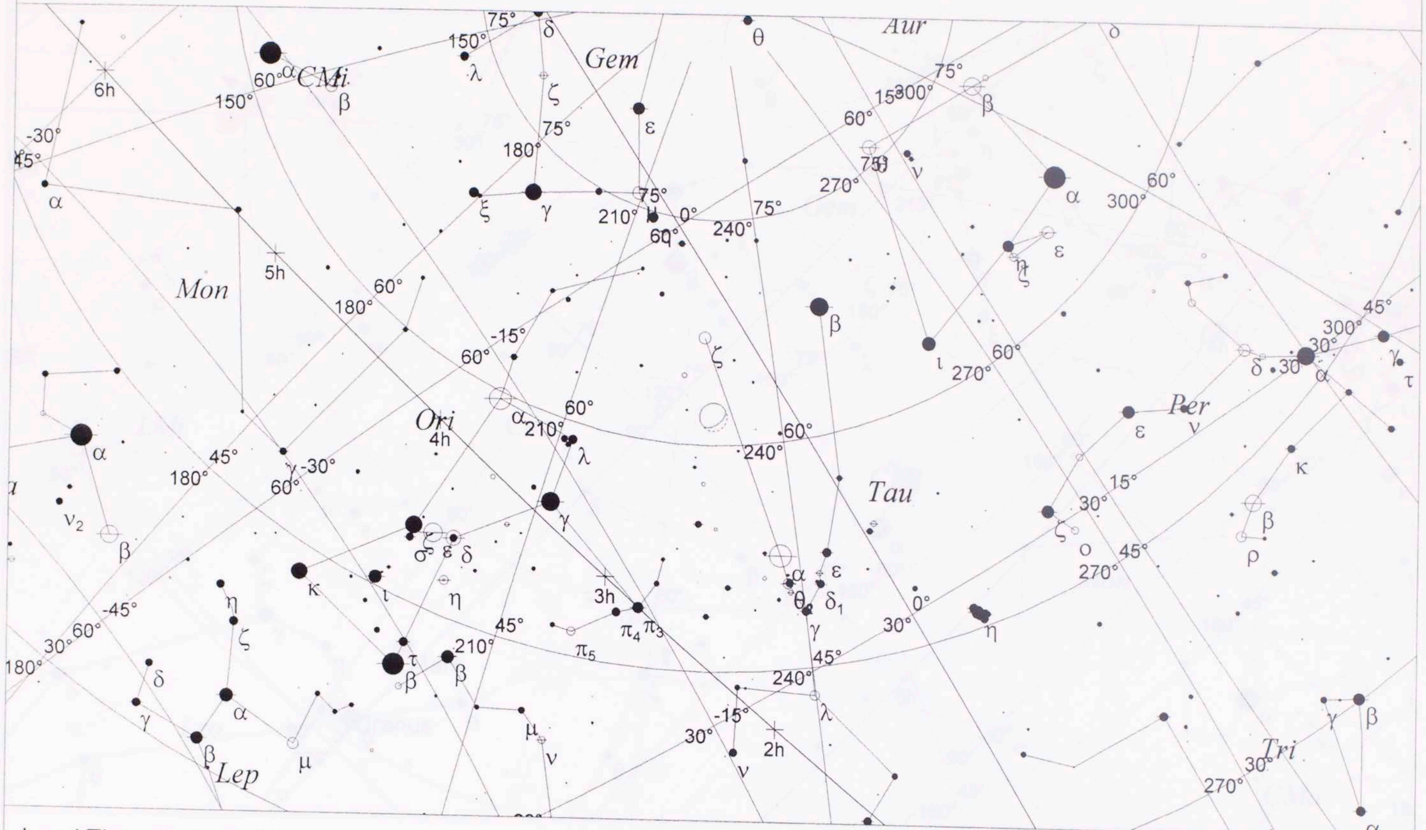


Local Time: 04:46:00 18-Sep-309BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 01:48:00 18-Sep-309BC
RA: 7h20m07s Dec: +23° 36' Field: 90.0°

Sidereal Time: 04:15:45
Julian Day: 1608821.5750

-308 VI 19

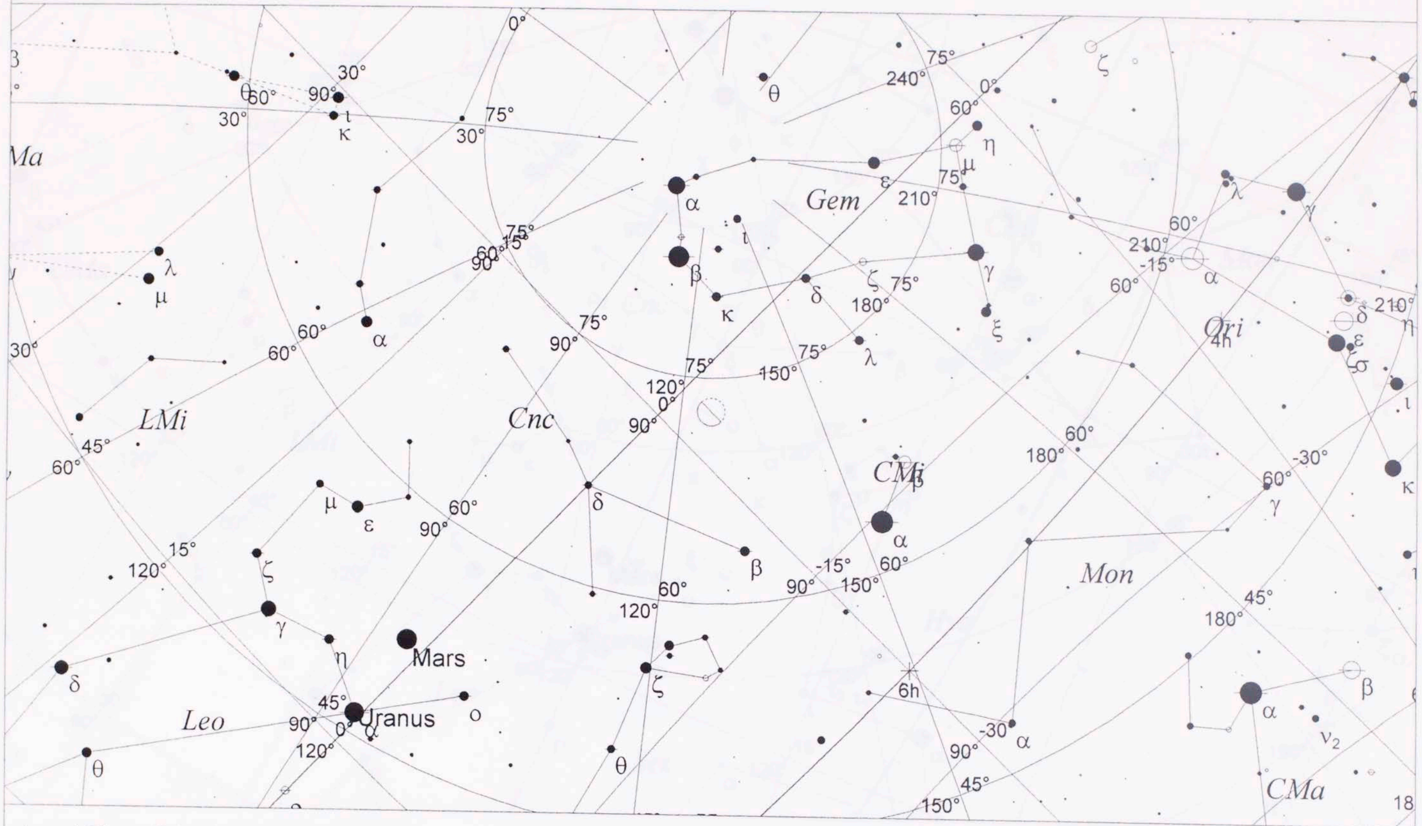


Local Time: 04:49:00 22-Sep-309BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:51:00 22-Sep-309BC
RA: 3h07m08s Dec: +12° 46' Field: 90.0°

Sidereal Time: 04:34:32
Julian Day: 1608825.5771

-308 VI 22

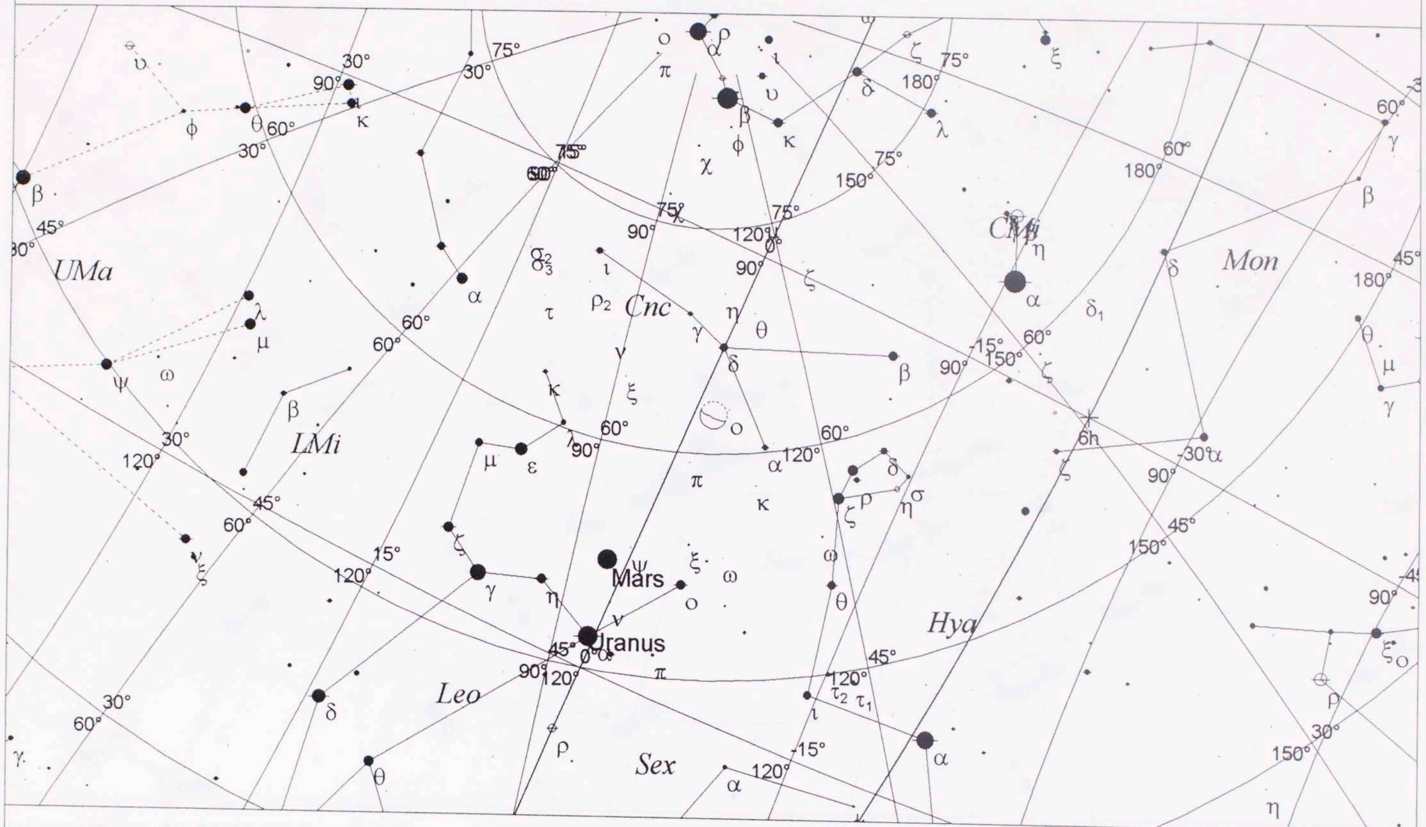


Local Time: 04:52:00 25-Sep-309BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:54:00 25-Sep-309BC
RA: 5h48m19s Dec: +21° 20' Field: 90.0°

Sidereal Time: 04:49:22
Julian Day: 1608828.5792

-308 VI 23

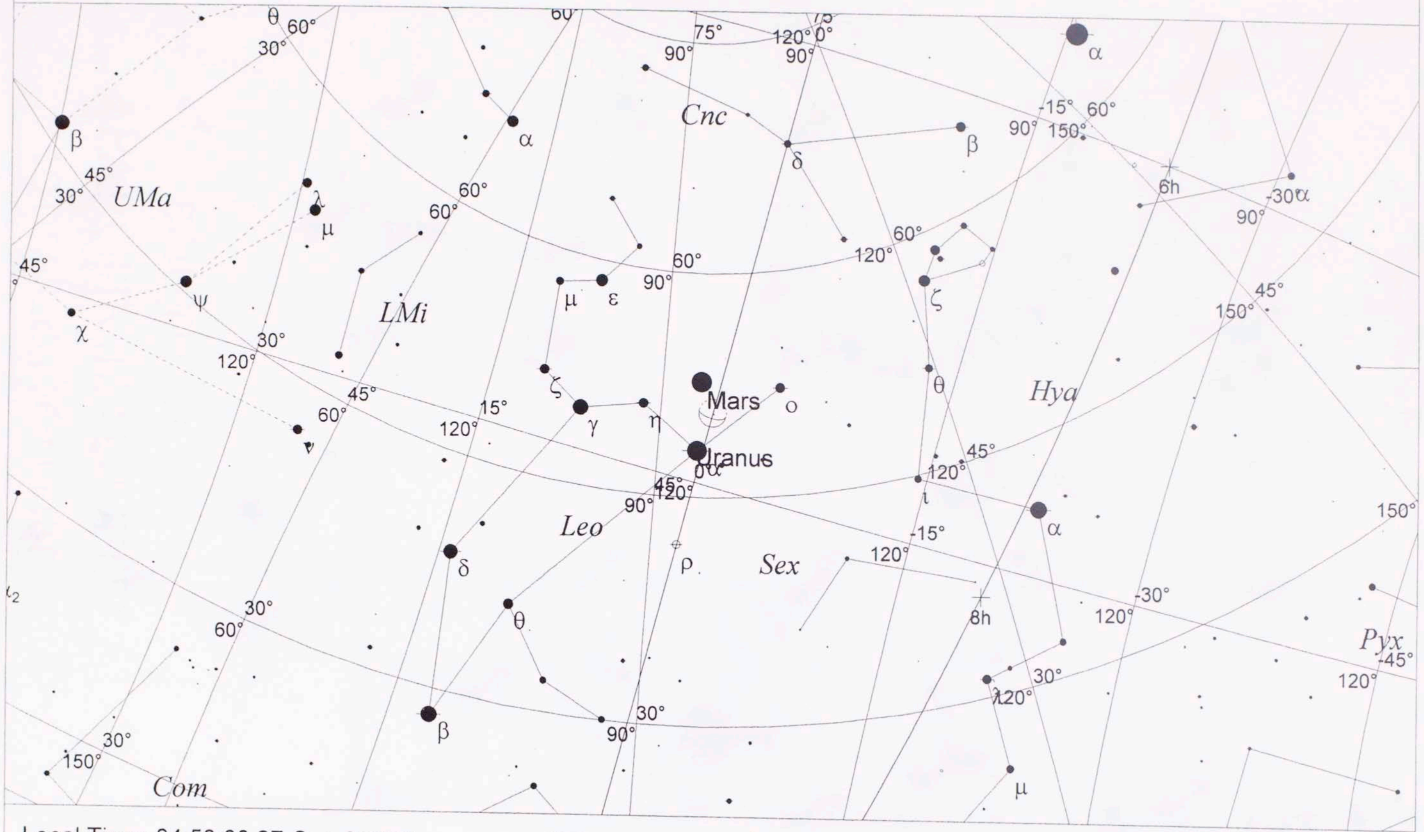


Local Time: 04:52:00 26-Sep-309BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:54:00 26-Sep-309BC
RA: 6h47m42s Dec: +22° 03' Field: 90.0°

Sidereal Time: 04:53:18
Julian Day: 1608829.5792

-308 VI 24

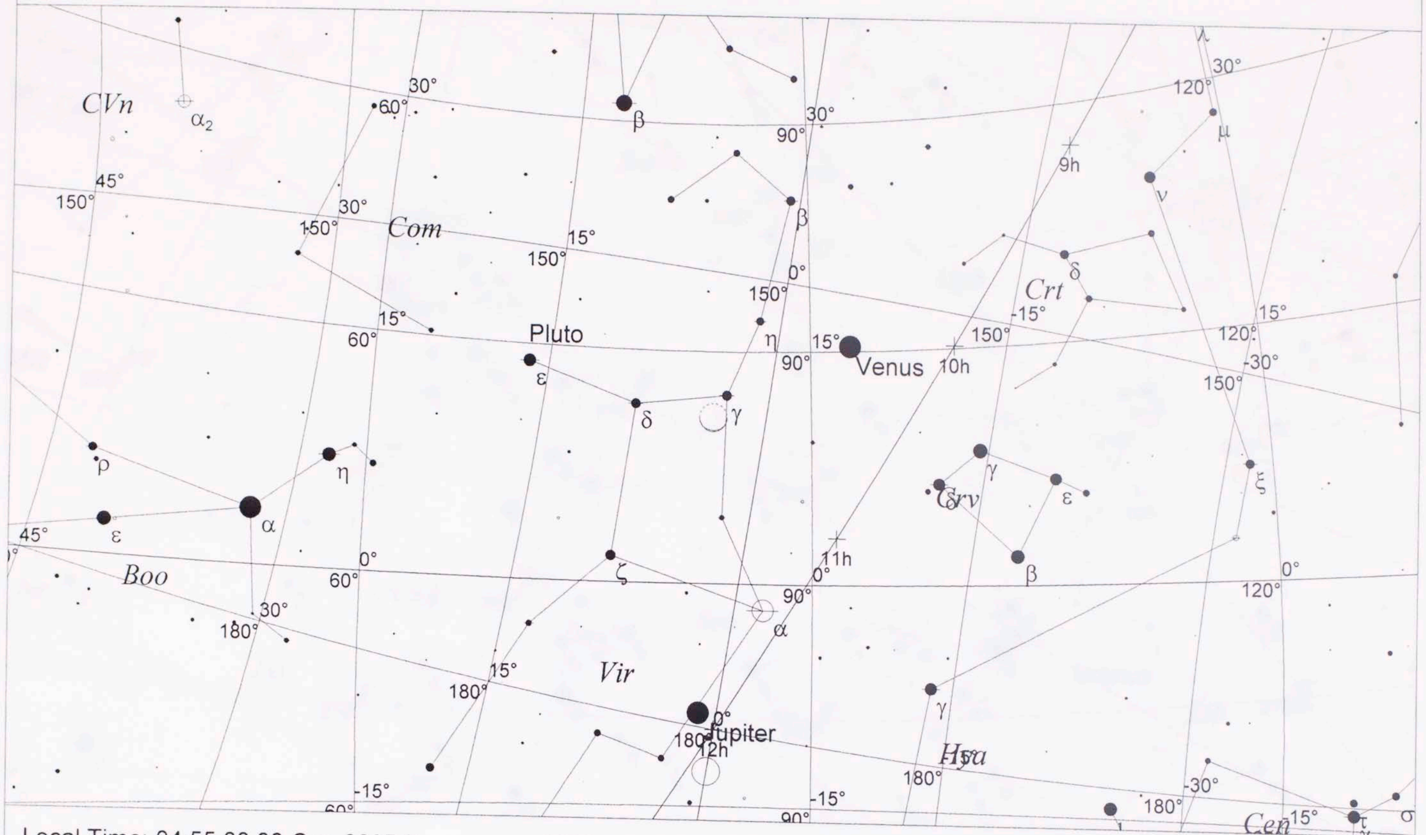


Local Time: 04:53:00 27-Sep-309BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:55:00 27-Sep-309BC
RA: 7h48m49s Dec: +21° 23' Field: 90.0°

Sidereal Time: 04:58:15
Julian Day: 1608830.5799

-308 VI 27

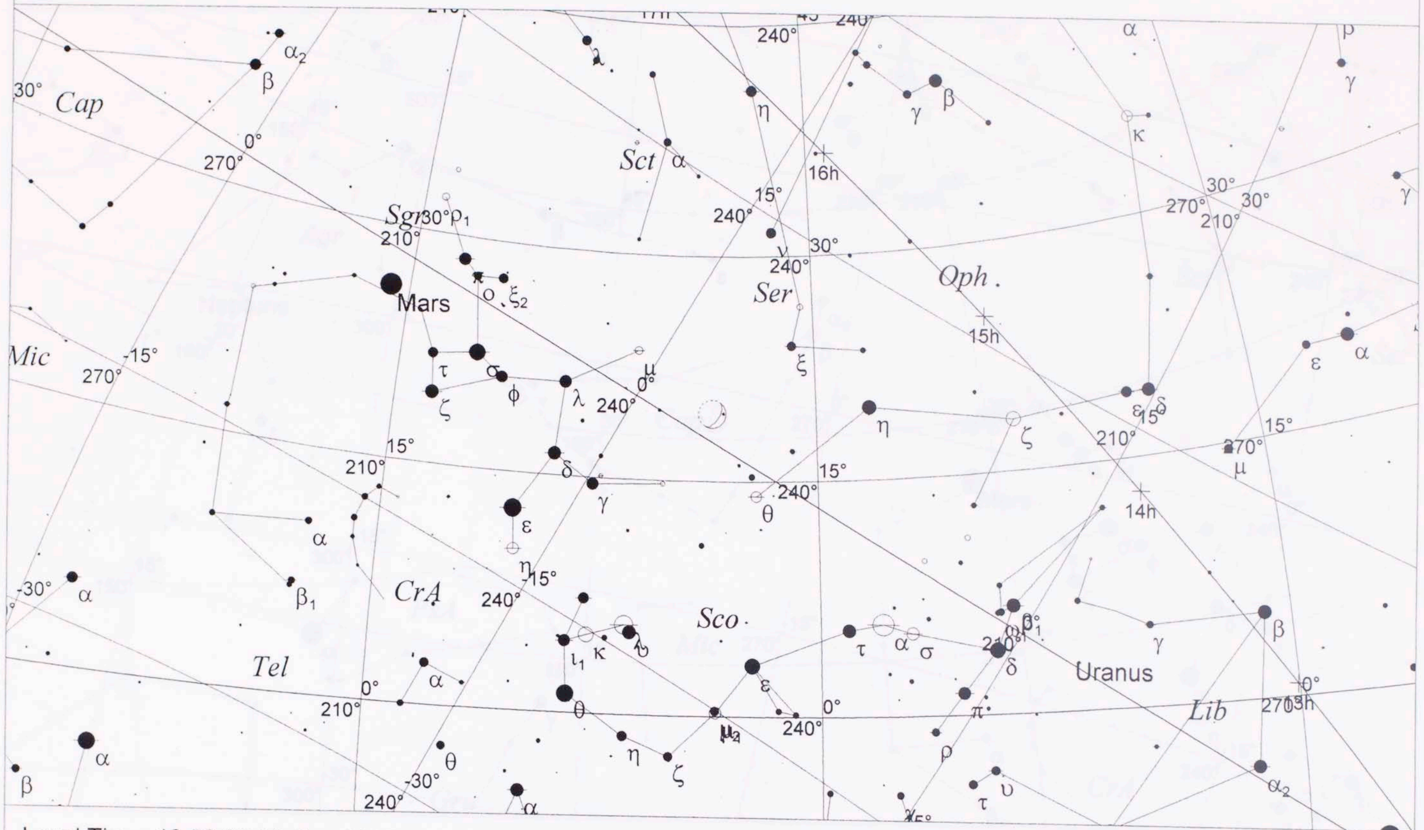


Local Time: 04:55:00 30-Sep-309BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:57:00 30-Sep-309BC
RA: 10h50m28s Dec: +11° 17' Field: 90.0°

Sidereal Time: 05:12:05
Julian Day: 1608833.5812

-288 VII 4

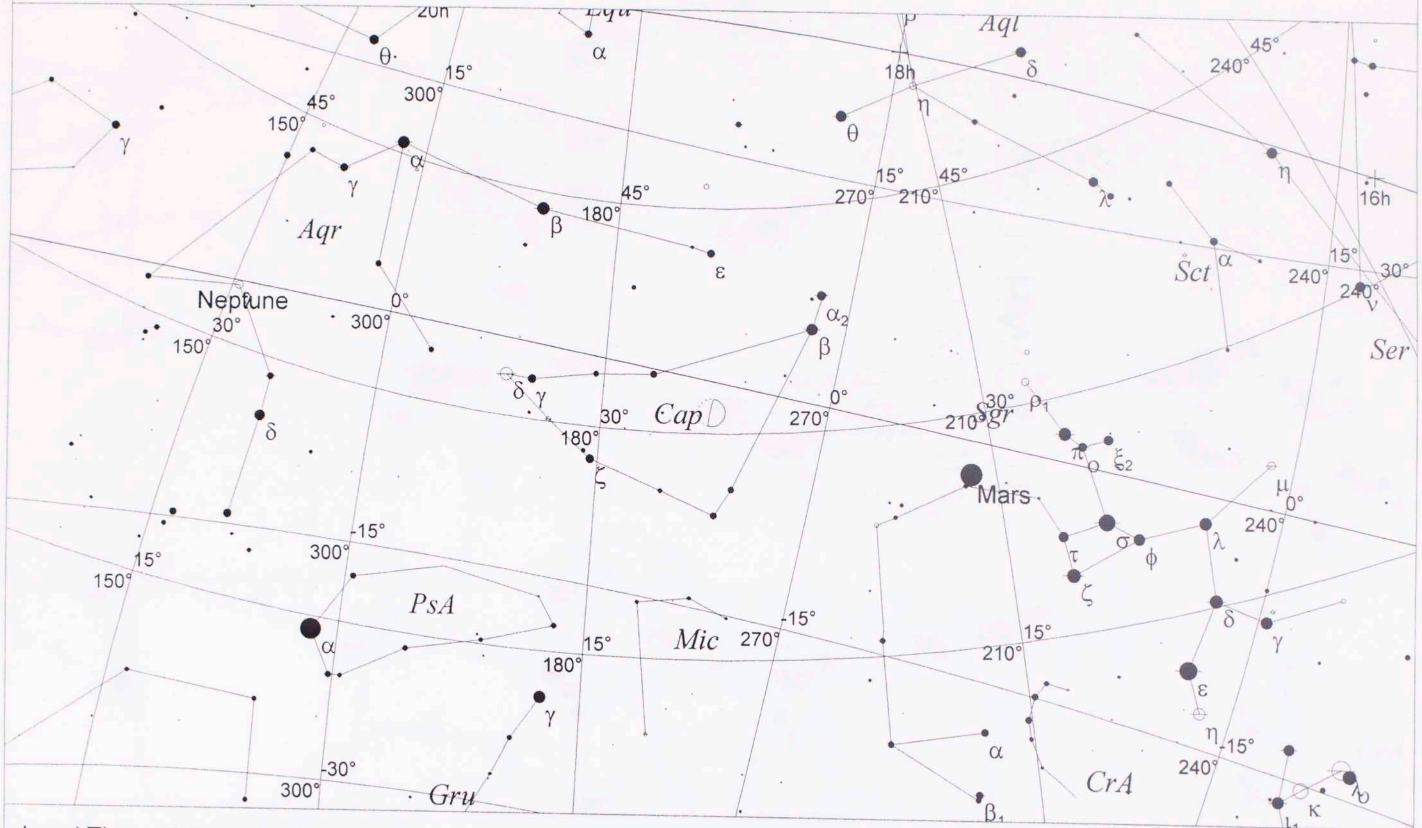


Local Time: 18:59:00 25-Sep-289BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 16:01:00 25-Sep-289BC
RA: 15h32m00s Dec: -17° 41' Field: 90.0°

Sidereal Time: 18:59:17
Julian Day: 1616134.1674

-288 VII 7

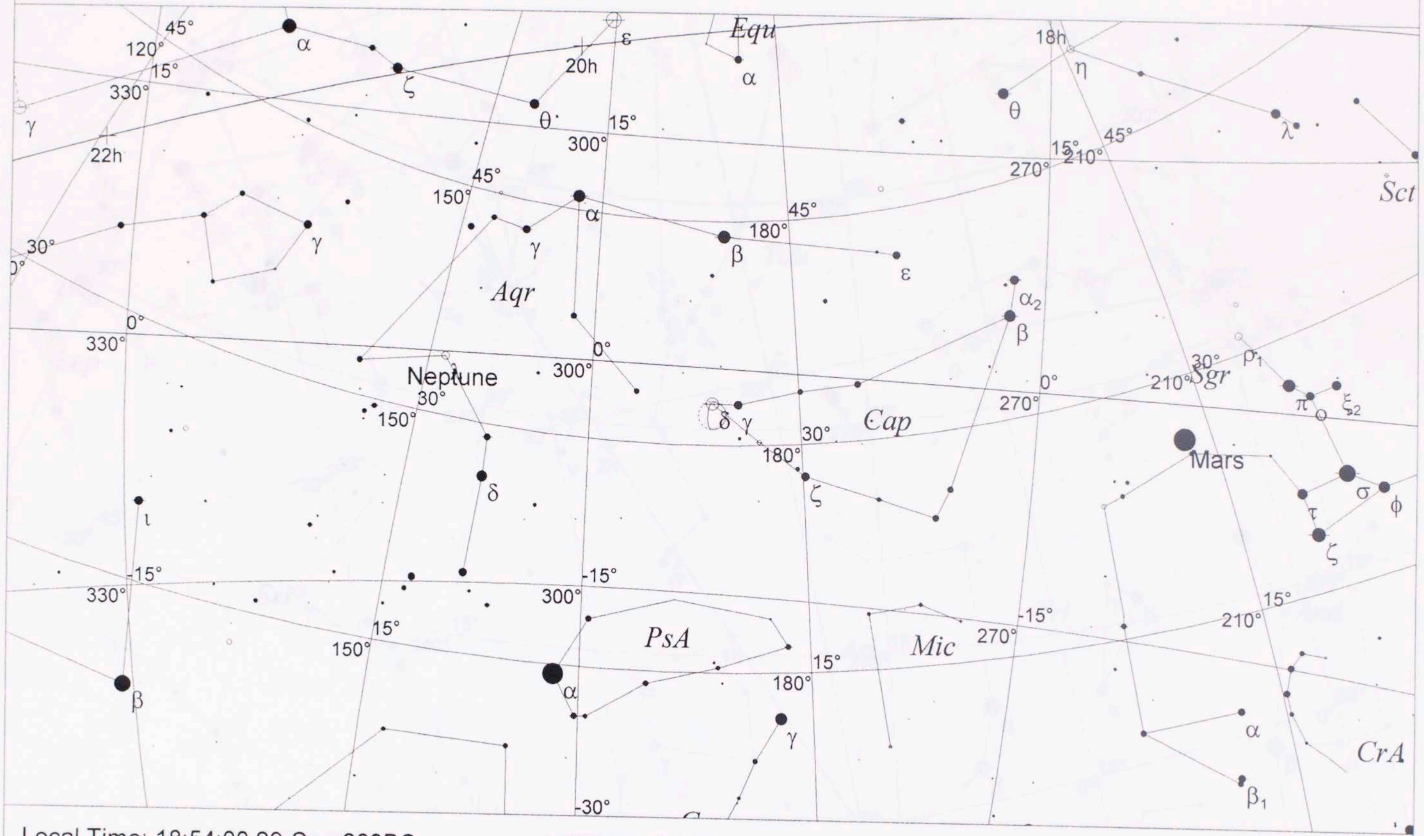


Local Time: 18:55:00 28-Sep-289BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 15:57:00 28-Sep-289BC
RA: 18h34m17s Dec: -25° 32' Field: 90.0°

Sidereal Time: 19:07:06
Julian Day: 1616137.1646

-288 VII 8

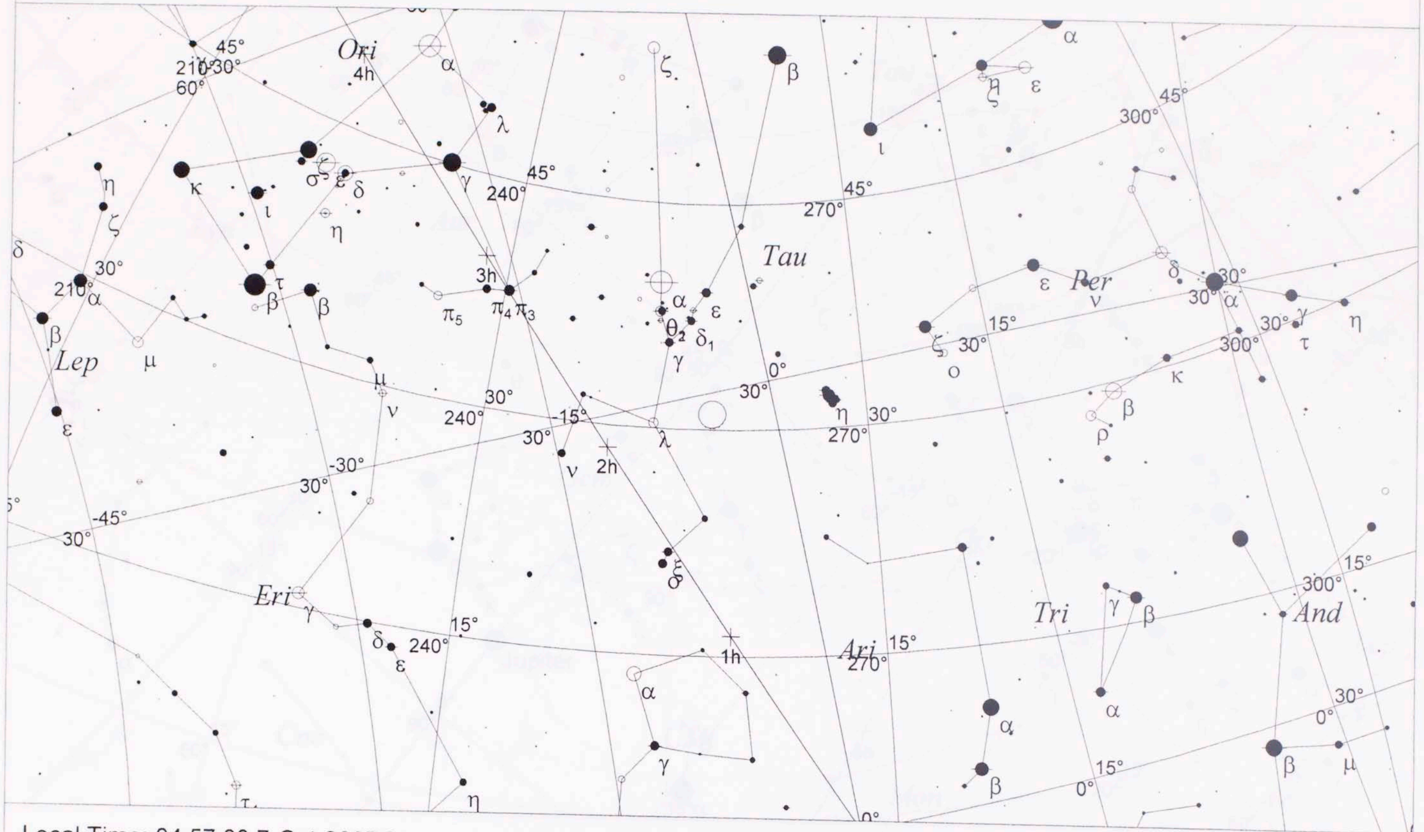


Local Time: 18:54:00 29-Sep-289BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 15:56:00 29-Sep-289BC
RA: 19h36m20s Dec: -25° 05' Field: 90.0°

Sidereal Time: 19:10:02
Julian Day: 1616138.1639

-288 VII 15

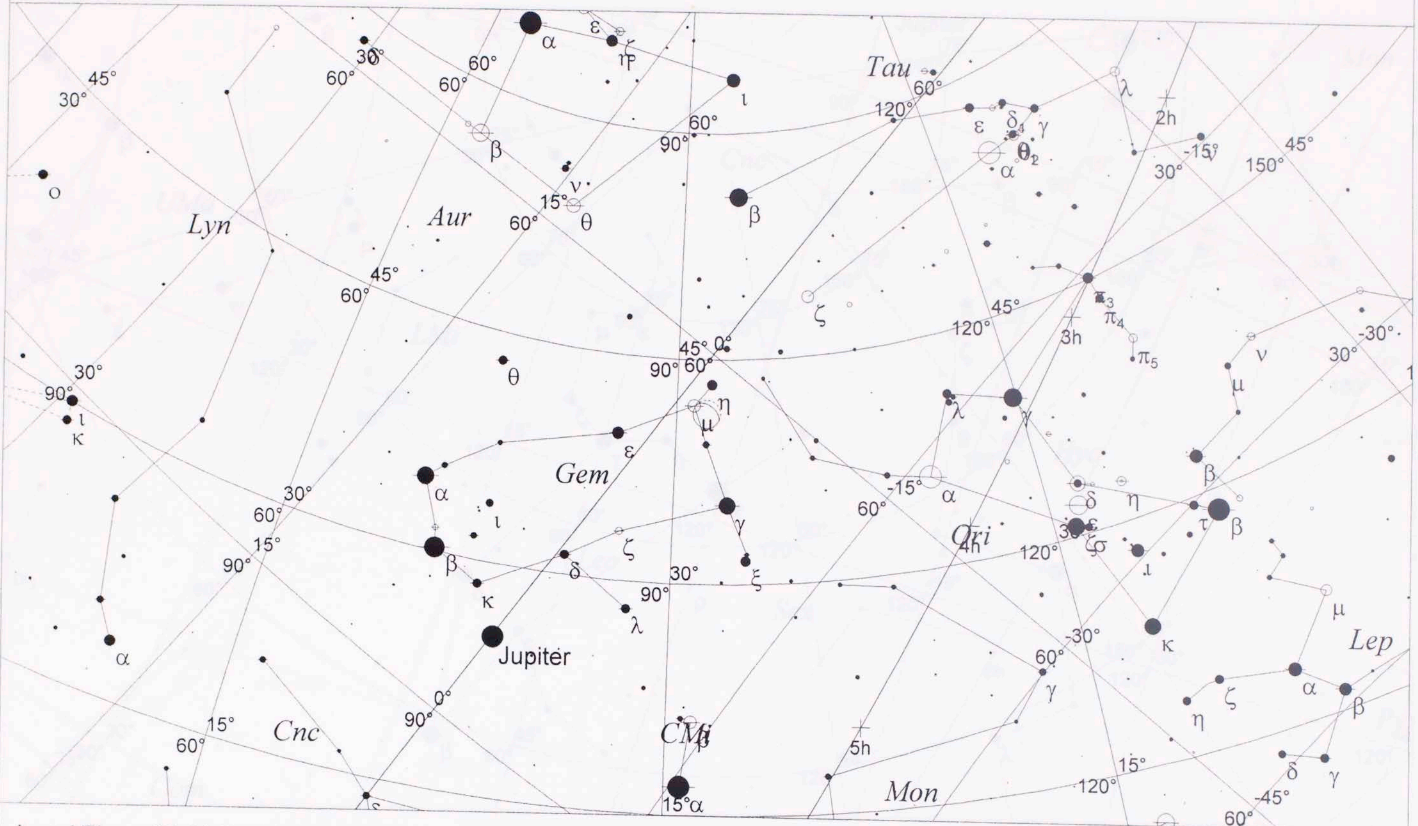


Local Time: 04:57:00 7-Oct-289BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:59:00 7-Oct-289BC
RA: 1h52m01s Dec: +7° 09' Field: 90.0°

Sidereal Time: 05:42:17
Julian Day: 1616145.5826

-288 VII 18

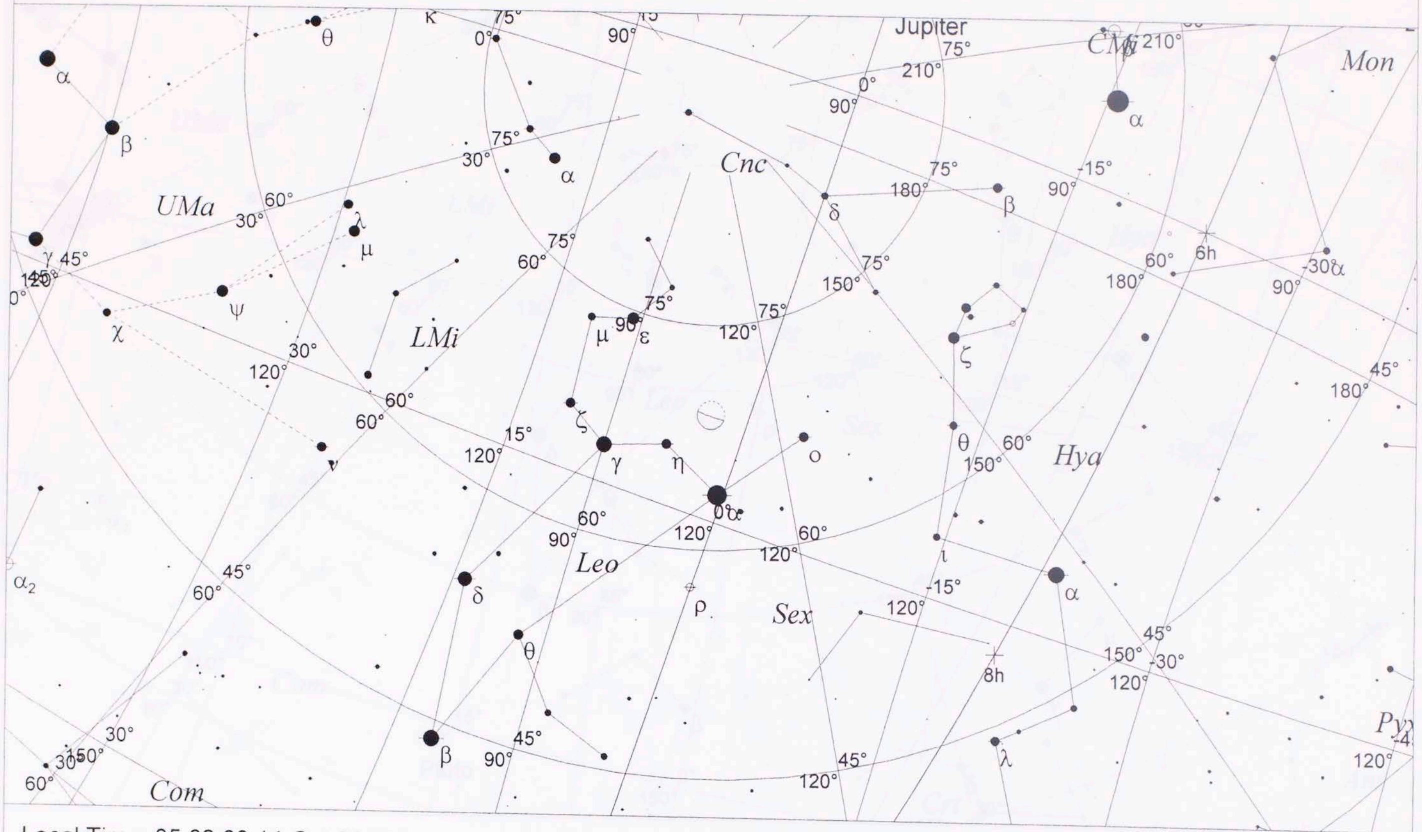


Local Time: 23:41:00 9-Oct-289BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 20:43:00 9-Oct-289BC
RA: 4h07m03s Dec: +19° 01' Field: 90.0°

Sidereal Time: 00:37:15
Julian Day: 1616148.3632

-288 VII 22

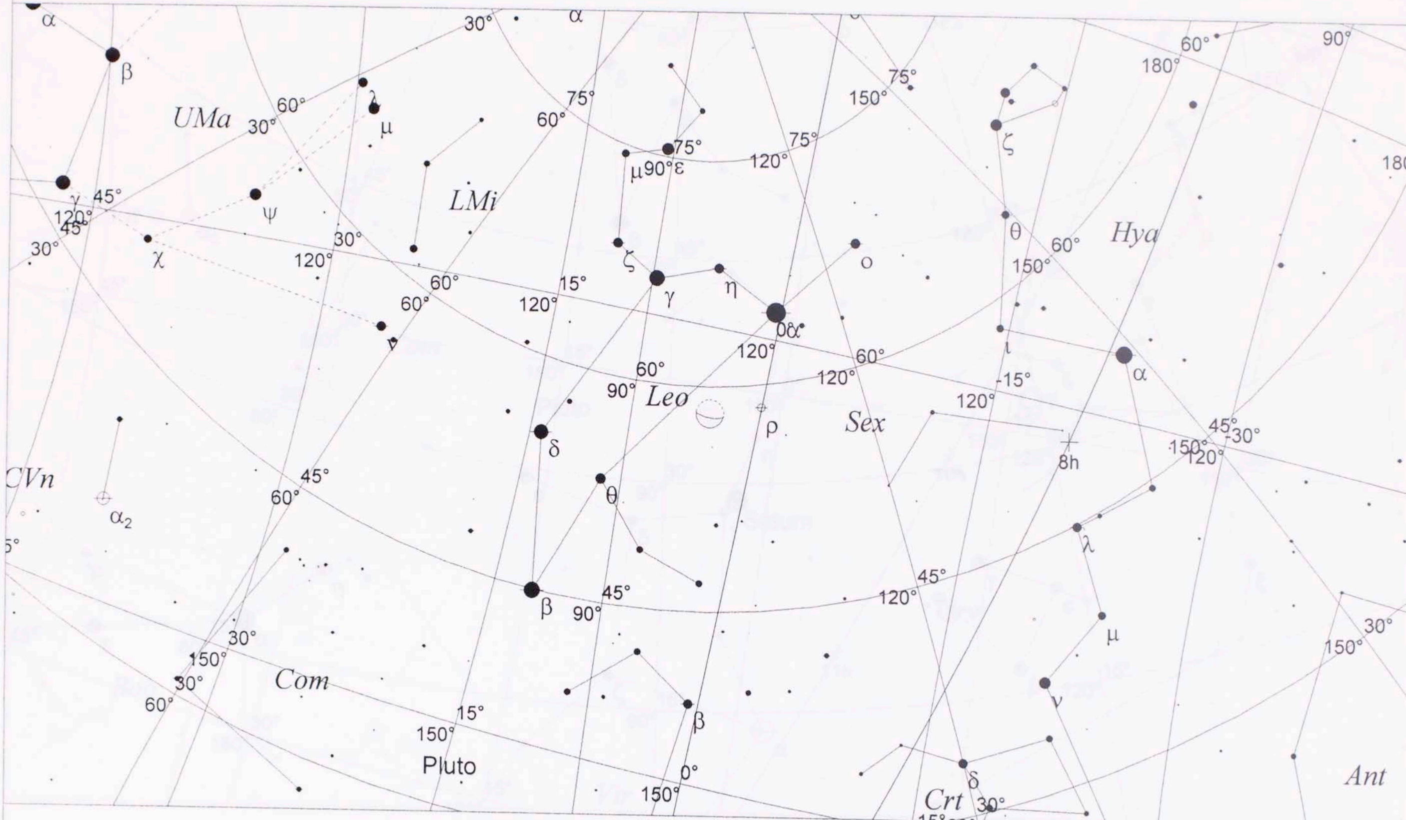


Local Time: 05:02:00 14-Oct-289BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:04:00 14-Oct-289BC
RA: 7h42m33s Dec: +24° 09' Field: 90.0°

Sidereal Time: 06:14:54
Julian Day: 1616152.5861

-288 VII 23

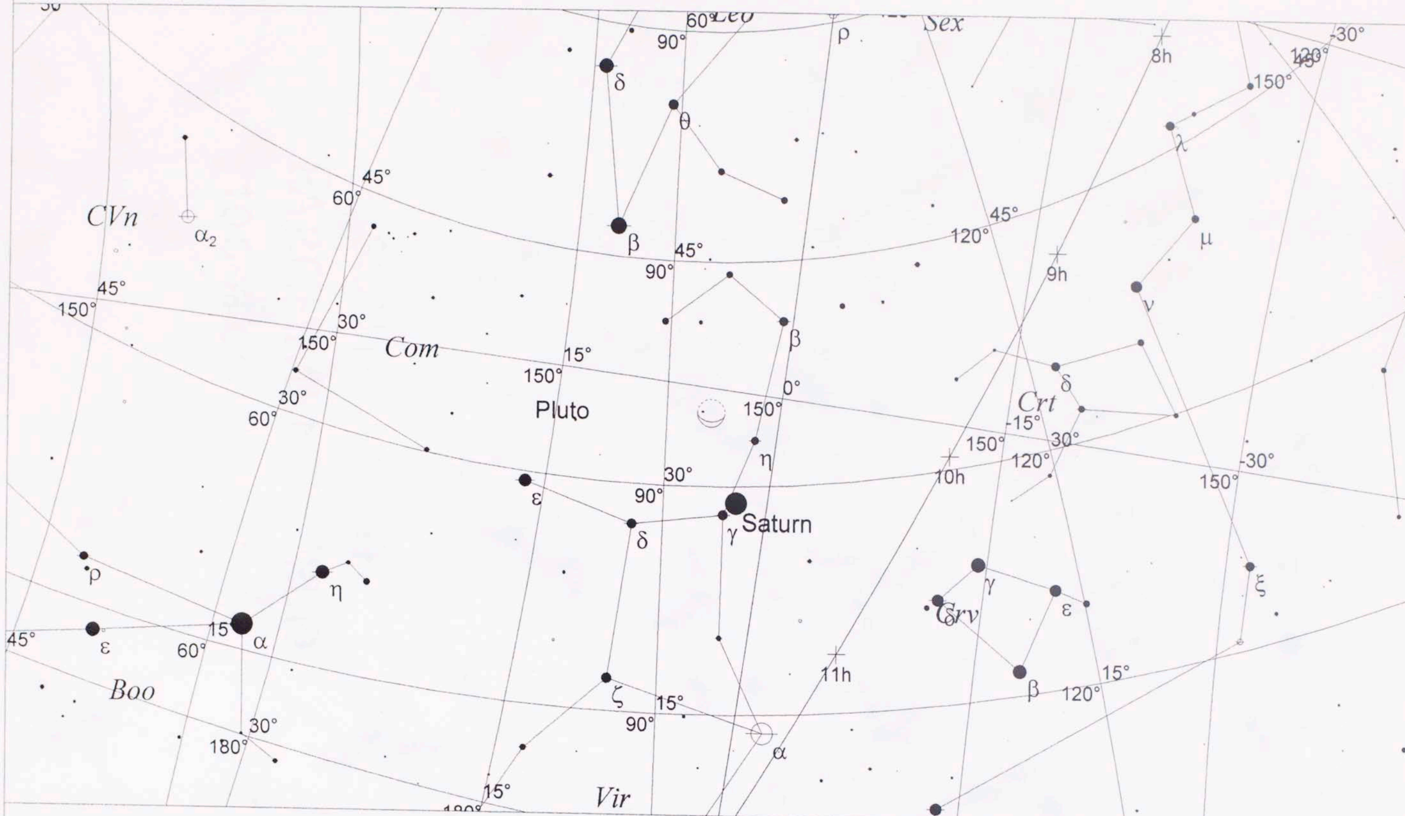


Local Time: 05:03:00 15-Oct-289BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:05:00 15-Oct-289BC
RA: 8h36m16s Dec: +22° 20' Field: 90.0°

Sidereal Time: 06:19:51
Julian Day: 1616153.5868

-288 VII 25

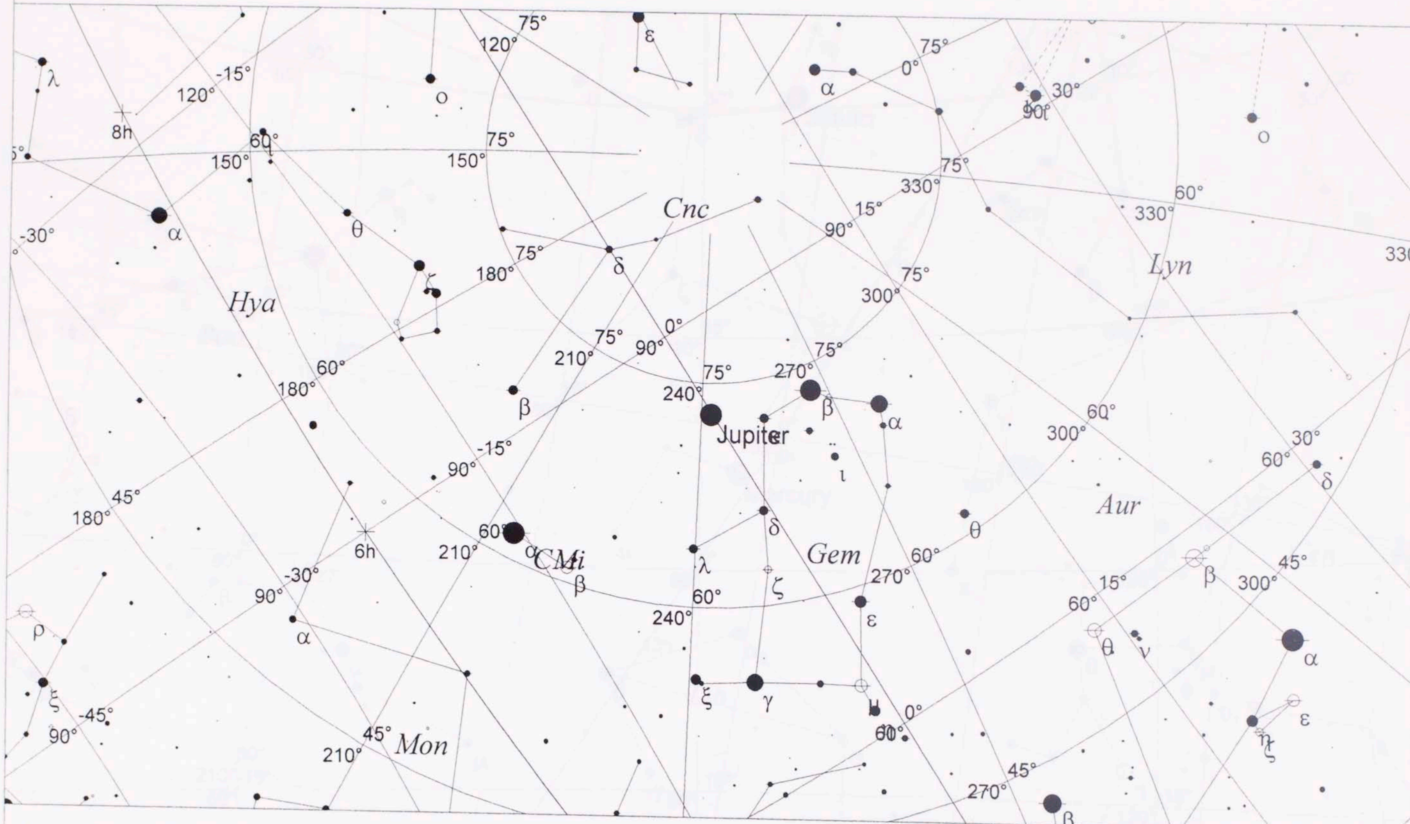


Local Time: 05:05:00 17-Oct-289BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 02:07:00 17-Oct-289BC
RA: 10h21m56s Dec: +15° 19' Field: 90.0°

Sidereal Time: 06:29:44
Julian Day: 1616155.5882

-288 VII 27

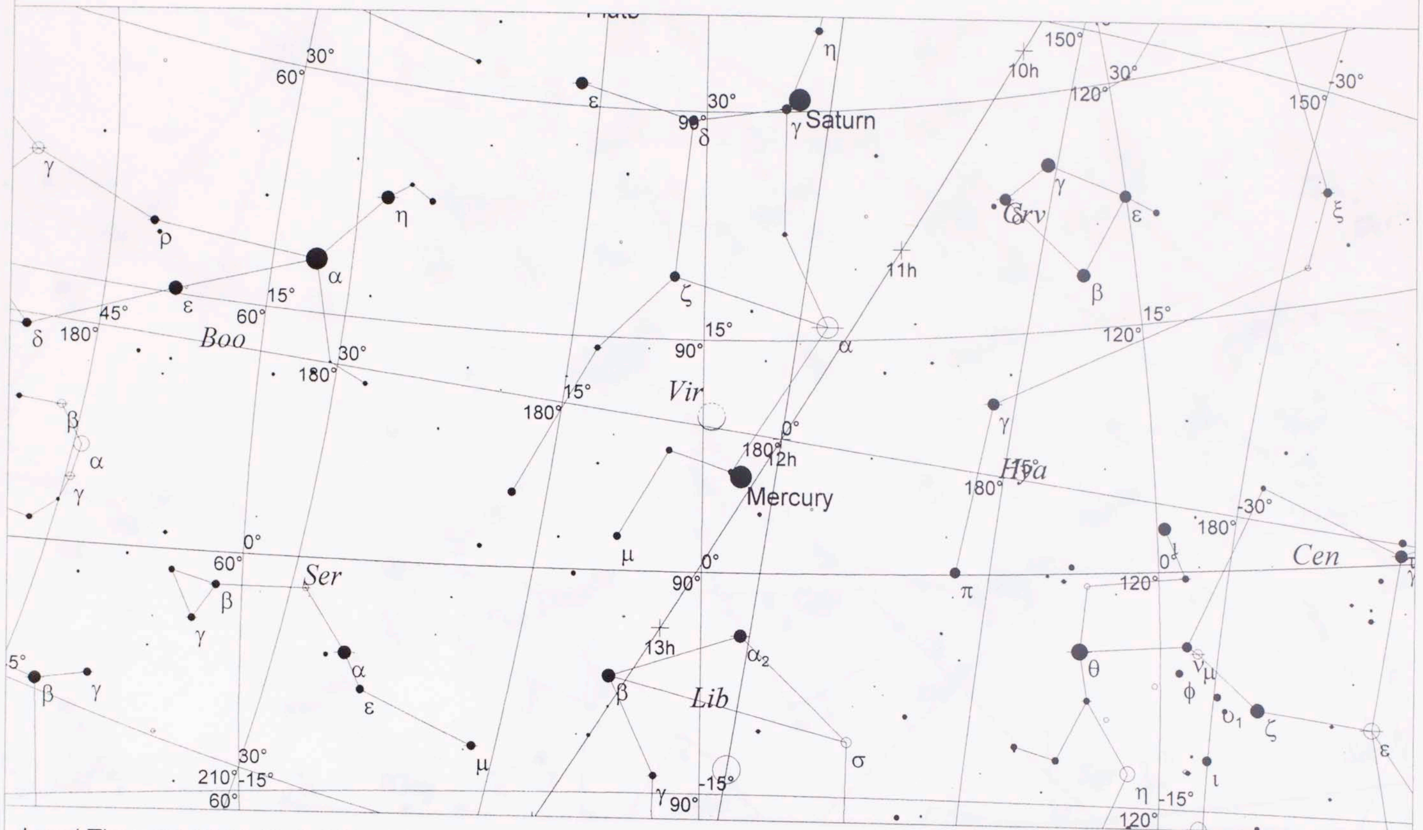


Local Time: 05:07:00 19-Oct-289BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:09:00 19-Oct-289BC
RA: 5h33m45s Dec: +23° 30' Field: 90.0°

Sidereal Time: 06:39:38
Julian Day: 1616157.5896

-288 VII 27

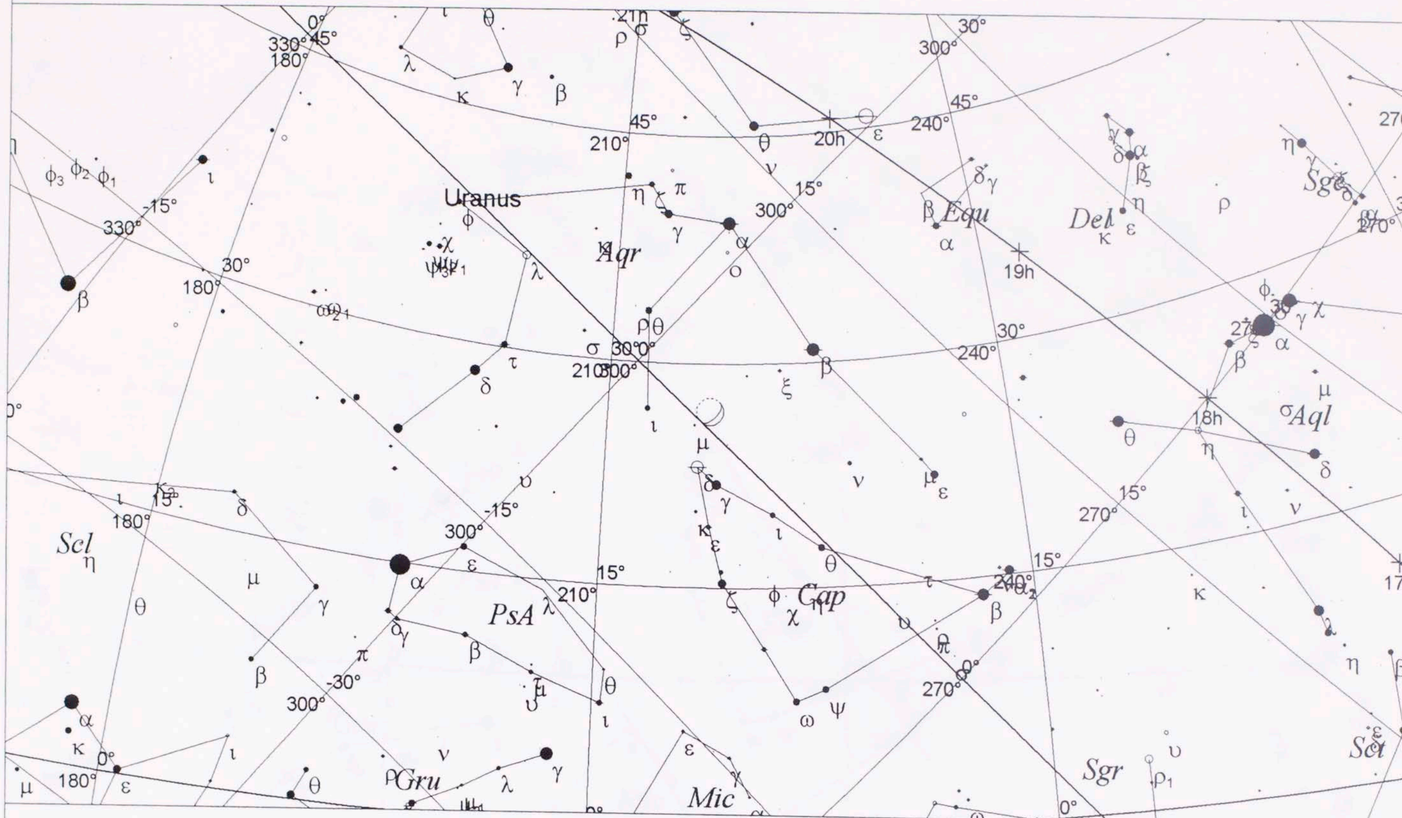


Local Time: 05:07:00 19-Oct-289BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:09:00 19-Oct-289BC
RA: 12h05m15s Dec: +4° 47' Field: 90.0°

Sidereal Time: 06:39:38
Julian Day: 1616157.5896

-261 IX 3

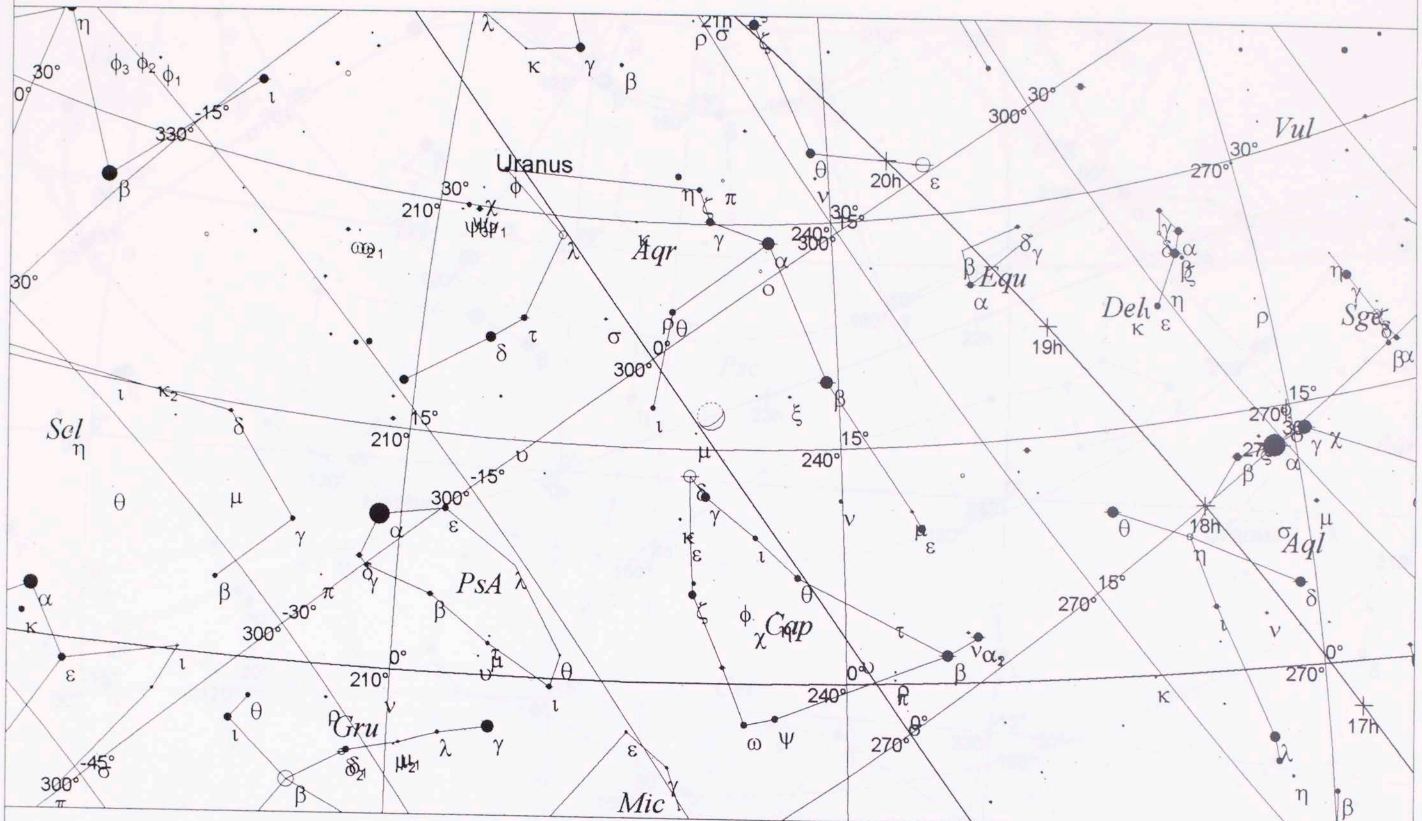


Local Time: 18:08:00 25-Nov-262BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 15:10:00 25-Nov-262BC
RA: 19h43m30s Dec: -20° 38' Field: 90.0°

Sidereal Time: 22:06:32
Julian Day: 1626056.1319

-261 IX 3

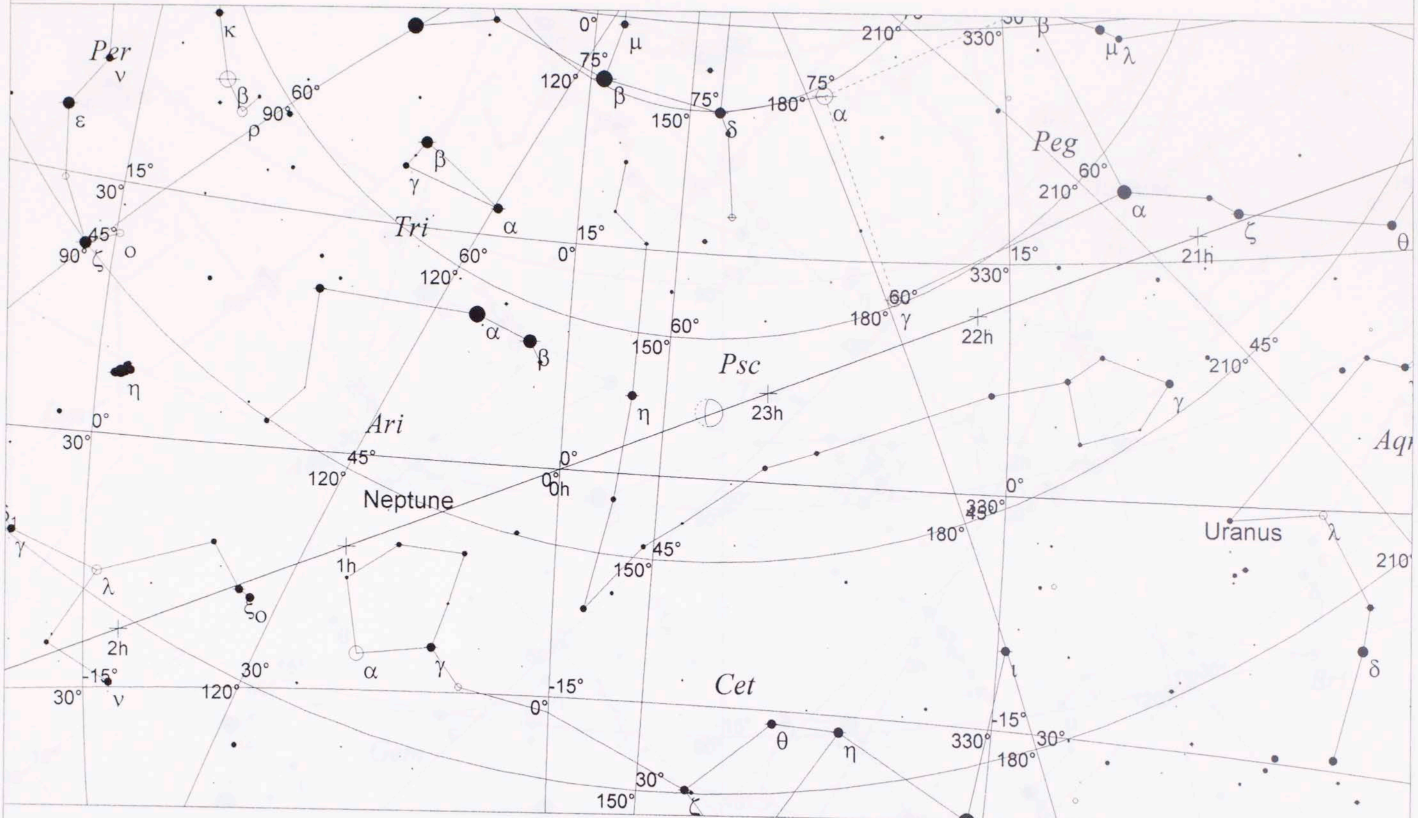


Local Time: 19:16:00 25-Nov-262BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:18:00 25-Nov-262BC
RA: 19h45m35s Dec: -20° 24' Field: 90.0°

Sidereal Time: 23:14:43
Julian Day: 1626056.1792

-261 IX 7

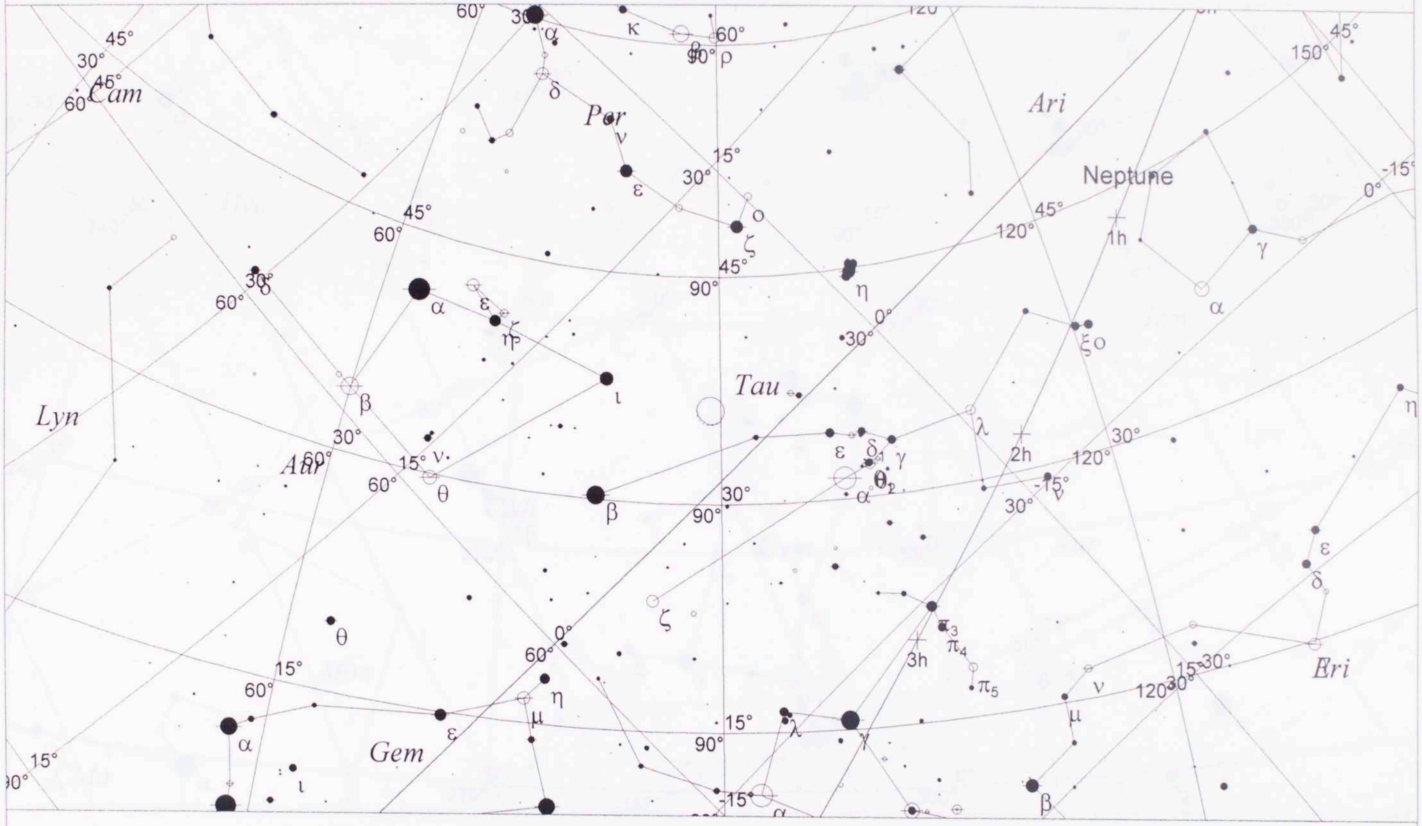


Local Time: 18:07:00 29-Nov-262BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 15:09:00 29-Nov-262BC
RA: 23h16m53s Dec: +0° 07' Field: 90.0°

Sidereal Time: 22:21:18
Julian Day: 1626060.1312

-261 IX 11

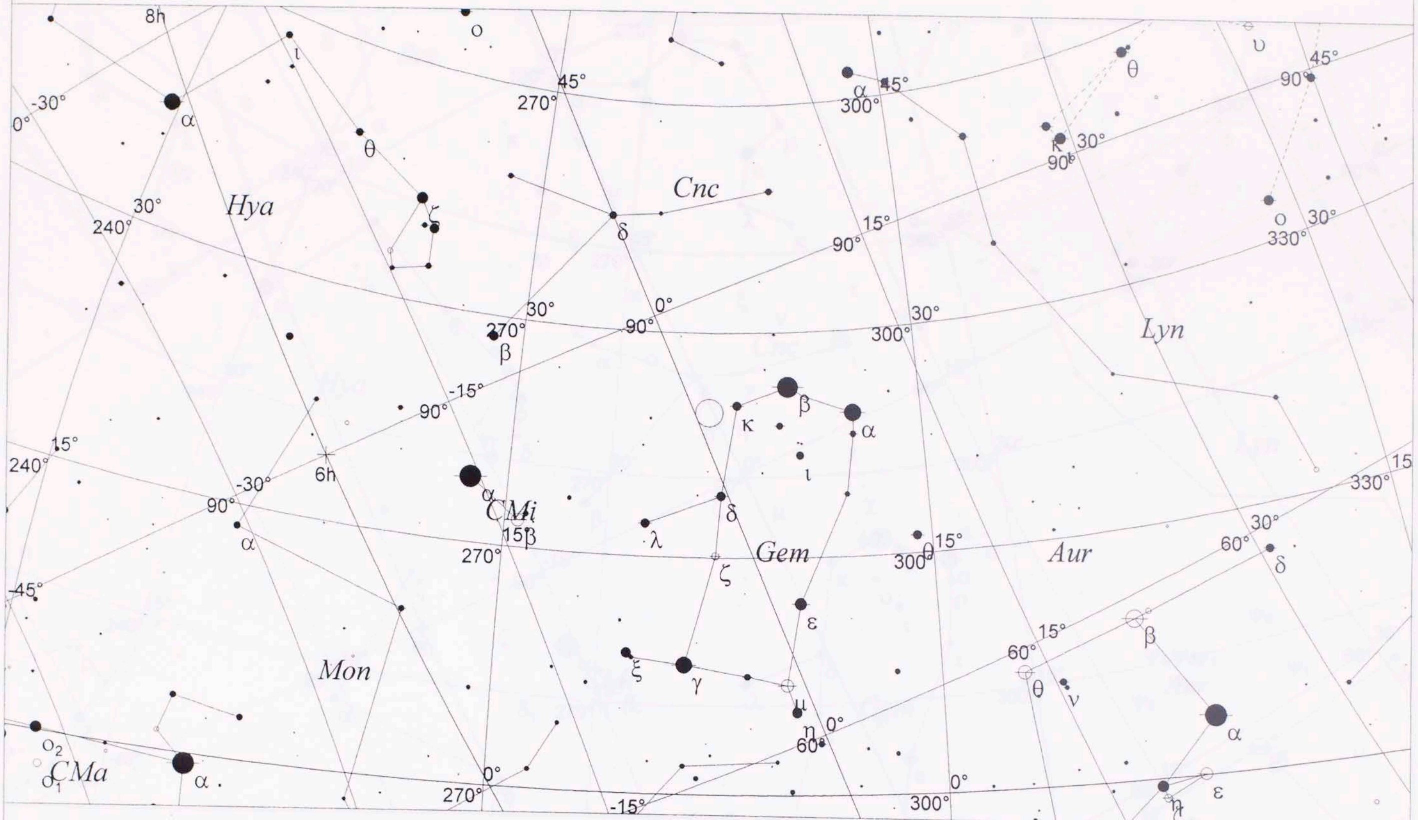


Local Time: 18:07:00 3-Dec-262BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 15:09:00 3-Dec-262BC
RA: 2h31m58s Dec: +19° 08' Field: 90.0°

Sidereal Time: 22:37:04
Julian Day: 1626064.1312

-261 IX 14

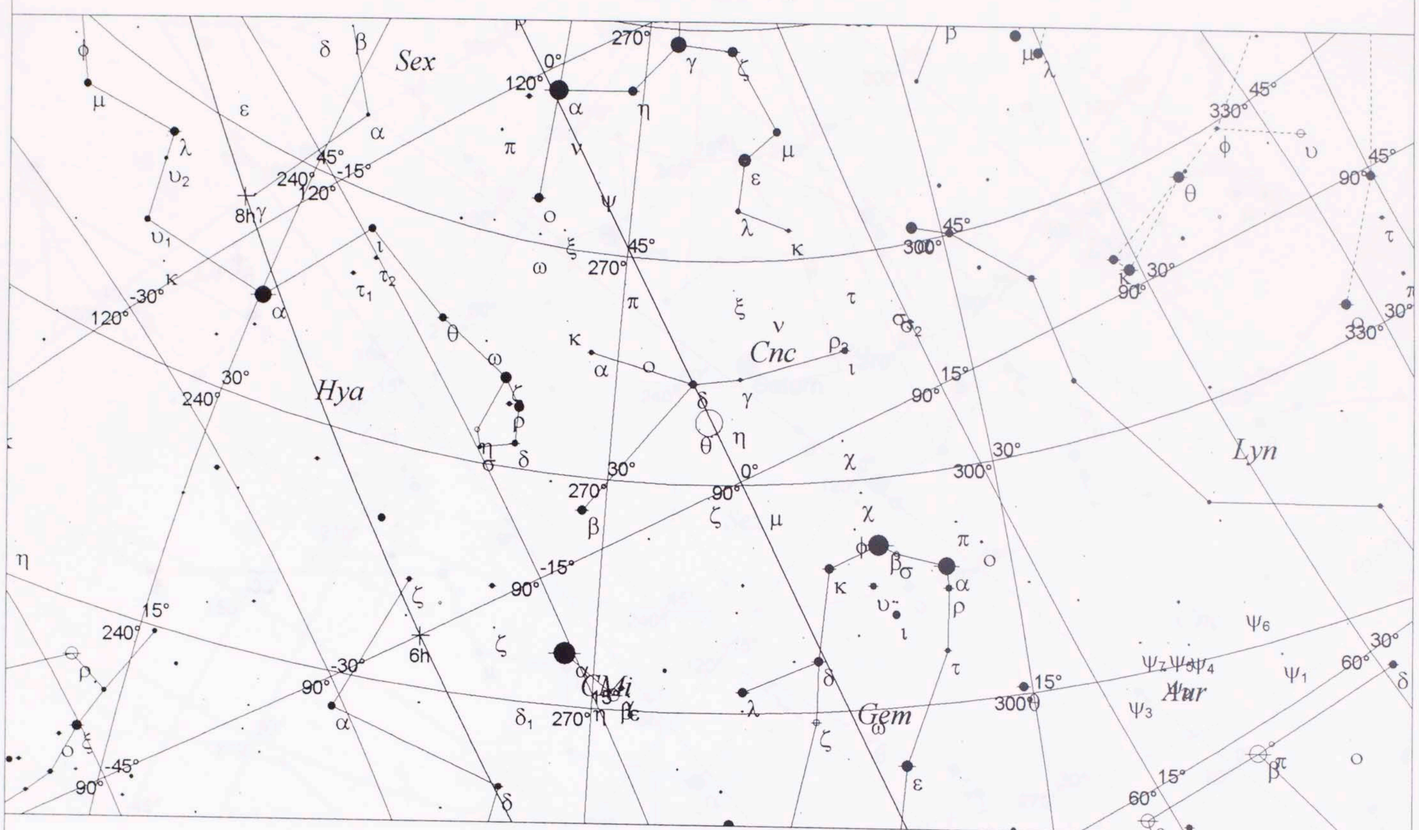


Local Time: 05:45:00 7-Dec-262BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:47:00 7-Dec-262BC
RA: 5h27m15s Dec: +24° 25' Field: 90.0°

Sidereal Time: 10:28:48
Julian Day: 1626067.6160

-261 IX 15

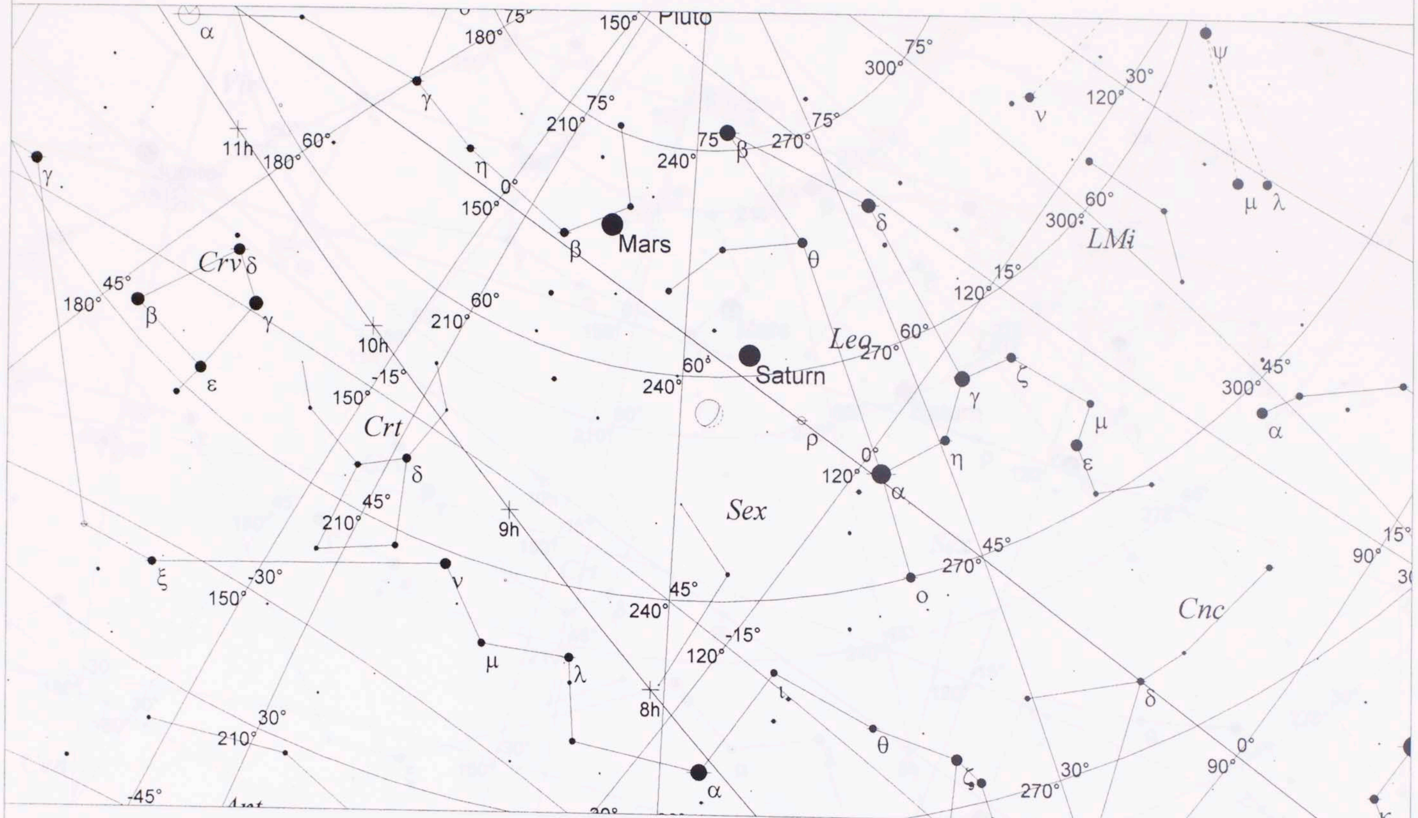


Local Time: 05:45:00 8-Dec-262BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:47:00 8-Dec-262BC
RA: 6h19m29s Dec: +23° 28' Field: 90.0°

Sidereal Time: 10:32:45
Julian Day: 1626068.6160

-261 IX 18

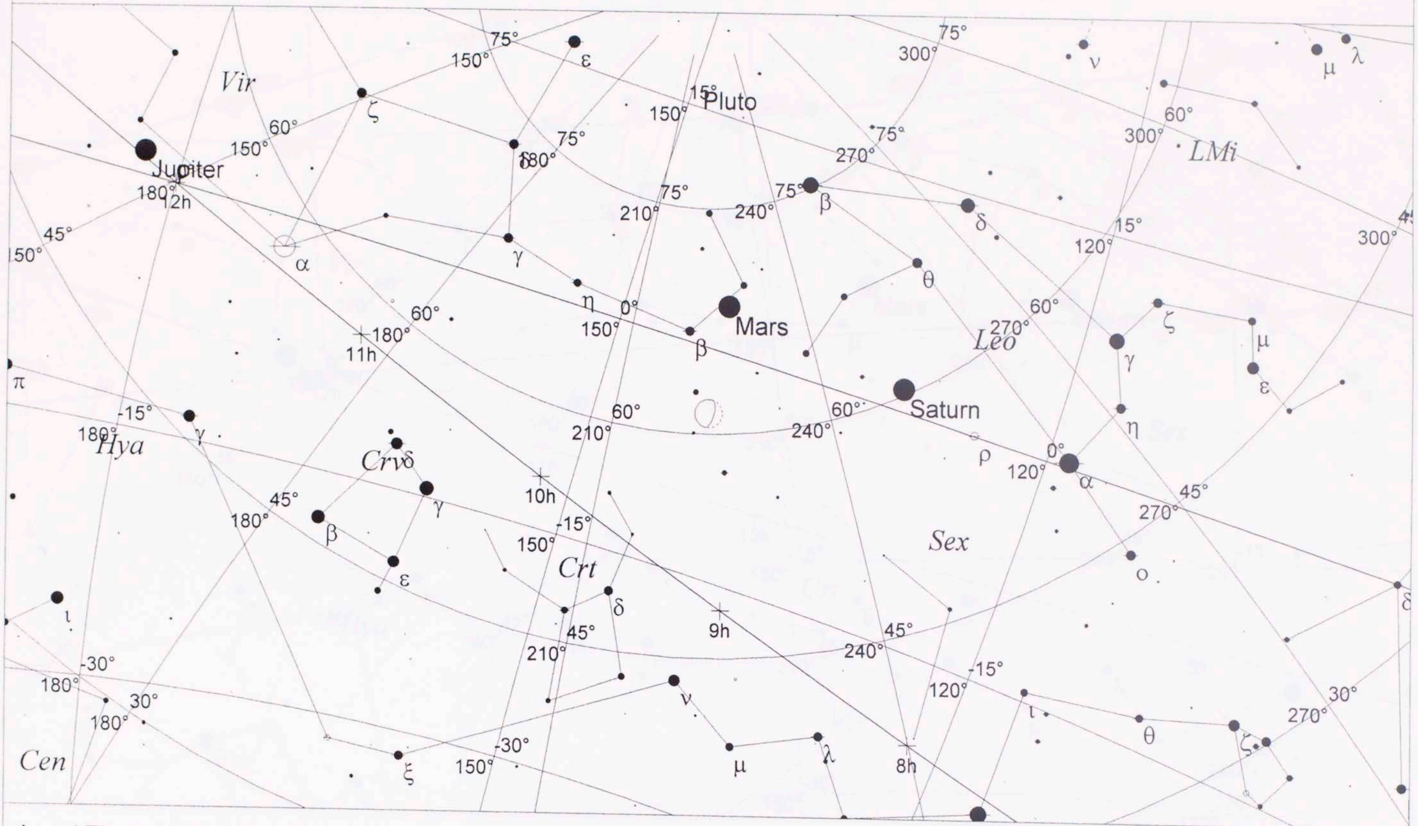


Local Time: 05:47:00 11-Dec-262BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:49:00 11-Dec-262BC
RA: 8h47m25s Dec: +14° 40' Field: 90.0°

Sidereal Time: 10:46:35
Julian Day: 1626071.6174

-261 IX 19

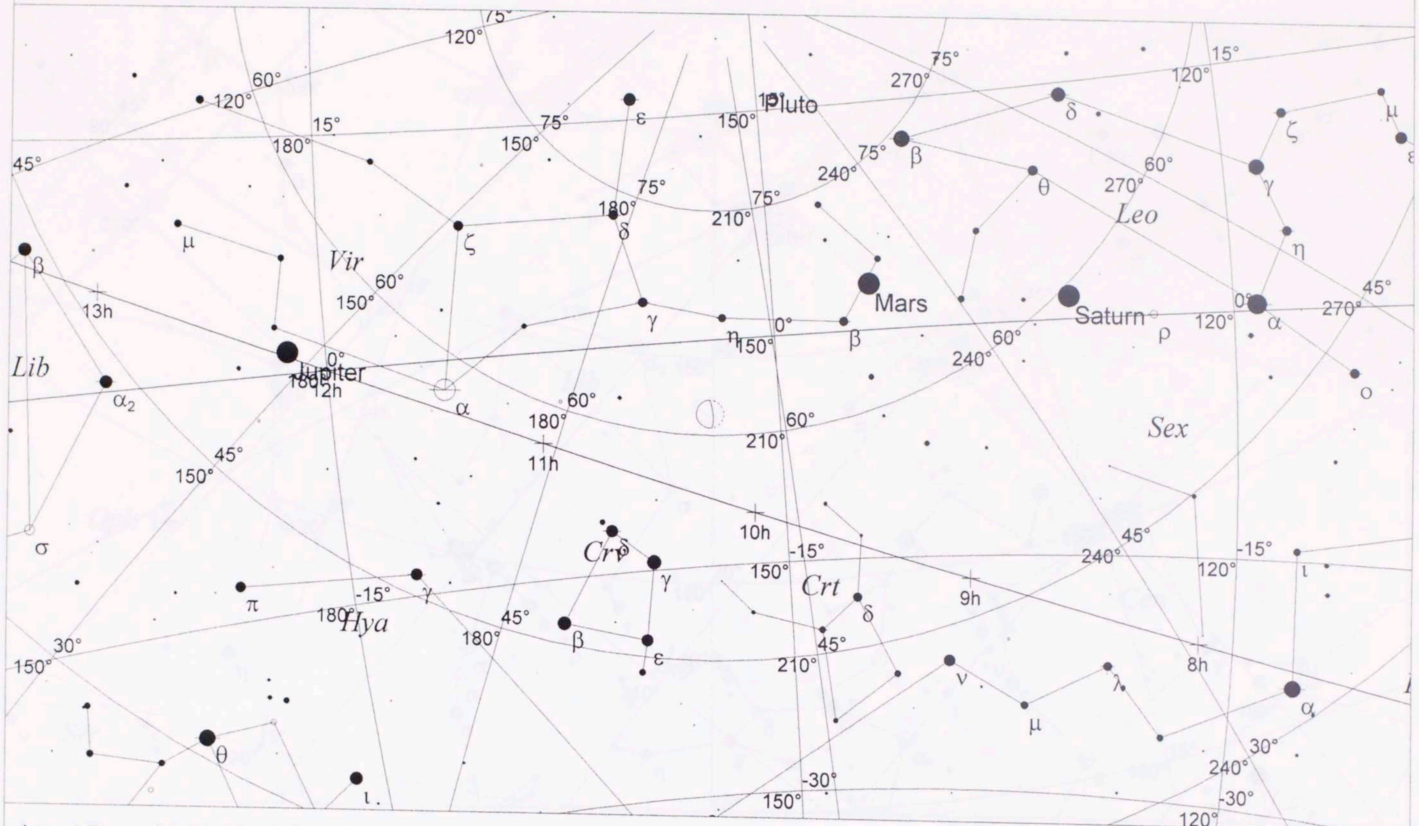


Local Time: 05:48:00 12-Dec-262BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:50:00 12-Dec-262BC
RA: 9h33m44s Dec: +10° 14' Field: 90.0°

Sidereal Time: 10:51:32
Julian Day: 1626072.6181

-261 IX 20

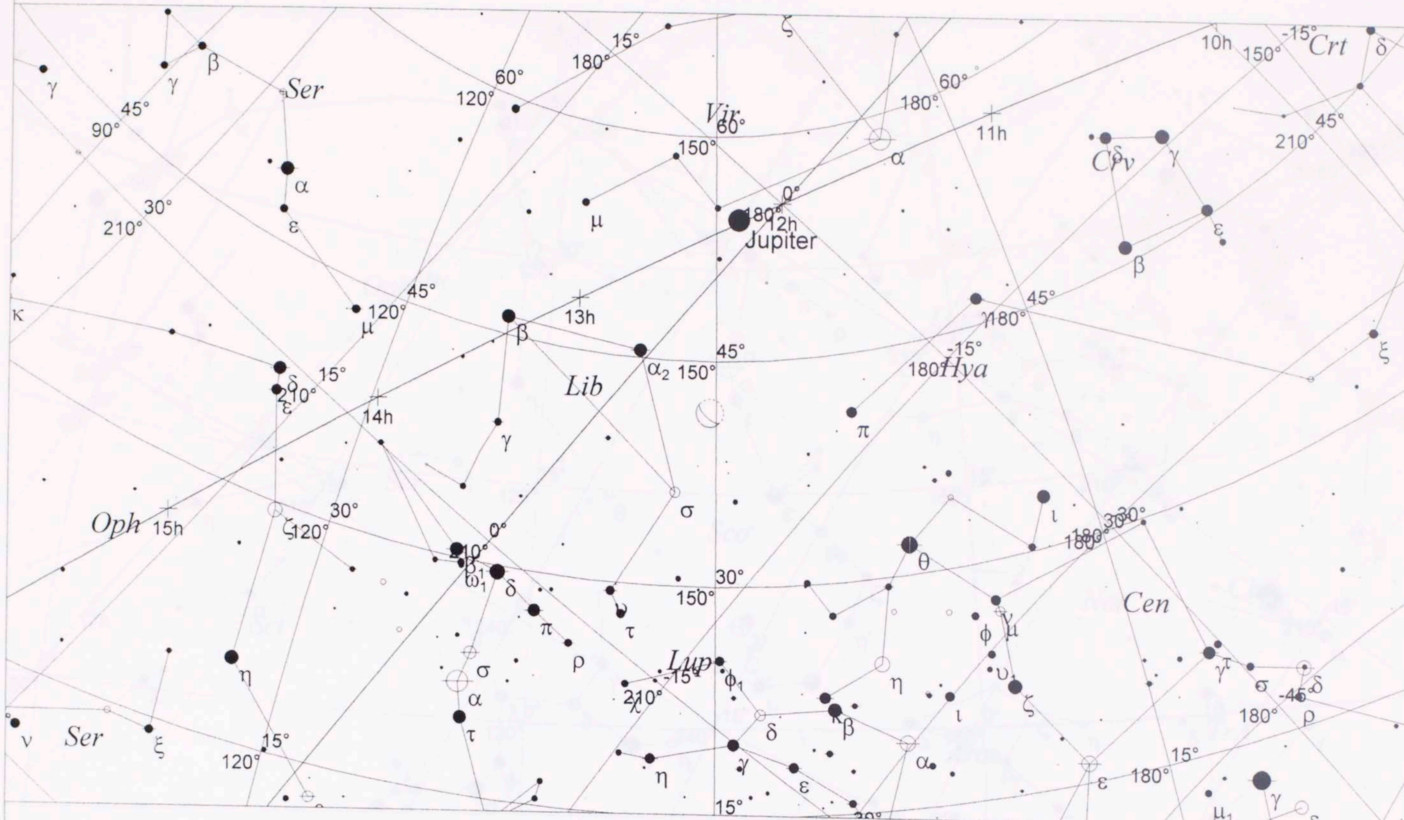


Local Time: 05:49:00 13-Dec-262BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:51:00 13-Dec-262BC
RA: 10h19m23s Dec: +5° 18' Field: 90.0°

Sidereal Time: 10:56:28
Julian Day: 1626073.6187

-261 IX 23

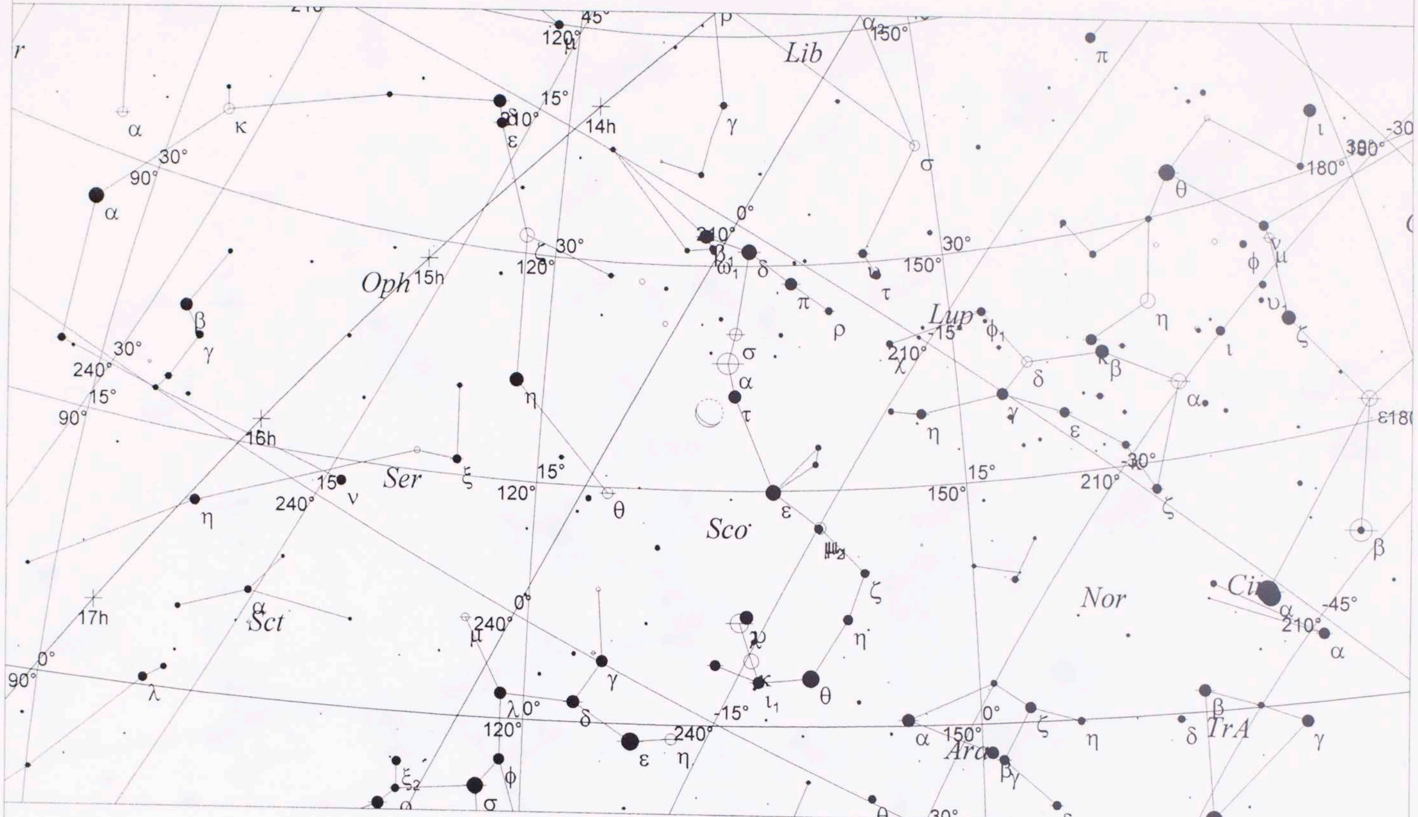


Local Time: 05:51:00 16-Dec-262BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:53:00 16-Dec-262BC
RA: 12h41m28s Dec: -10° 44' Field: 90.0°

Sidereal Time: 11:10:18
Julian Day: 1626076.6201

-261 IX 25

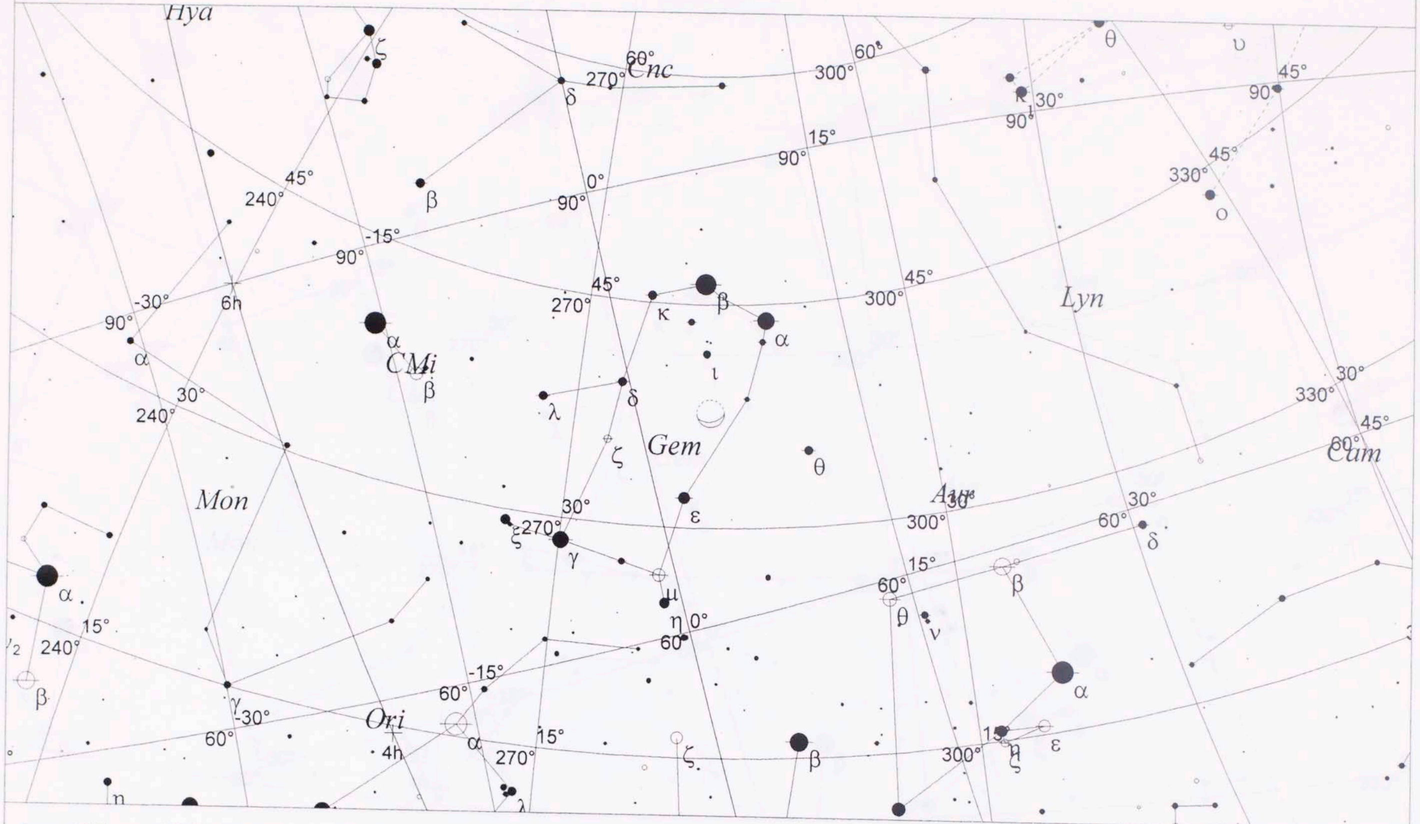


Local Time: 05:52:00 18-Dec-262BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:54:00 18-Dec-262BC
RA: 14h31m06s Dec: -20° 09' Field: 90.0°

Sidereal Time: 11:19:12
Julian Day: 1626078.6208

-246 / 4

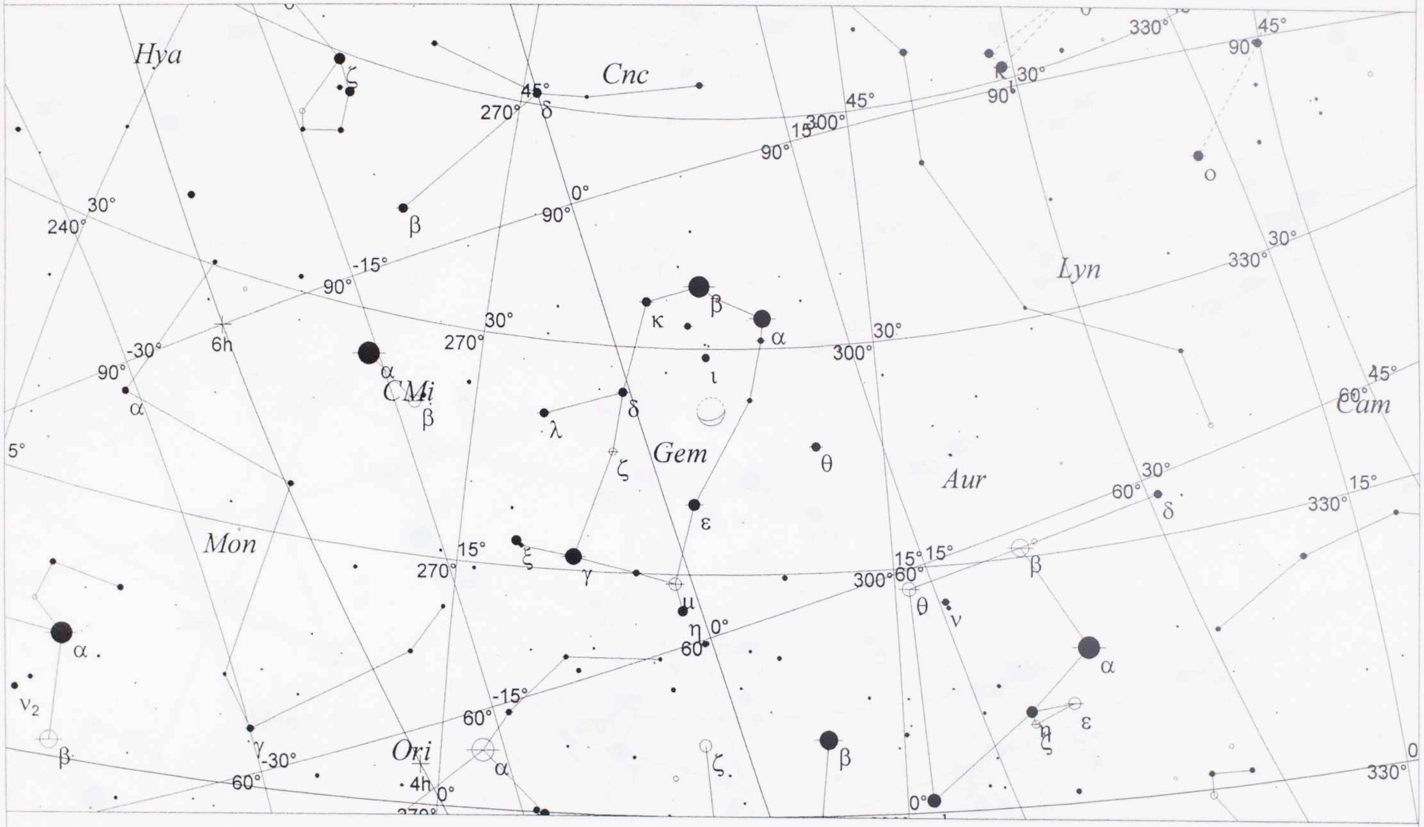


Local Time: 19:26:00 17-Apr-247BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:28:00 17-Apr-247BC
RA: 4h47m09s Dec: +27° 32' Field: 90.0°

Sidereal Time: 08:50:54
Julian Day: 1631313.1861

-246 / 4

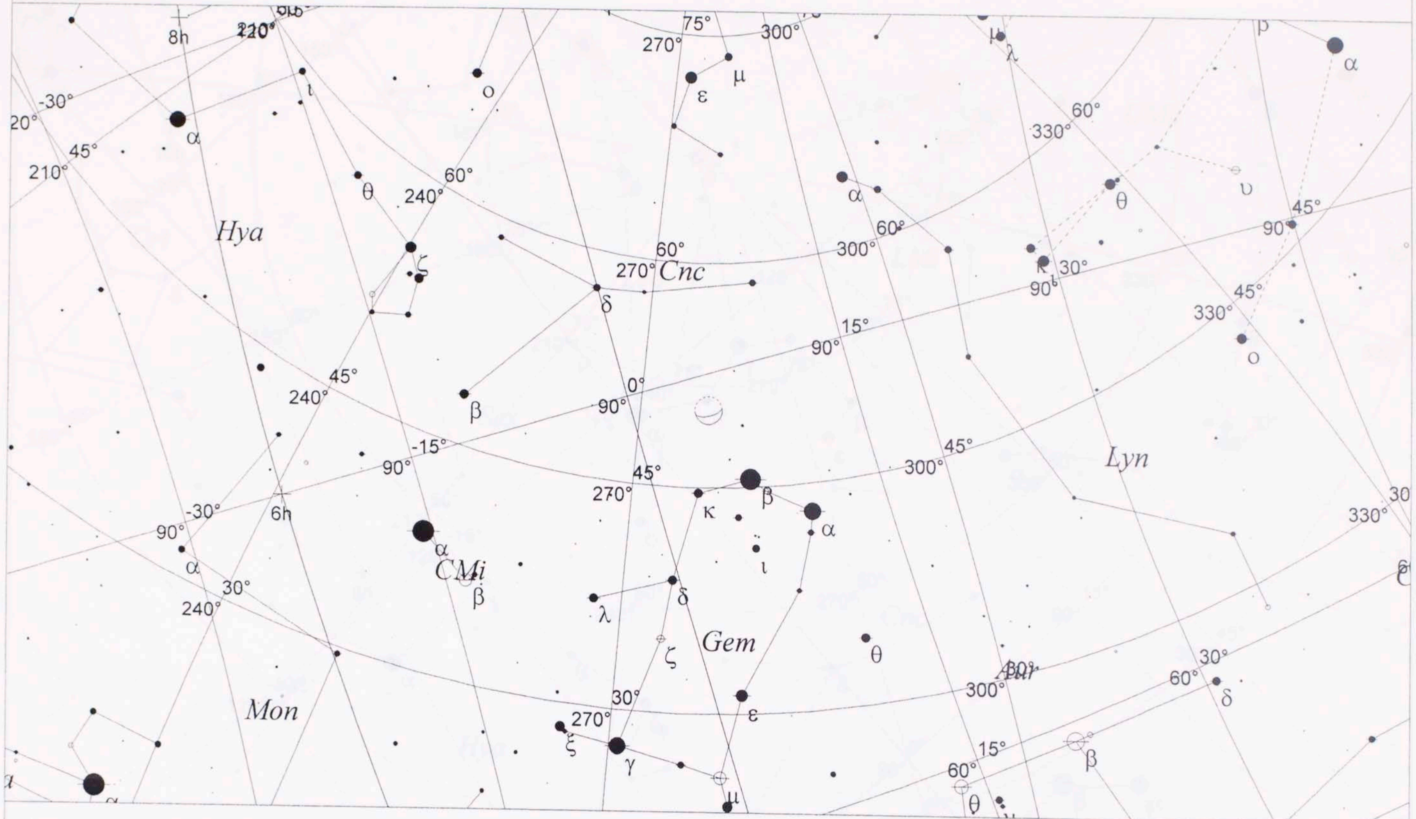


Local Time: 20:26:00 17-Apr-247BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 17:28:00 17-Apr-247BC
RA: 4h49m19s Dec: +27° 32' Field: 90.0°

Sidereal Time: 09:51:04
Julian Day: 1631313.2278

-246 / 5

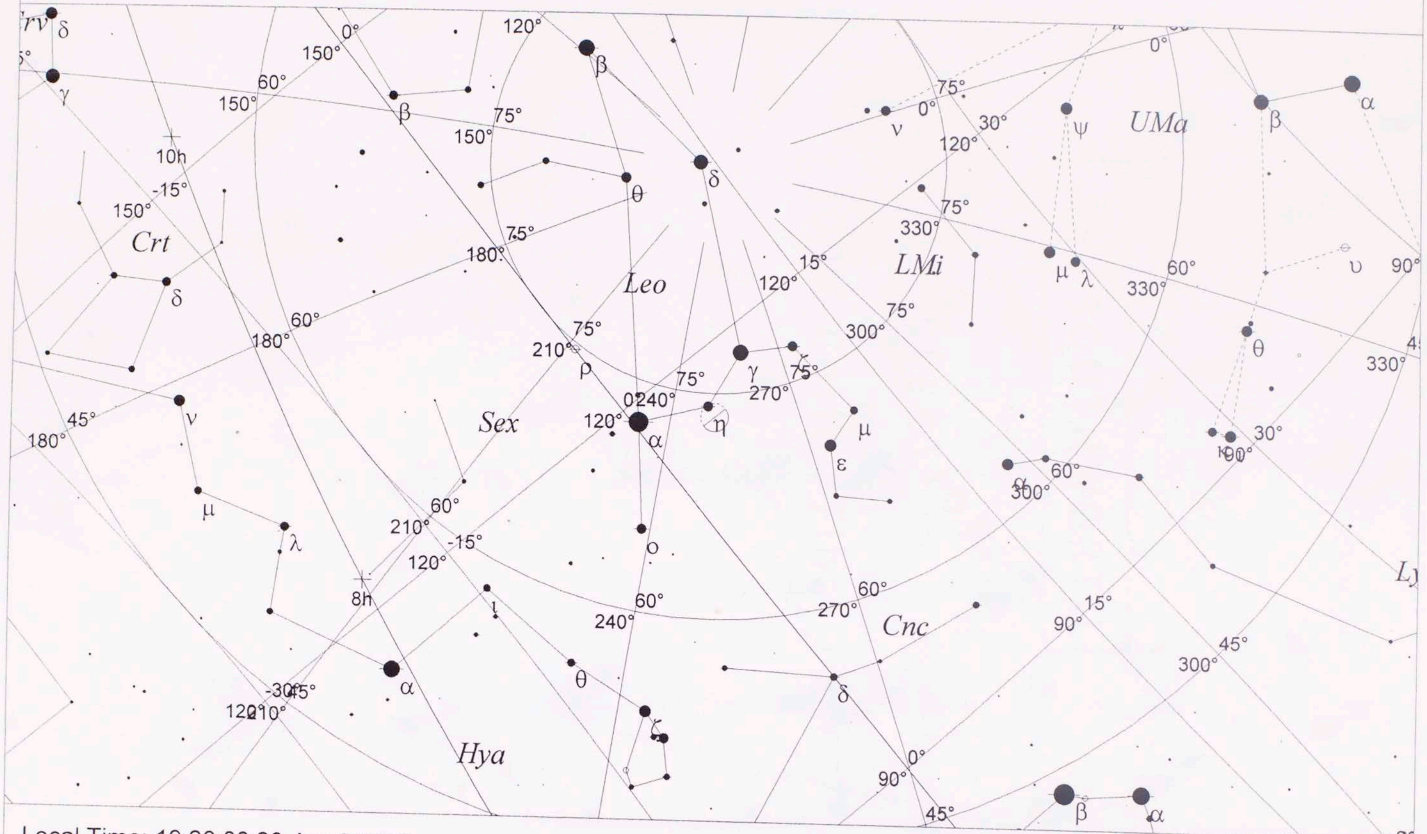


Local Time: 19:26:00 18-Apr-247BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:28:00 18-Apr-247BC
RA: 5h49m07s Dec: +28° 46' Field: 90.0°

Sidereal Time: 08:54:51
Julian Day: 1631314.1861

-246 / 7

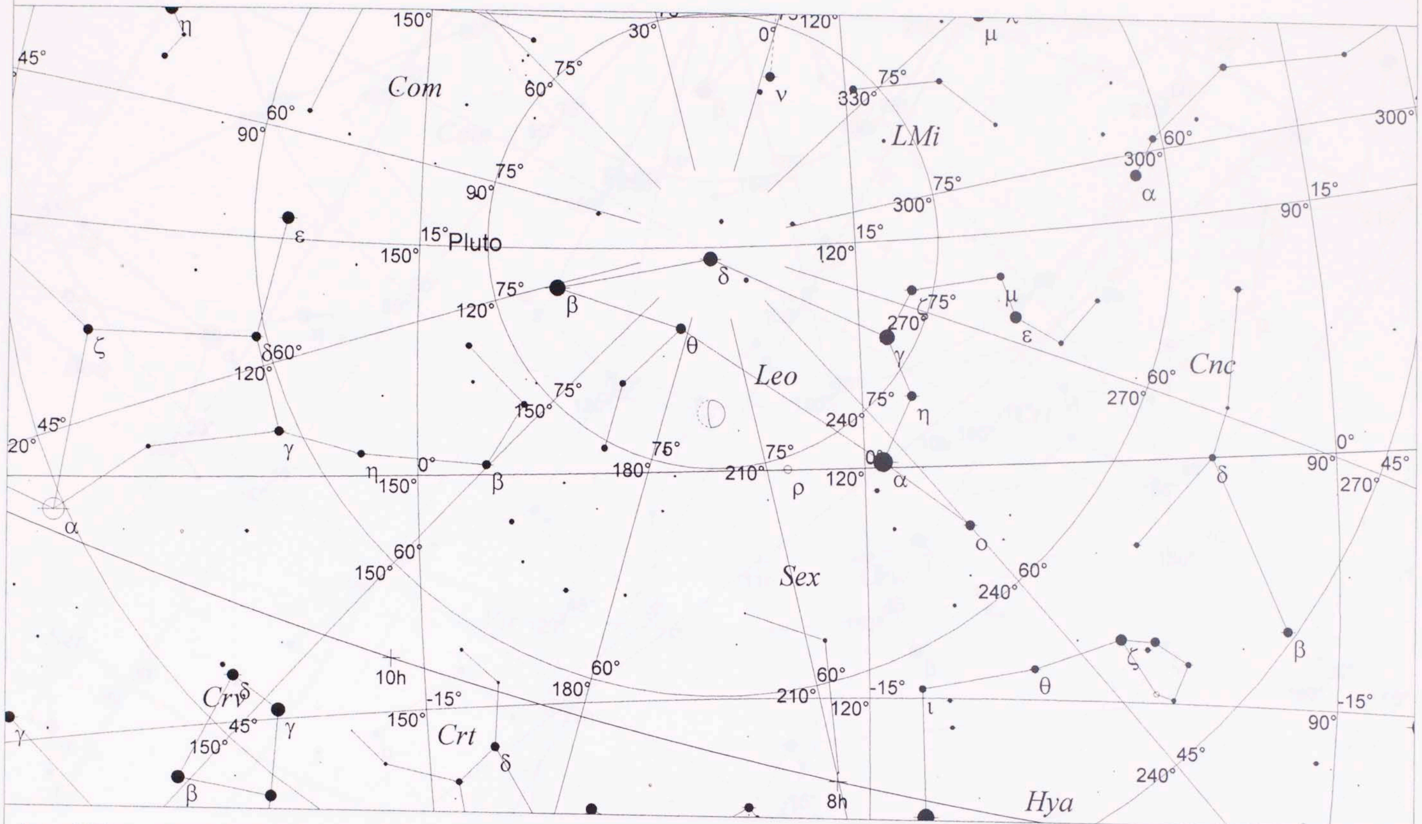


Local Time: 19:28:00 20-Apr-247BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:30:00 20-Apr-247BC
RA: 7h55m21s Dec: +25° 43' Field: 90.0°

Sidereal Time: 09:04:45
Julian Day: 1631316.1875

-246 / 8

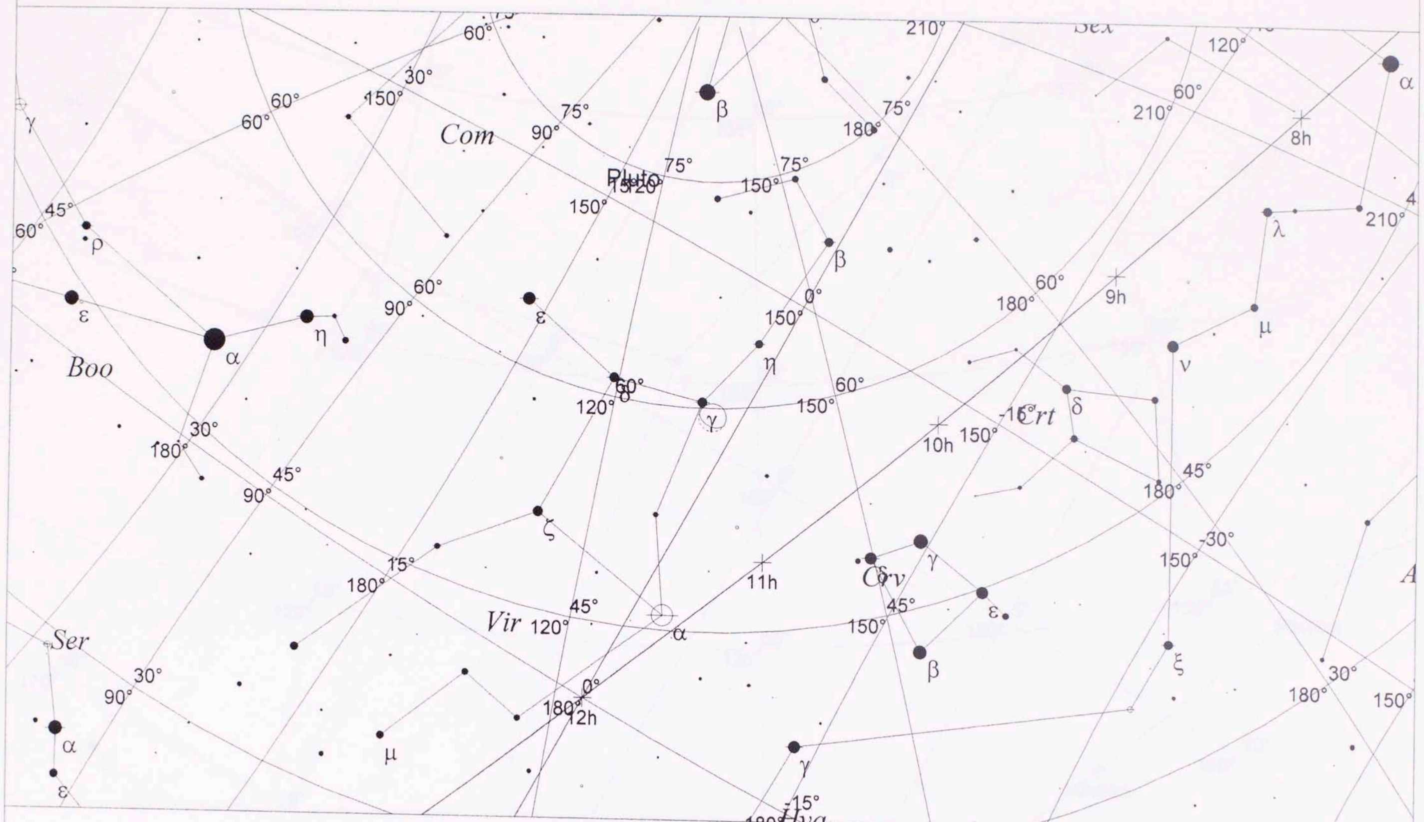


Local Time: 19:28:00 21-Apr-247BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:30:00 21-Apr-247BC
RA: 8h55m36s Dec: +21° 36' Field: 90.0°

Sidereal Time: 09:08:41
Julian Day: 1631317.1875

-246 / 10

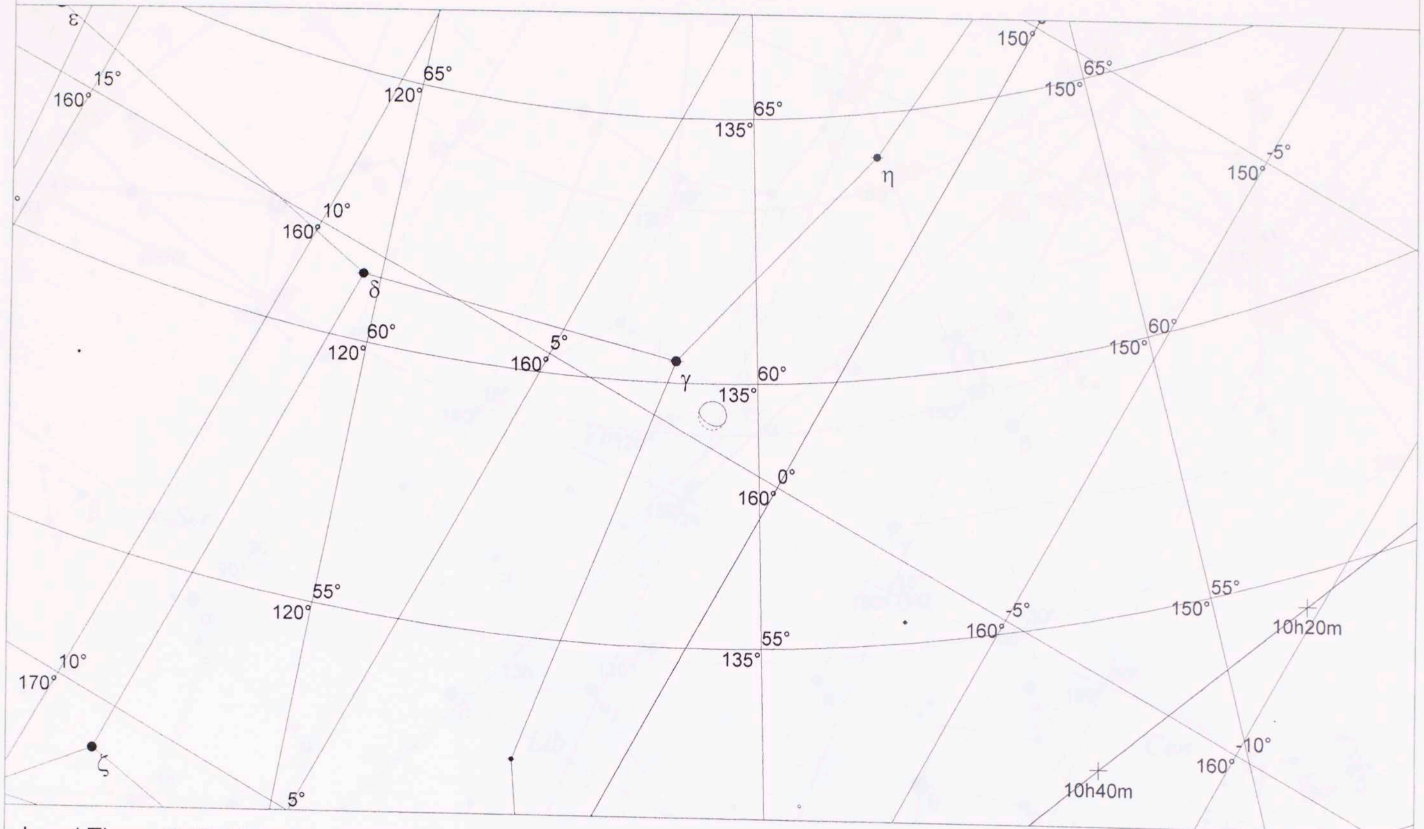


Local Time: 19:30:00 23-Apr-247BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:32:00 23-Apr-247BC
RA: 10h46m55s Dec: +9° 43' Field: 90.0°

Sidereal Time: 09:18:35
Julian Day: 1631319.1889

-246 / 10

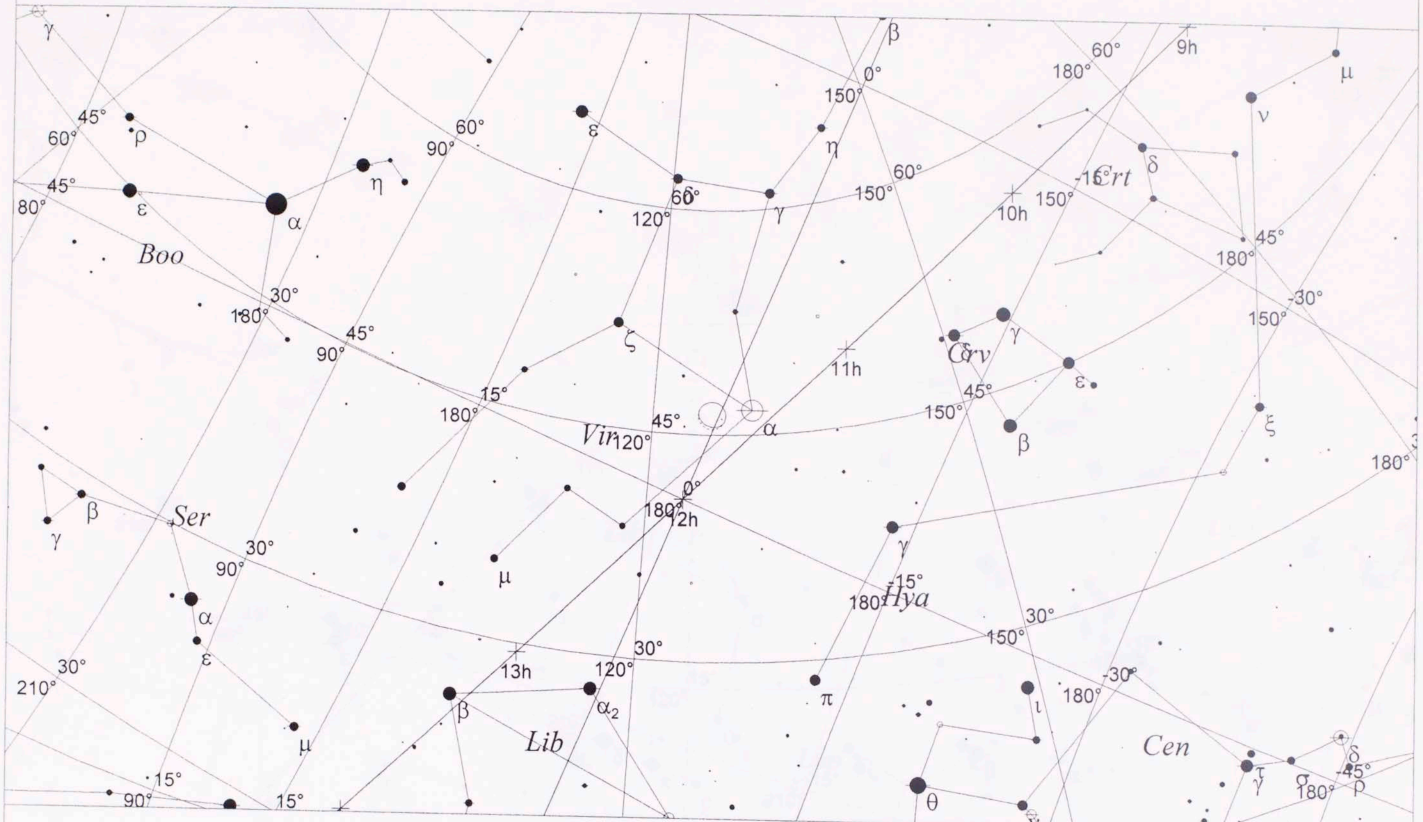


Local Time: 19:30:00 23-Apr-247BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:32:00 23-Apr-247BC
RA: 10h46m55s Dec: +9° 43' Field: 26.7°

Sidereal Time: 09:18:35
Julian Day: 1631319.1889

-246 / 11

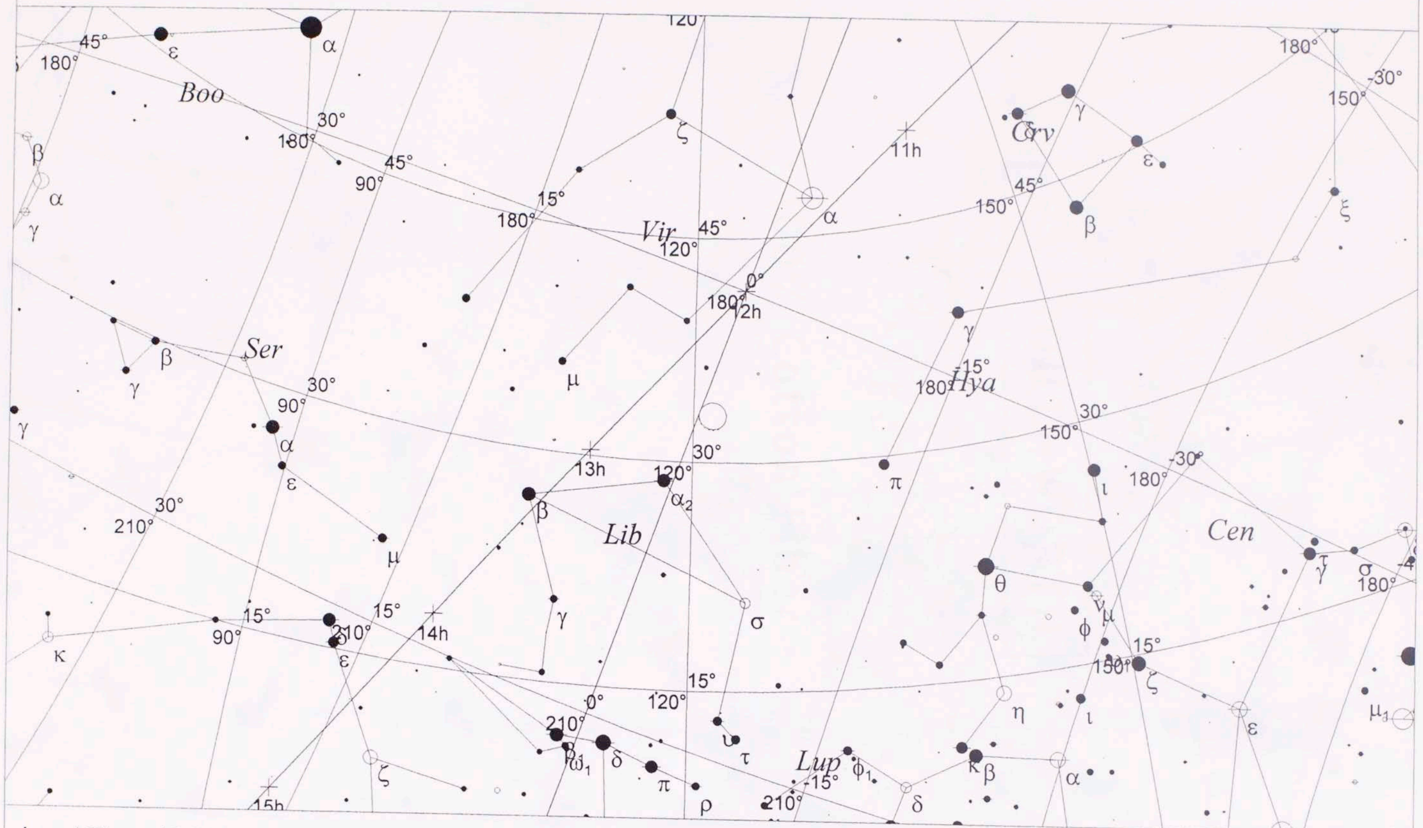


Local Time: 19:30:00 24-Apr-247BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:32:00 24-Apr-247BC
RA: 11h39m04s Dec: +2° 46' Field: 90.0°

Sidereal Time: 09:22:31
Julian Day: 1631320.1889

-246 / 12

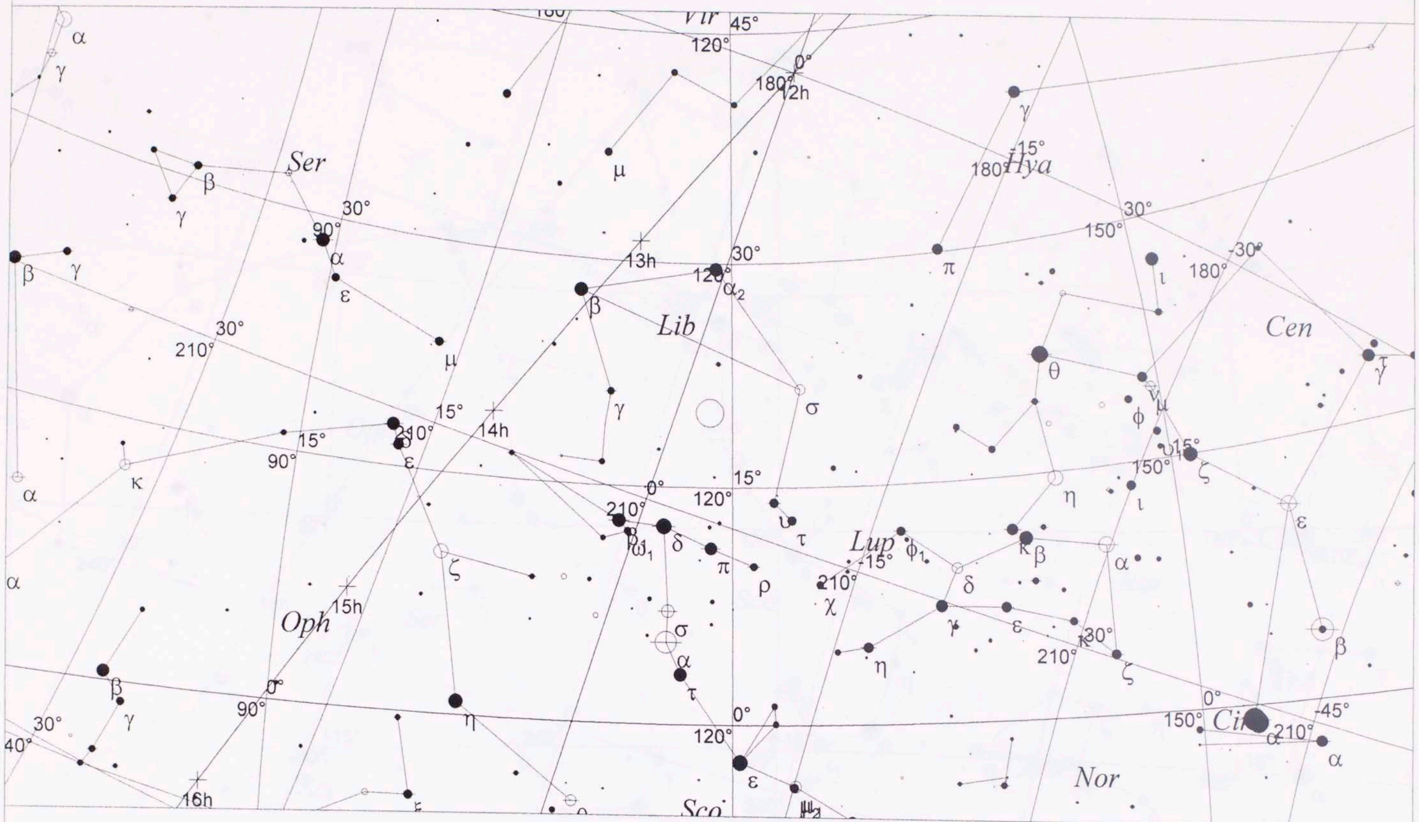


Local Time: 19:31:00 25-Apr-247BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:33:00 25-Apr-247BC
RA: 12h30m22s Dec: -4° 18' Field: 90.0°

Sidereal Time: 09:27:28
Julian Day: 1631321.1896

-246 / 13

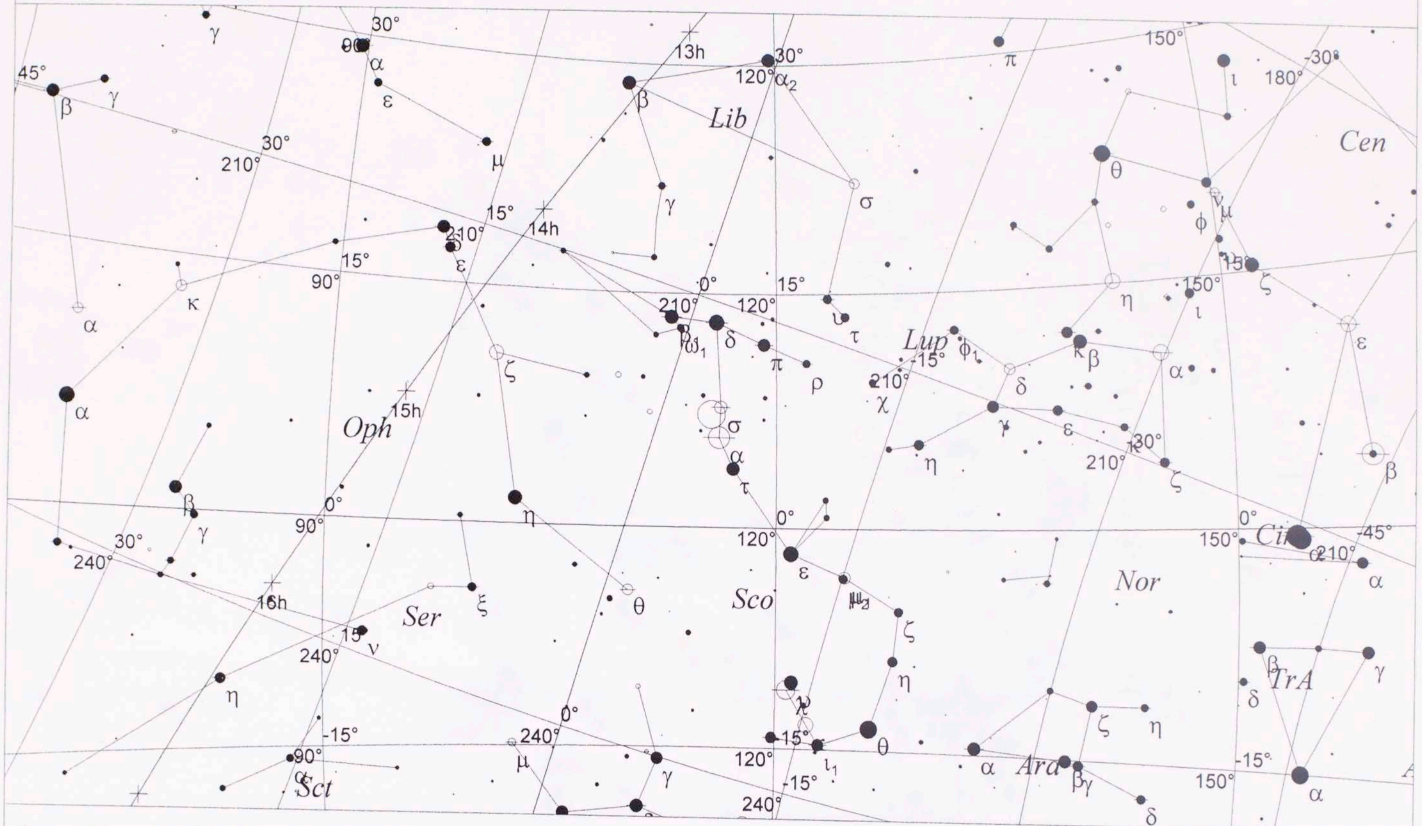


Local Time: 19:32:00 26-Apr-247BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:34:00 26-Apr-247BC
RA: 13h21m57s Dec: -11° 05' Field: 90.0°

Sidereal Time: 09:32:24
Julian Day: 1631322.1903

-246 / 14

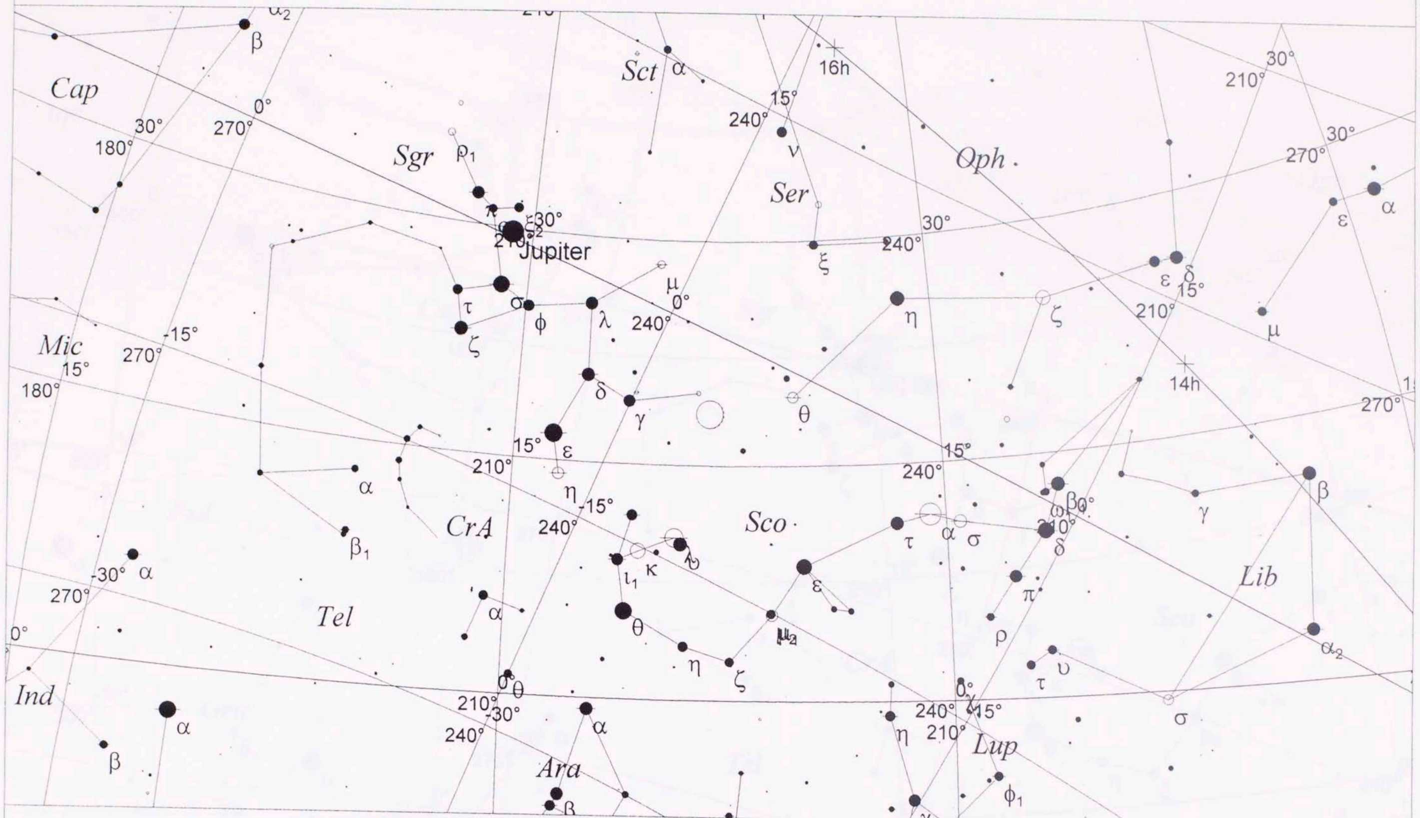


Local Time: 19:32:00 27-Apr-247BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:34:00 27-Apr-247BC
RA: 14h14m45s Dec: -17° 12' Field: 90.0°

Sidereal Time: 09:36:21
Julian Day: 1631323.1903

-246 / 15

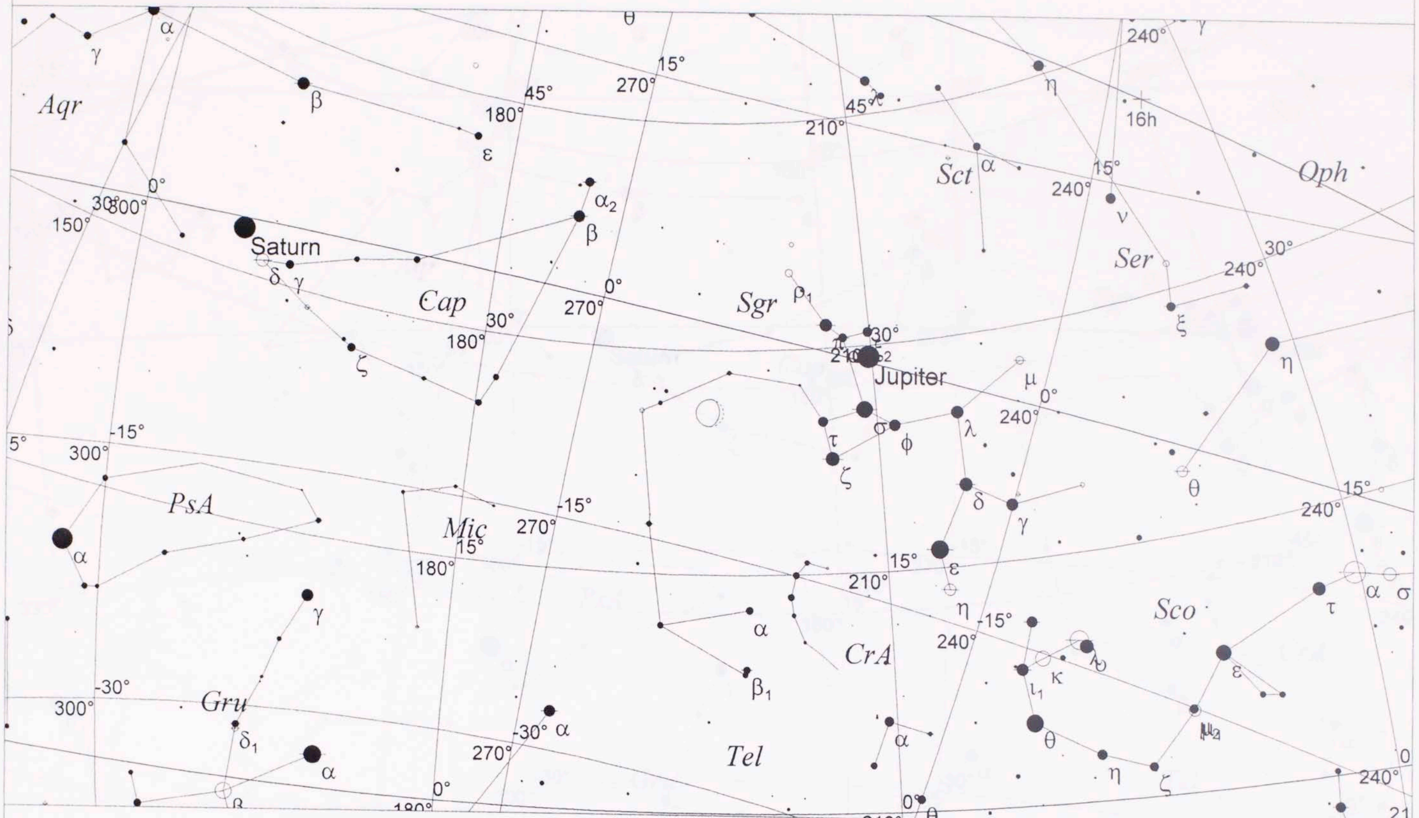


Local Time: 04:18:00 29-Apr-247BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:20:00 29-Apr-247BC
RA: 15h23m48s Dec: -24° 03' Field: 90.0°

Sidereal Time: 18:27:44
Julian Day: 1631324.5556

-246 / 17

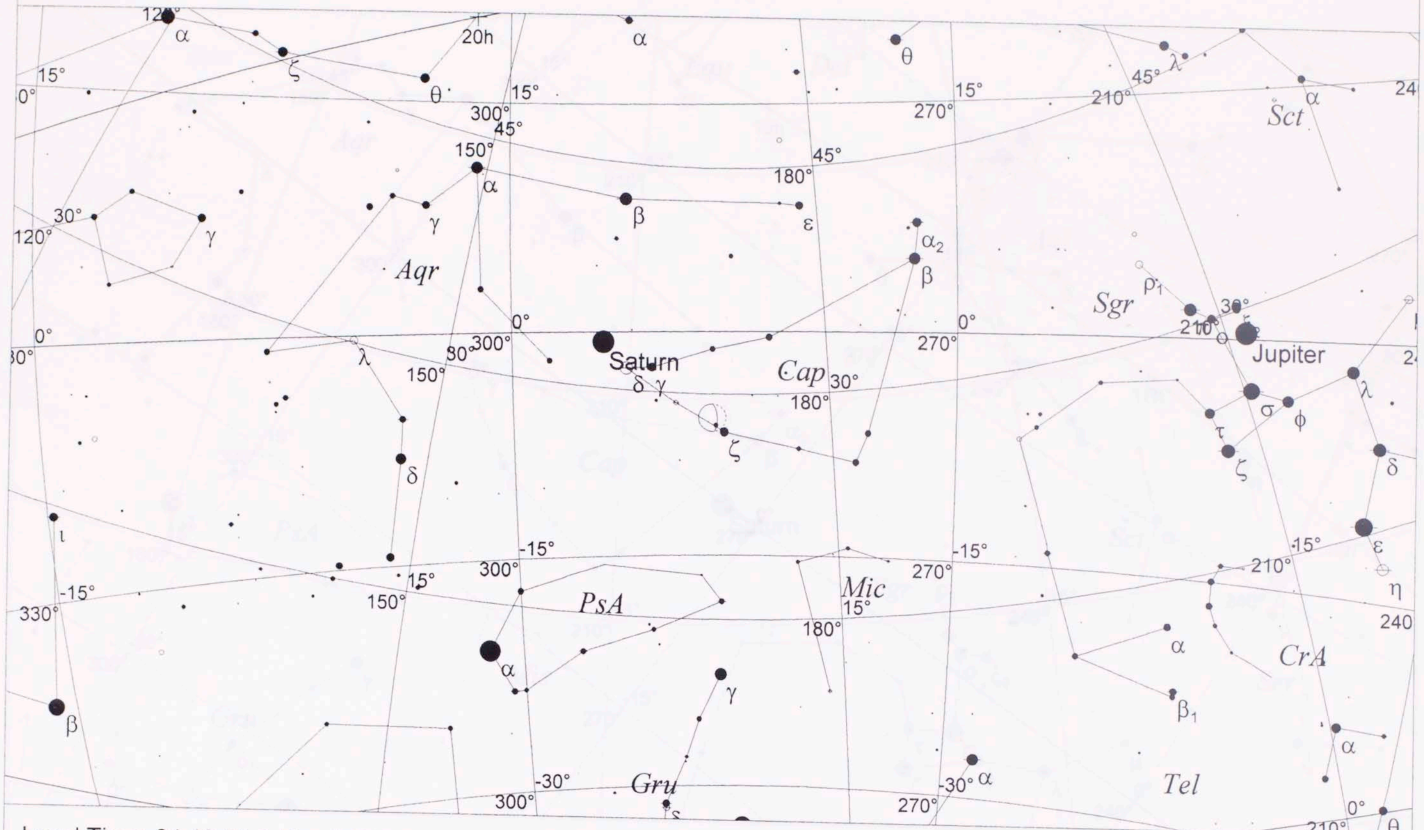


Local Time: 04:15:00 1-May-247BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:17:00 1-May-247BC
RA: 17h20m11s Dec: -29° 21' Field: 90.0°

Sidereal Time: 18:32:37
Julian Day: 1631326.5535

-246 / 19

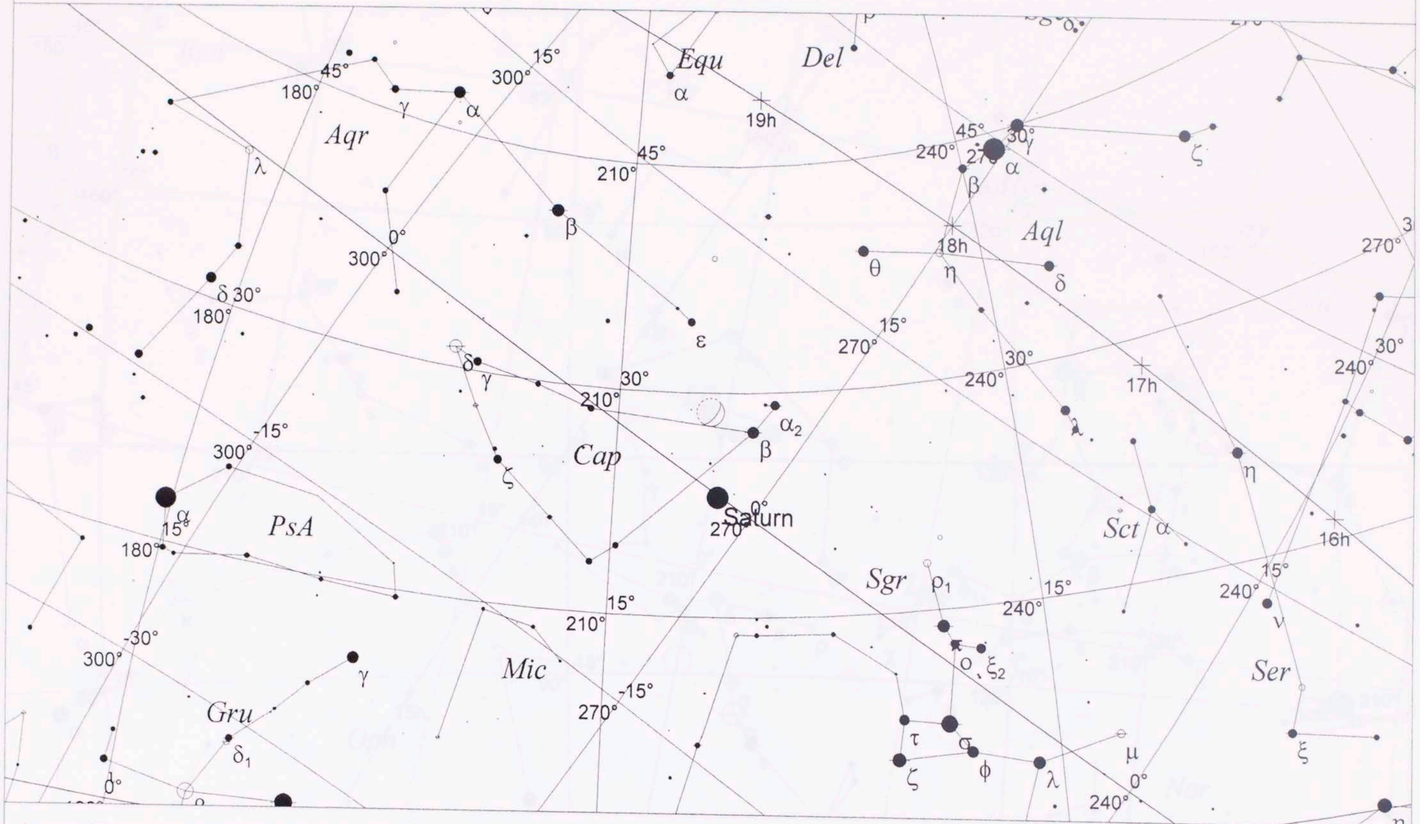


Local Time: 04:13:00 3-May-247BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:15:00 3-May-247BC
RA: 19h15m06s Dec: -28° 26' Field: 90.0°

Sidereal Time: 18:38:29
Julian Day: 1631328.5521

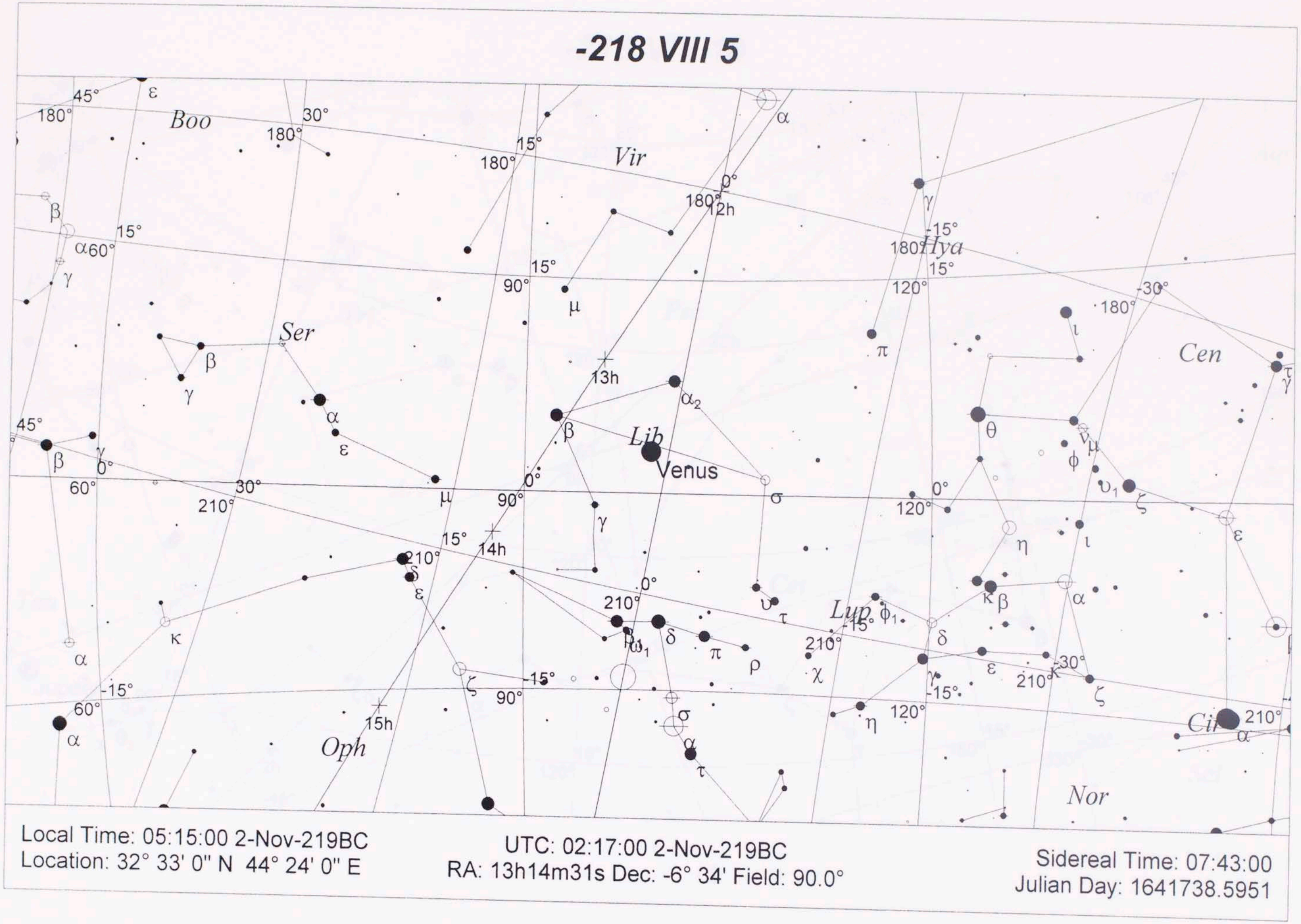
-218 VIII 4



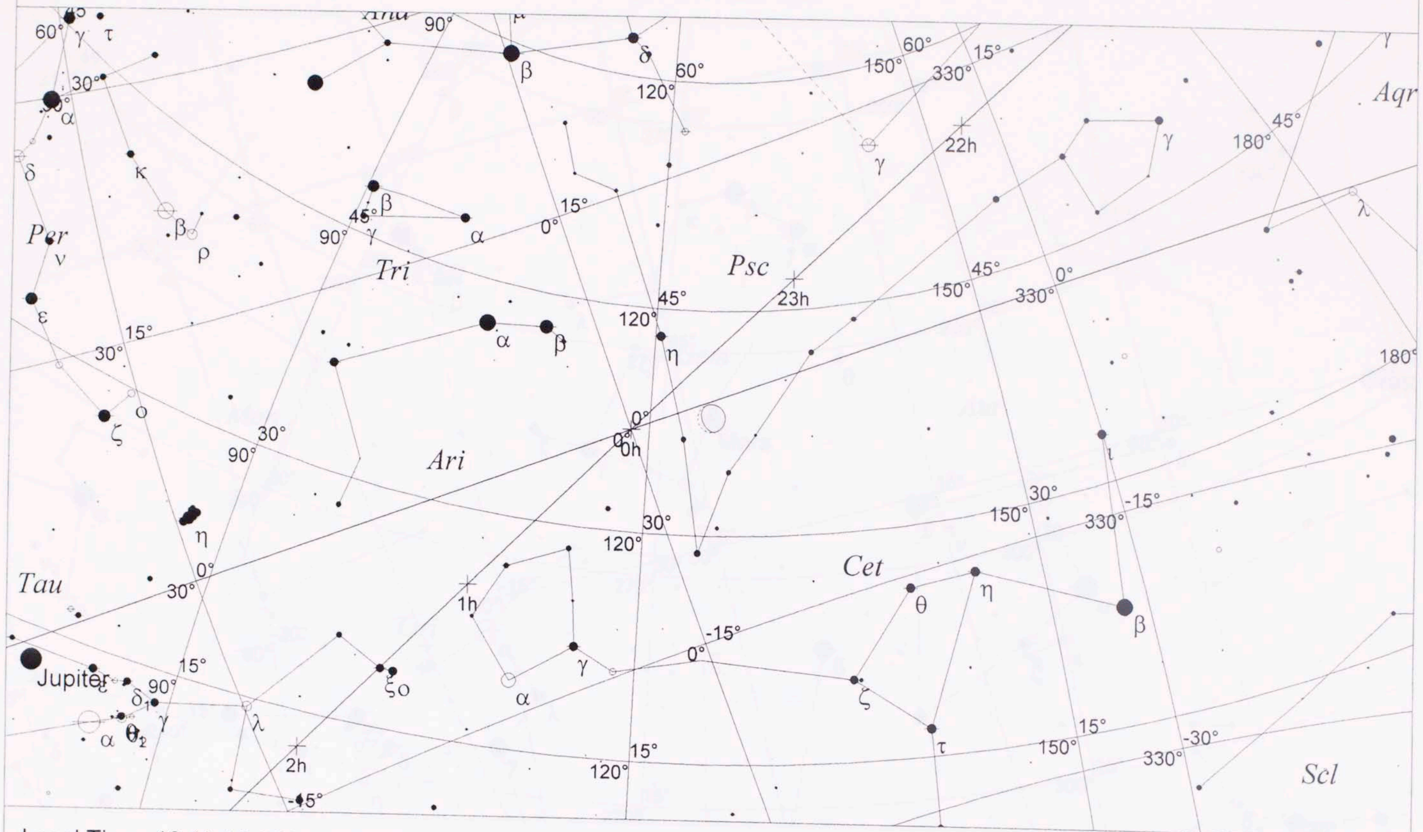
Local Time: 18:21:00 31-Oct-219BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 15:23:00 31-Oct-219BC
RA: 18h26m55s Dec: -19° 20' Field: 90.0°

Sidereal Time: 20:43:16
Julian Day: 1641737.1410


-218 VIII 5
Boo
Vir
Hya
Ser
Cen
Lib
Venus
Lup
Oph
Cir
Nor
Local Time: 05:15:00 2-Nov-219BC
Location: 32° 33' 0" N 44° 24' 0" E
UTC: 02:17:00 2-Nov-219BC
RA: 13h14m31s Dec: -6° 34' Field: 90.0°
Sidereal Time: 07:43:00
Julian Day: 1641738.5951

-218 VIII 10

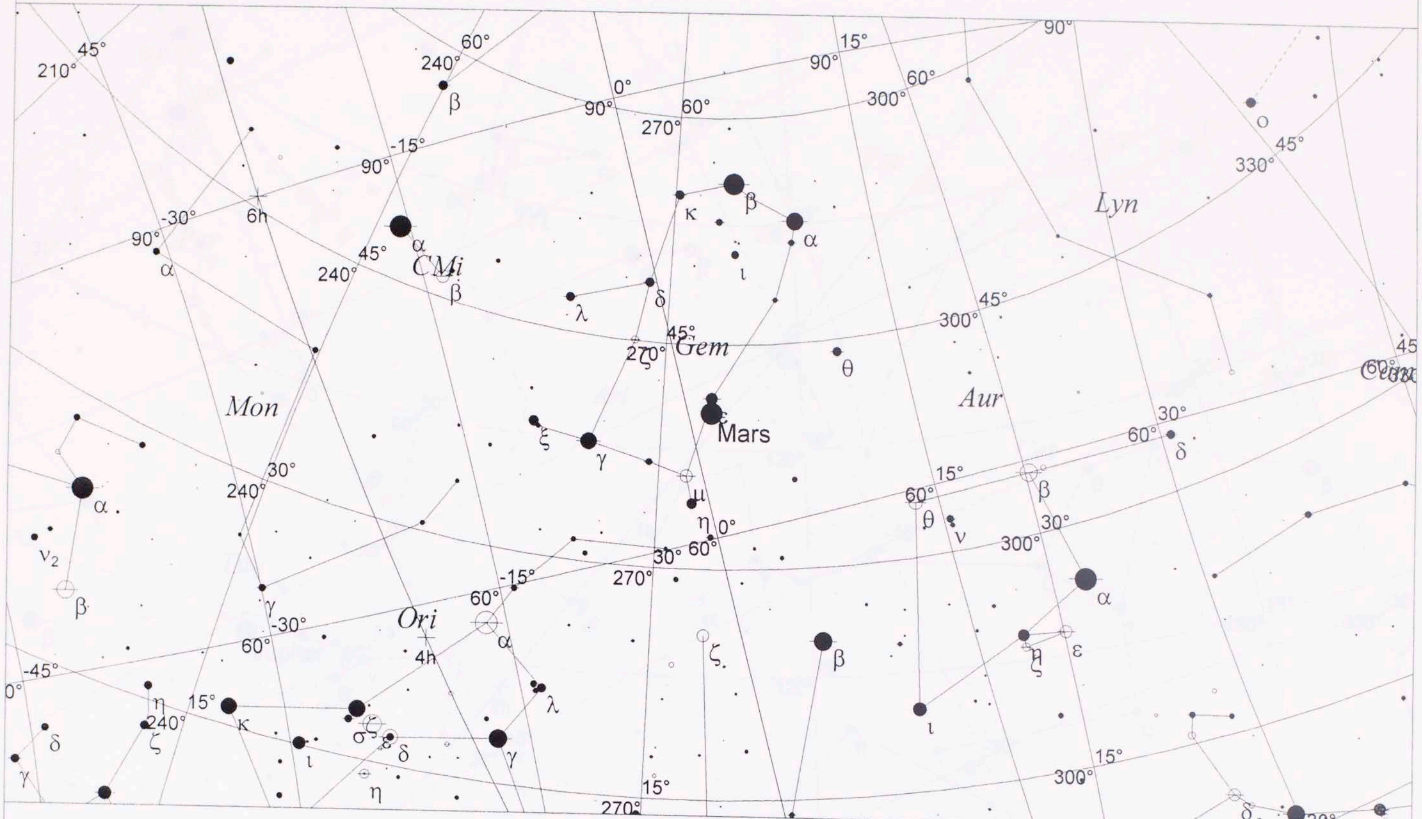


Local Time: 18:15:00 6-Nov-219BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 15:17:00 6-Nov-219BC
RA: 23h41m54s Dec: -3° 09' Field: 90.0°

Sidereal Time: 21:00:54
Julian Day: 1641743.1368

-218 VIII 10

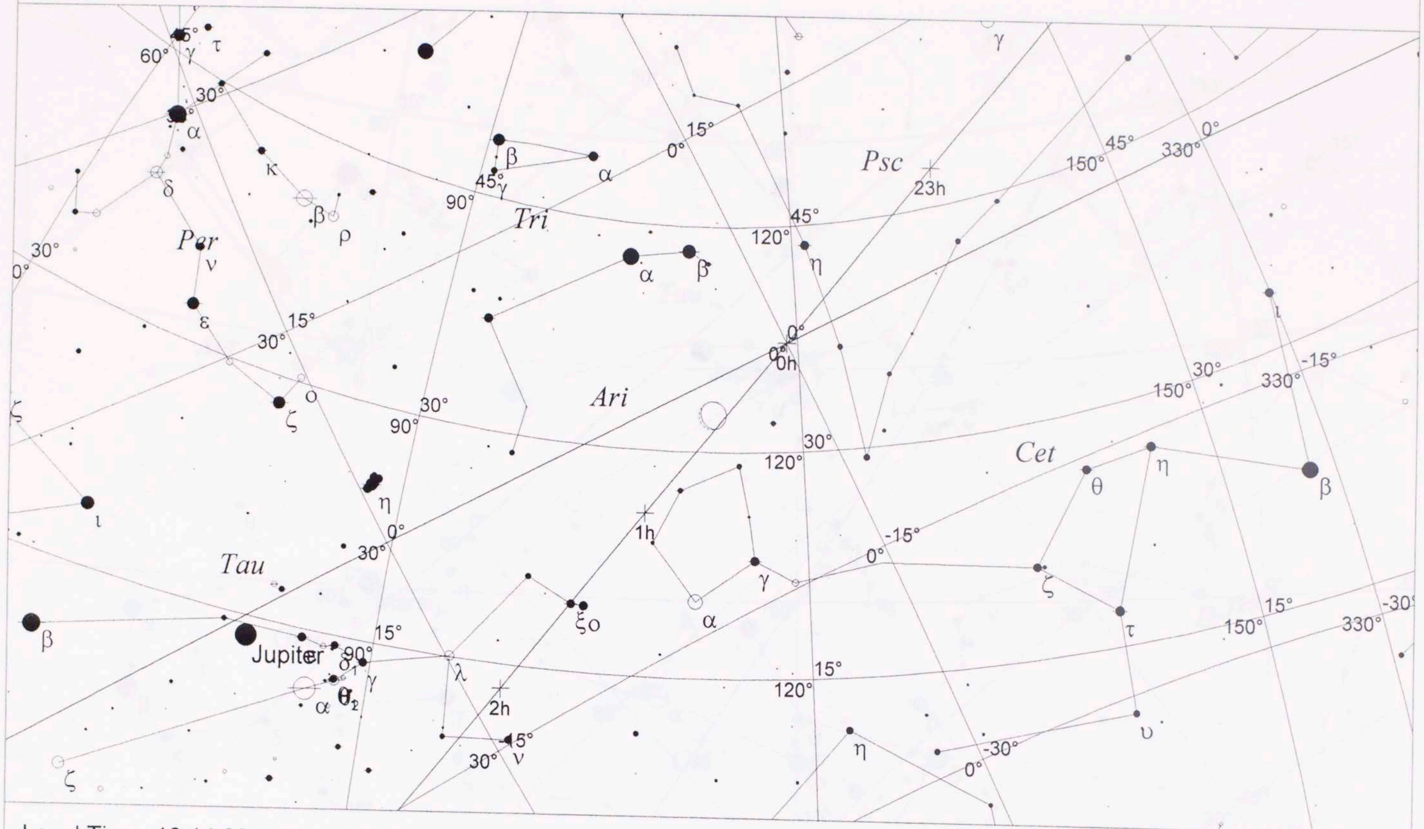


Local Time: 05:20:00 7-Nov-219BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:22:00 7-Nov-219BC
RA: 4h24m17s Dec: +23° 26' Field: 90.0°

Sidereal Time: 08:07:43
Julian Day: 1641743.5986

-218 VIII 11

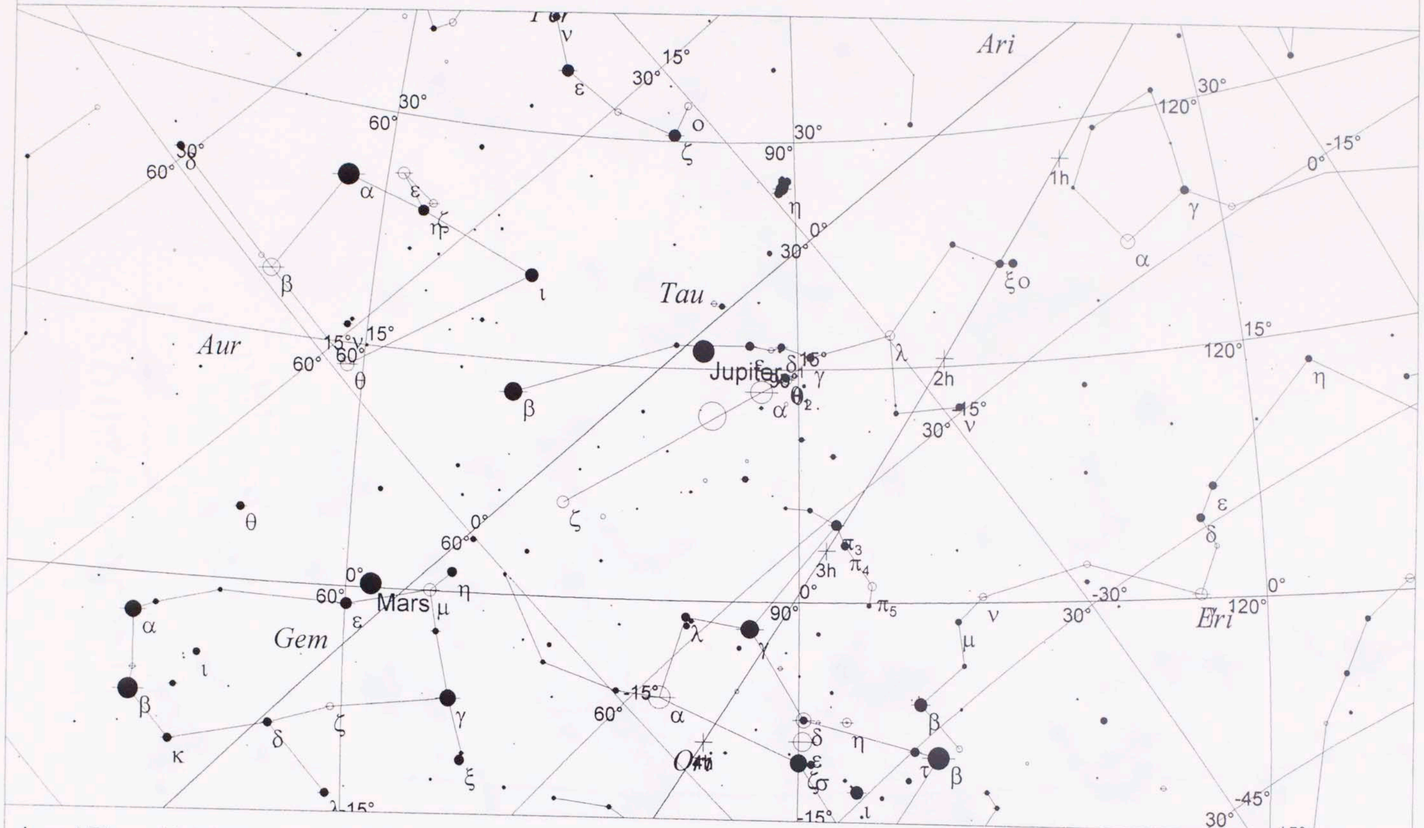


Local Time: 18:14:00 7-Nov-219BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 15:16:00 7-Nov-219BC
RA: 0h27m56s Dec: +0° 44' Field: 90.0°

Sidereal Time: 21:03:50
Julian Day: 1641744.1361

-218 VIII 14

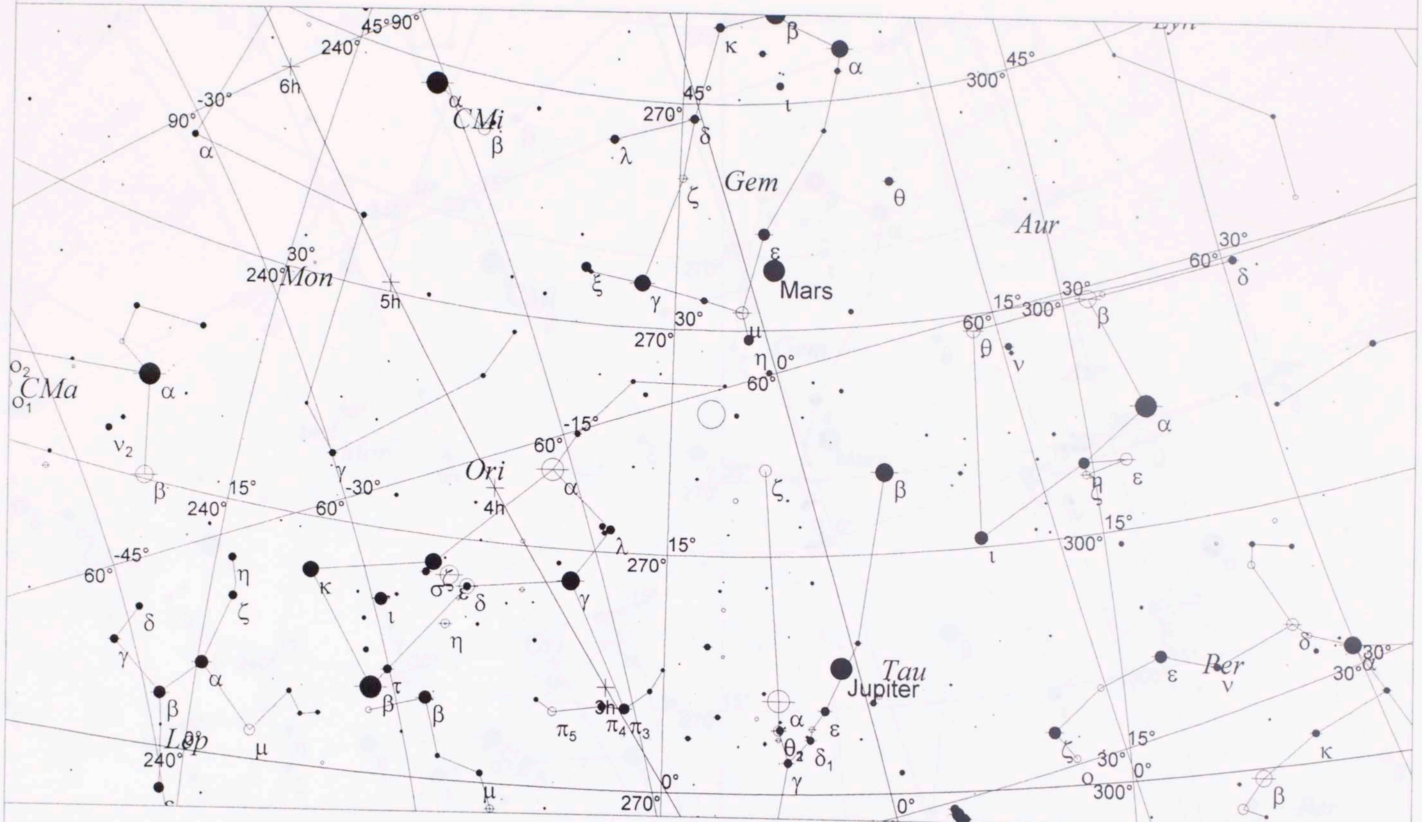


Local Time: 18:12:00 10-Nov-219BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 15:14:00 10-Nov-219BC
RA: 2h45m55s Dec: +11° 18' Field: 90.0°

Sidereal Time: 21:13:40
Julian Day: 1641747.1347

-218 VIII 15

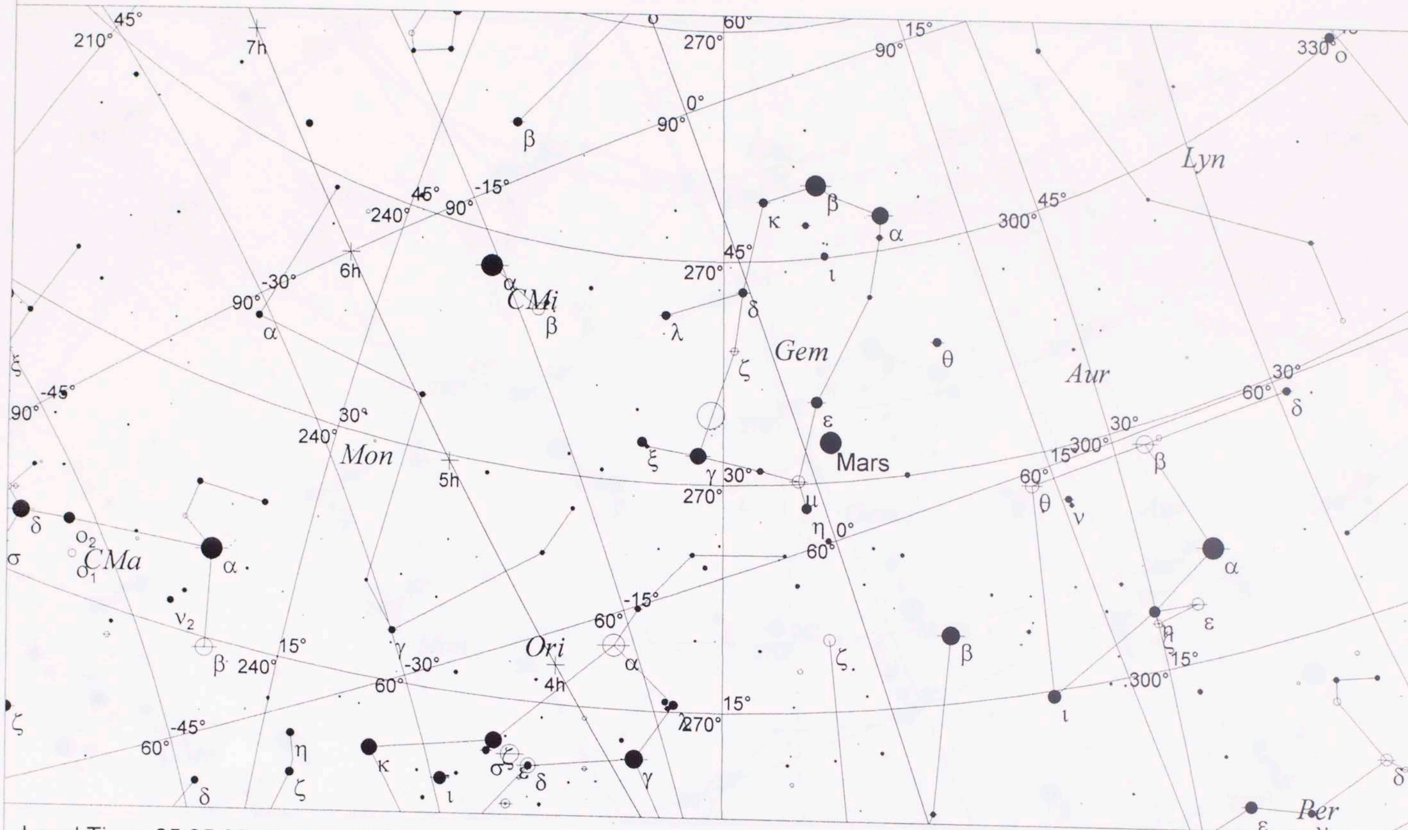


Local Time: 05:24:00 12-Nov-219BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:26:00 12-Nov-219BC
RA: 3h49m39s Dec: +15° 11' Field: 90.0°

Sidereal Time: 08:31:27
Julian Day: 1641748.6014

-218 VIII 16

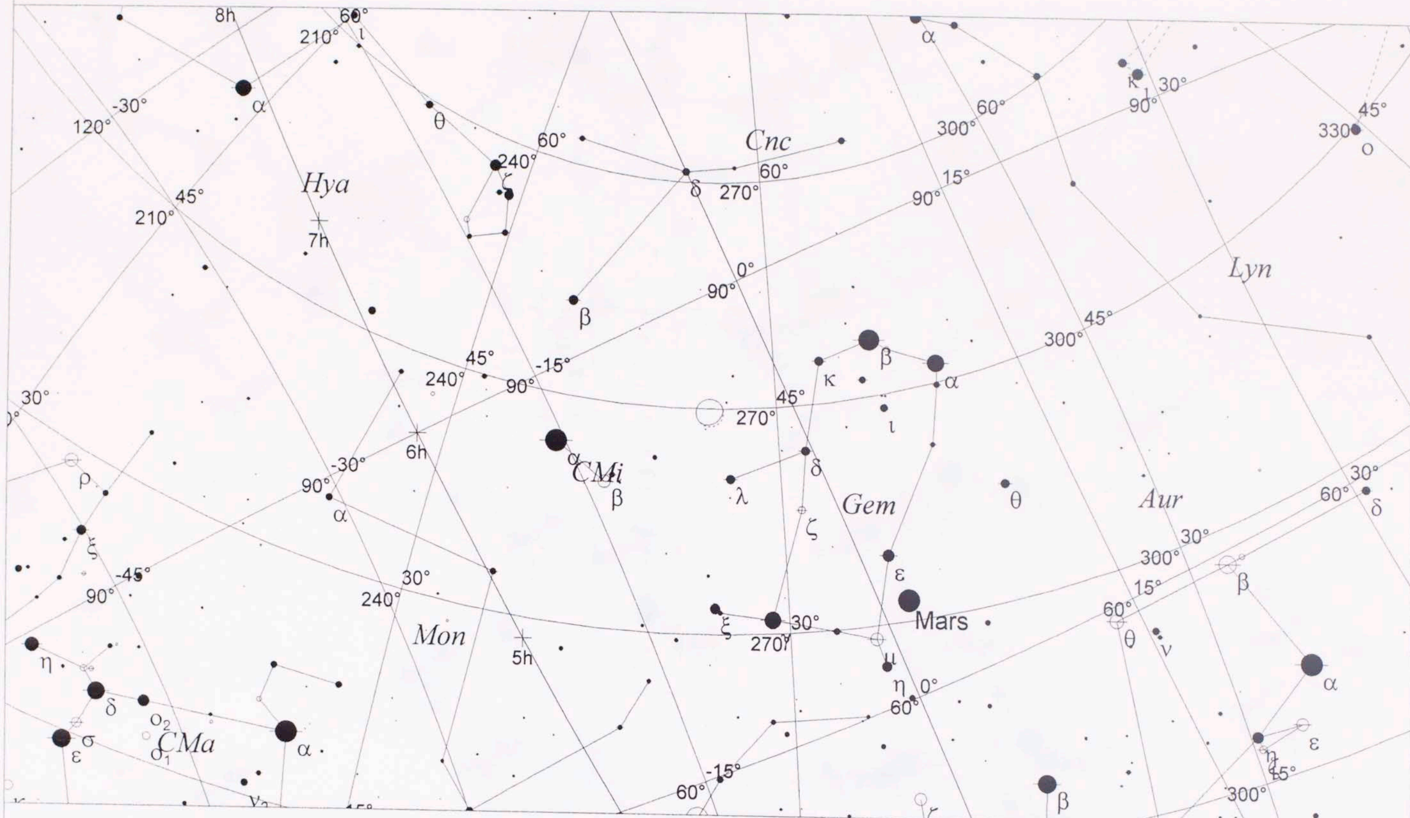


Local Time: 05:25:00 13-Nov-219BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:27:00 13-Nov-219BC
RA: 4h38m54s Dec: +17° 04' Field: 90.0°

Sidereal Time: 08:36:23
Julian Day: 1641749.6021

-218 VIII 17

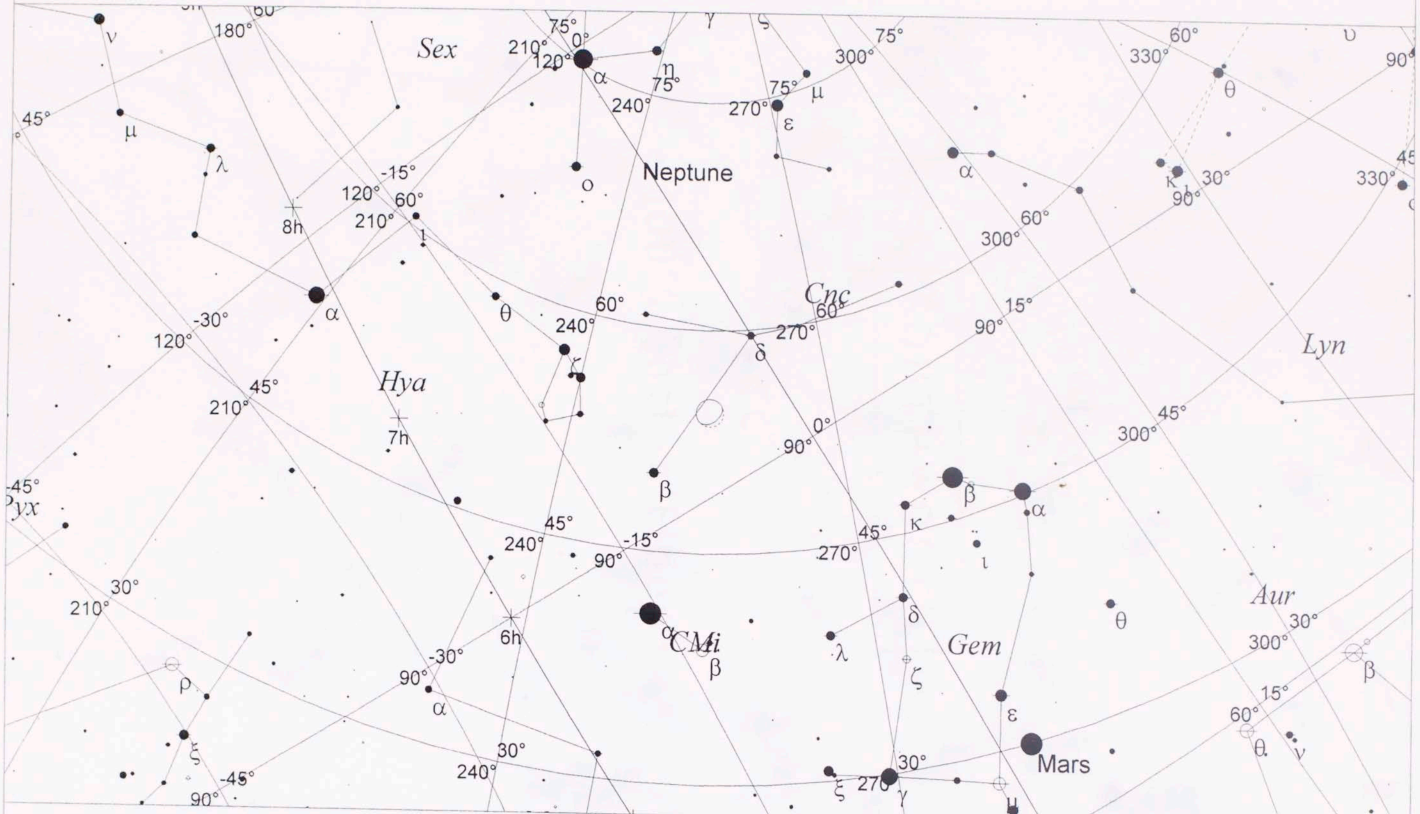


Local Time: 05:26:00 14-Nov-219BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:28:00 14-Nov-219BC
RA: 5h29m21s Dec: +18° 12' Field: 90.0°

Sidereal Time: 08:41:20
Julian Day: 1641750.6028

-218 VIII 18

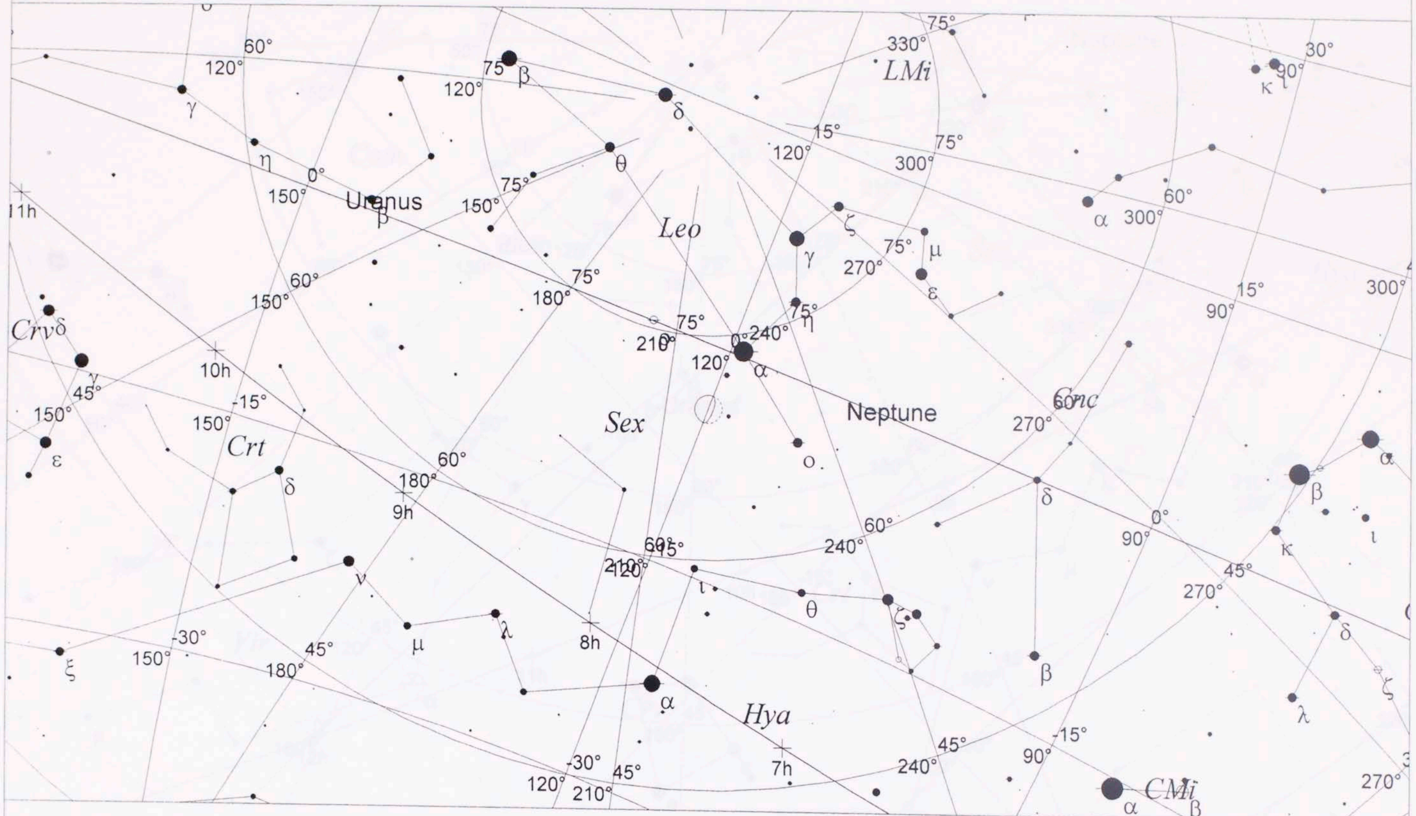


Local Time: 05:27:00 15-Nov-219BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 02:29:00 15-Nov-219BC
RA: 6h20m46s Dec: +18° 29' Field: 90.0°

Sidereal Time: 08:46:17
Julian Day: 1641751.6035

-218 VIII 20

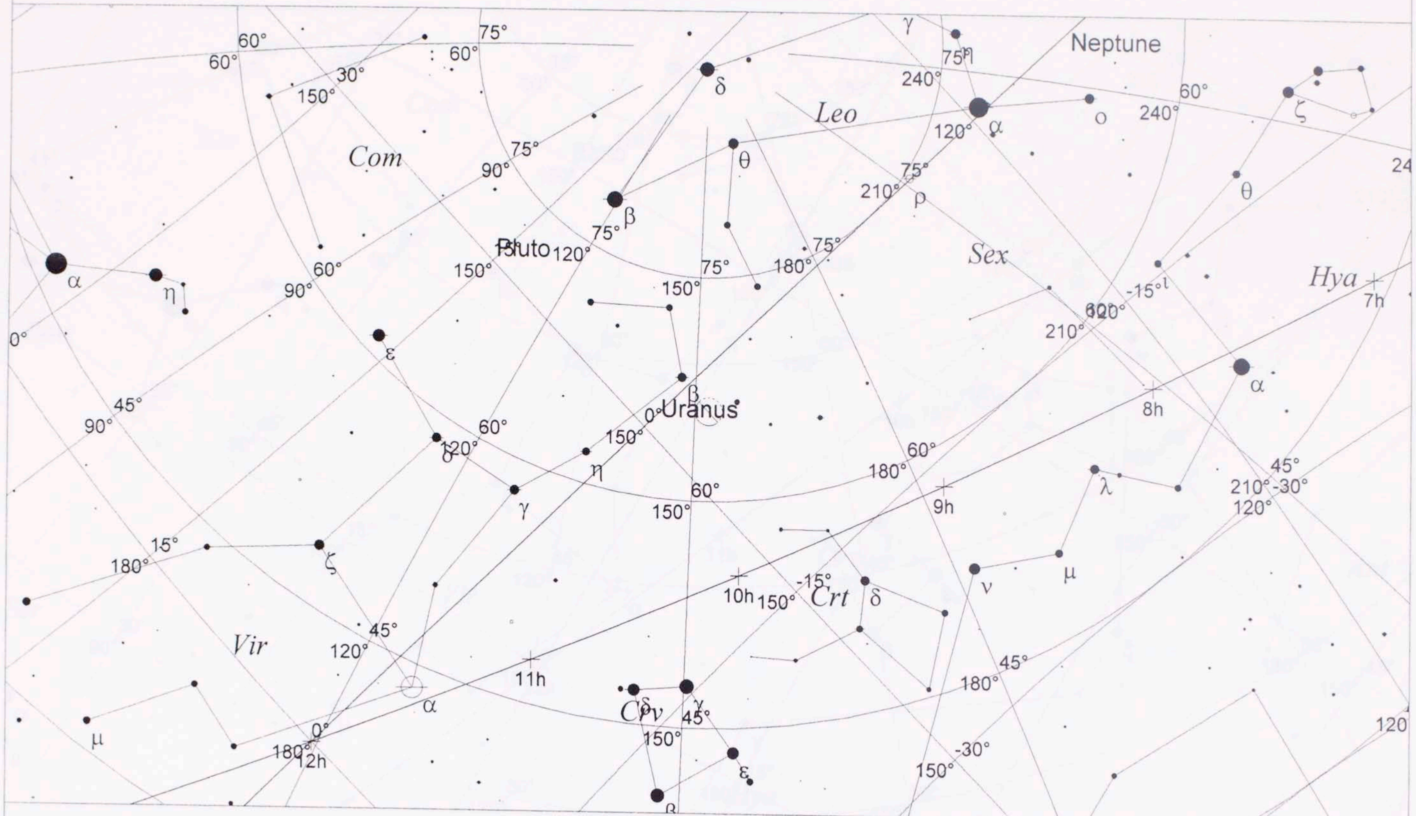


Local Time: 05:29:00 17-Nov-219BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:31:00 17-Nov-219BC
RA: 8h05m15s Dec: +16° 23' Field: 90.0°

Sidereal Time: 08:56:10
Julian Day: 1641753.6049

-218 VIII 22

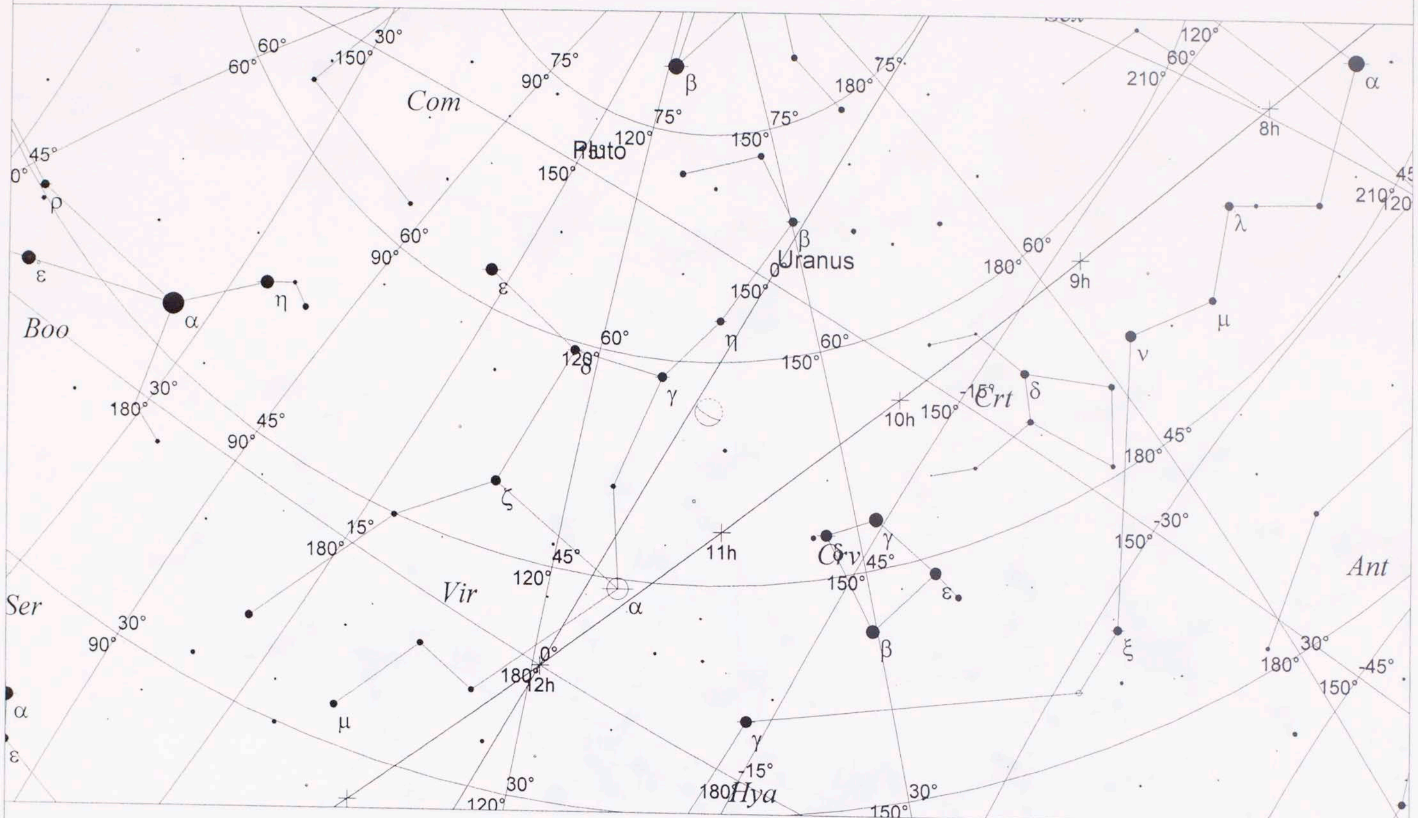


Local Time: 05:31:00 19-Nov-219BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:33:00 19-Nov-219BC
RA: 9h50m30s Dec: +10° 51' Field: 90.0°

Sidereal Time: 09:06:04
Julian Day: 1641755.6063

-218 VIII 23

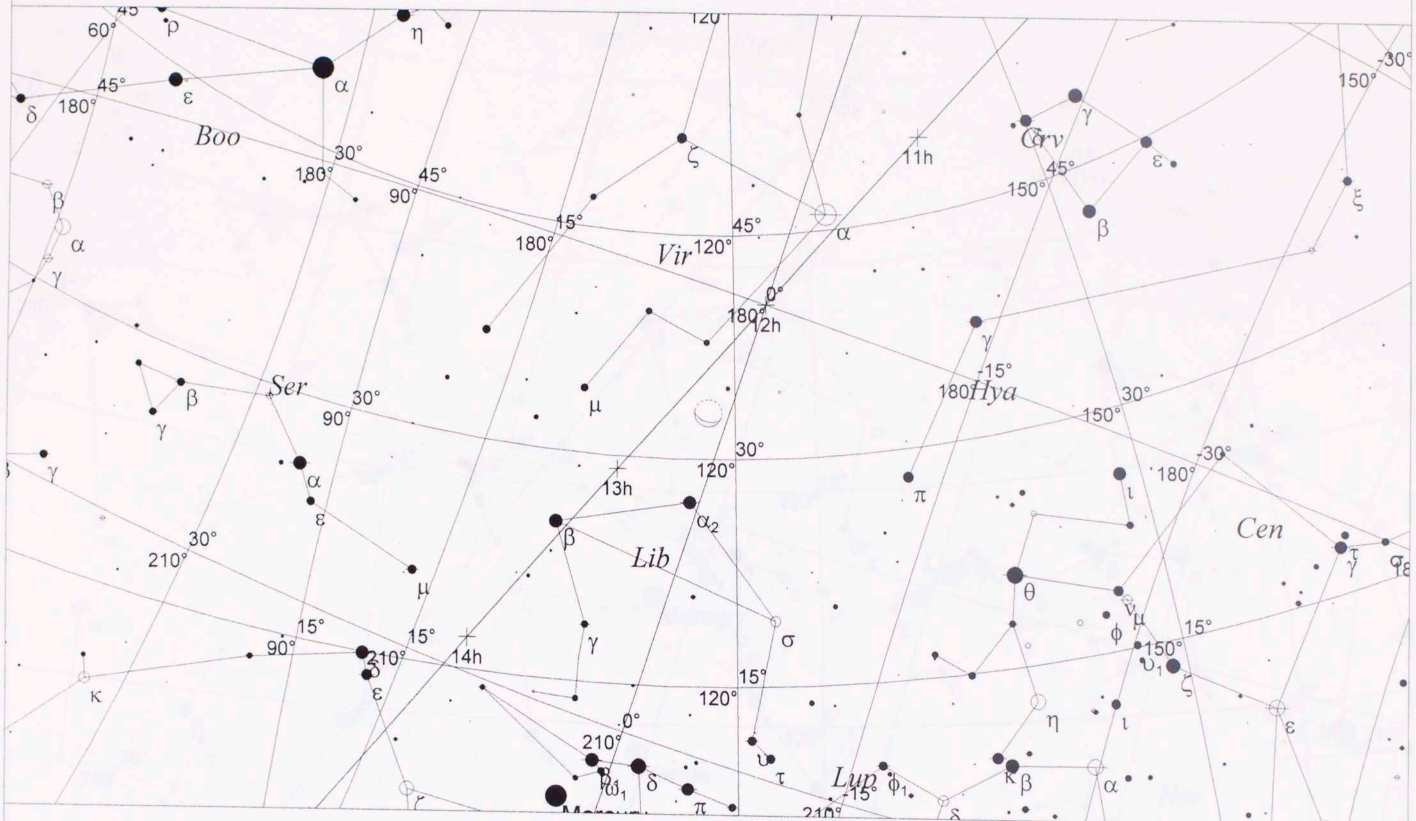


Local Time: 05:32:00 20-Nov-219BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:34:00 20-Nov-219BC
RA: 10h43m32s Dec: +7° 00' Field: 90.0°

Sidereal Time: 09:11:00
Julian Day: 1641756.6069

-218 VIII 25

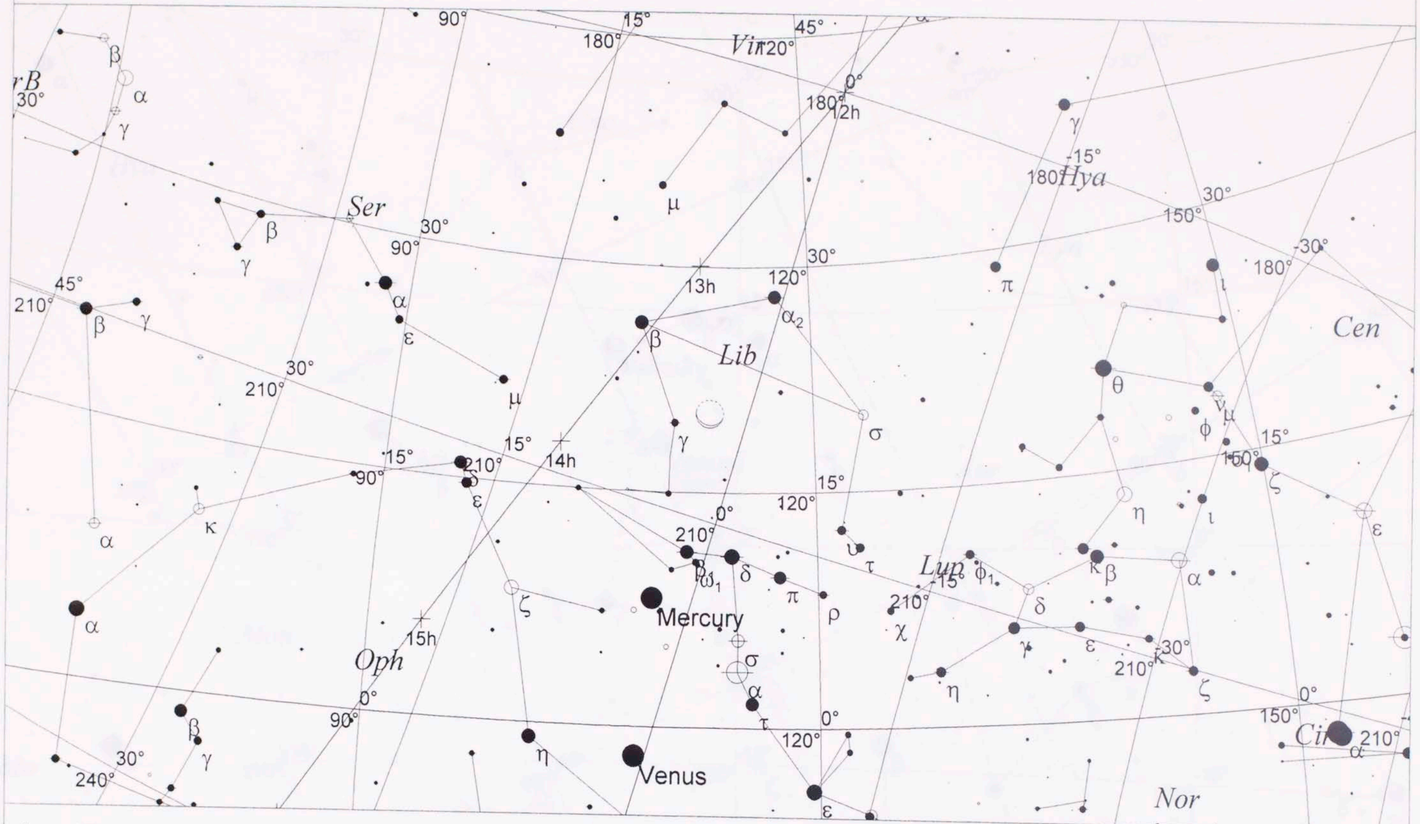


Local Time: 05:34:00 22-Nov-219BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:36:00 22-Nov-219BC
RA: 12h32m10s Dec: -2° 00' Field: 90.0°

Sidereal Time: 09:20:54
Julian Day: 1641758.6083

-218 VIII 26

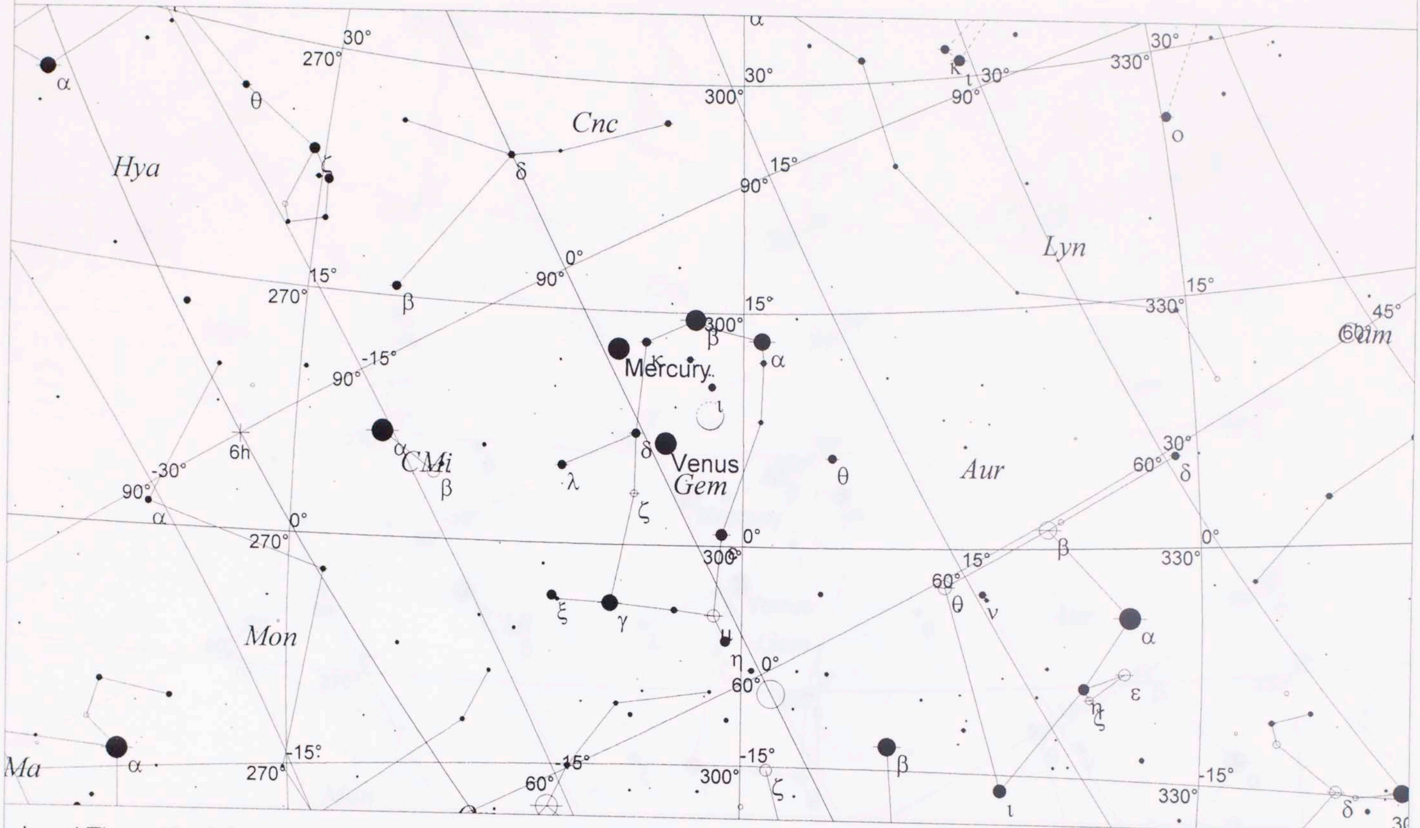


Local Time: 05:35:00 23-Nov-219BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:37:00 23-Nov-219BC
RA: 13h28m49s Dec: -6° 41' Field: 90.0°

Sidereal Time: 09:25:50
Julian Day: 1641759.6090

-190 III 1

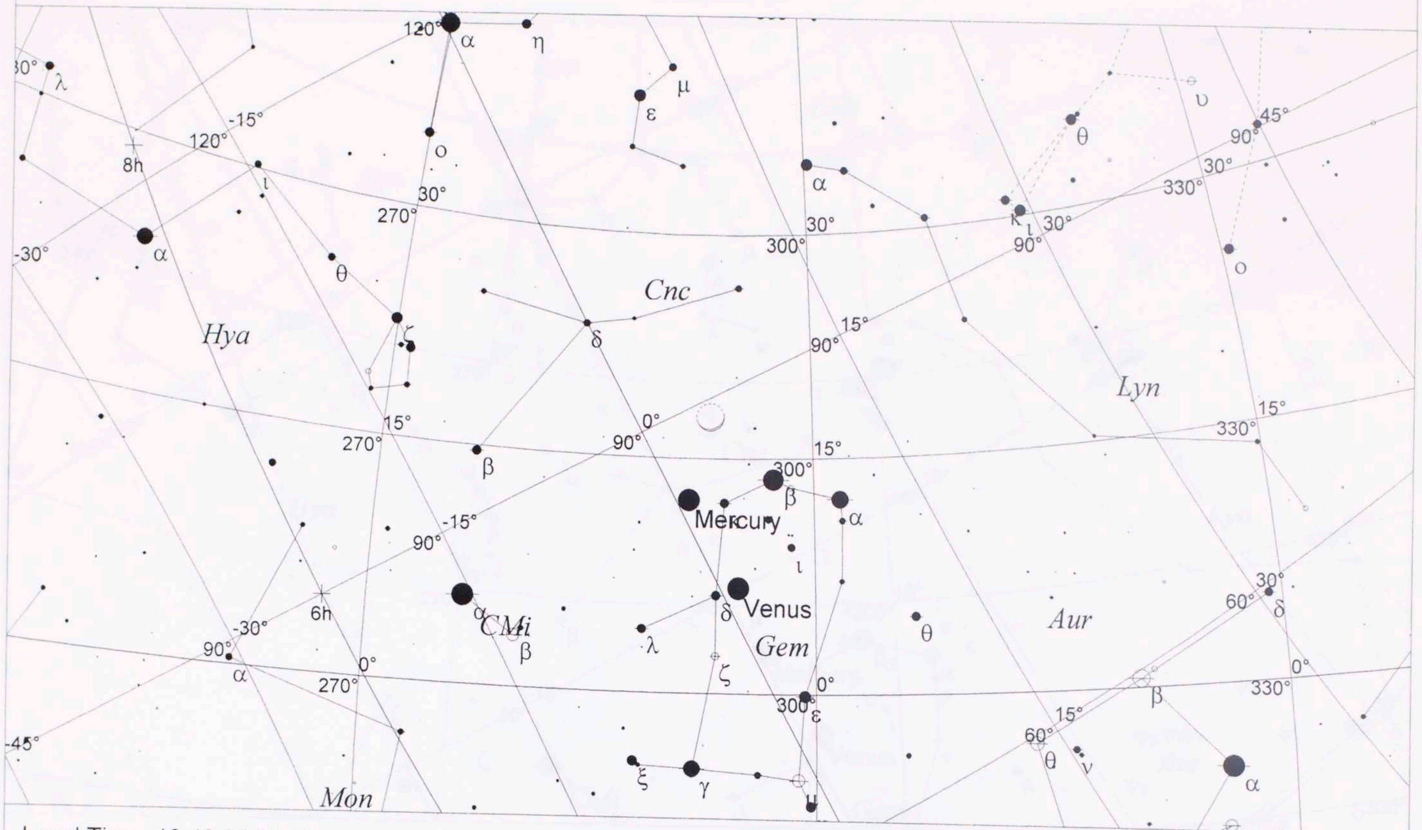


Local Time: 19:42:00 24-May-191BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 16:44:00 24-May-191BC
RA: 5h00m58s Dec: +27° 38' Field: 90.0°

Sidereal Time: 11:34:31
Julian Day: 1651804.1972

-190 III 2

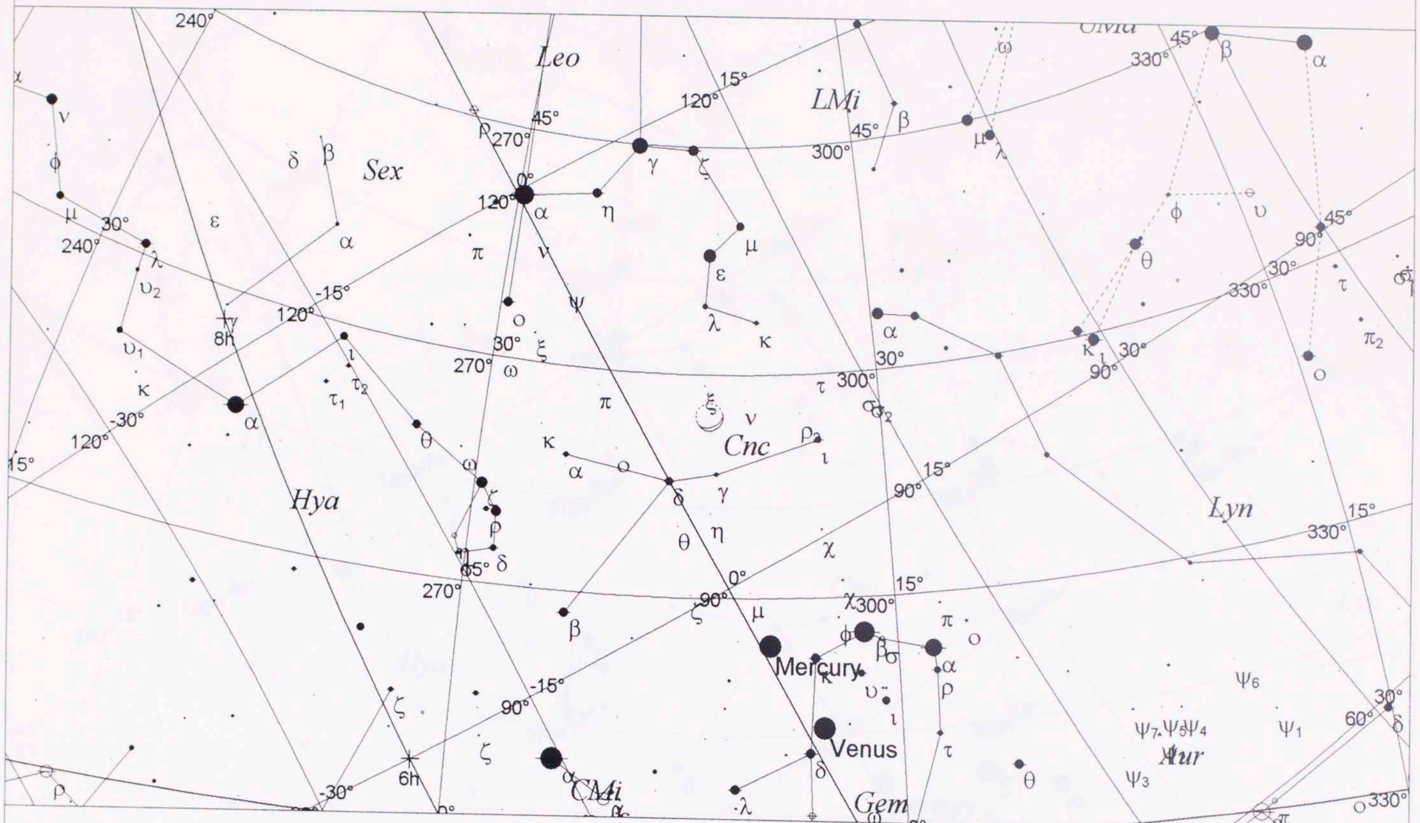


Local Time: 19:43:00 25-May-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:45:00 25-May-191BC
RA: 5h54m42s Dec: +28° 21' Field: 90.0°

Sidereal Time: 11:39:28
Julian Day: 1651805.1979

-190 III 3

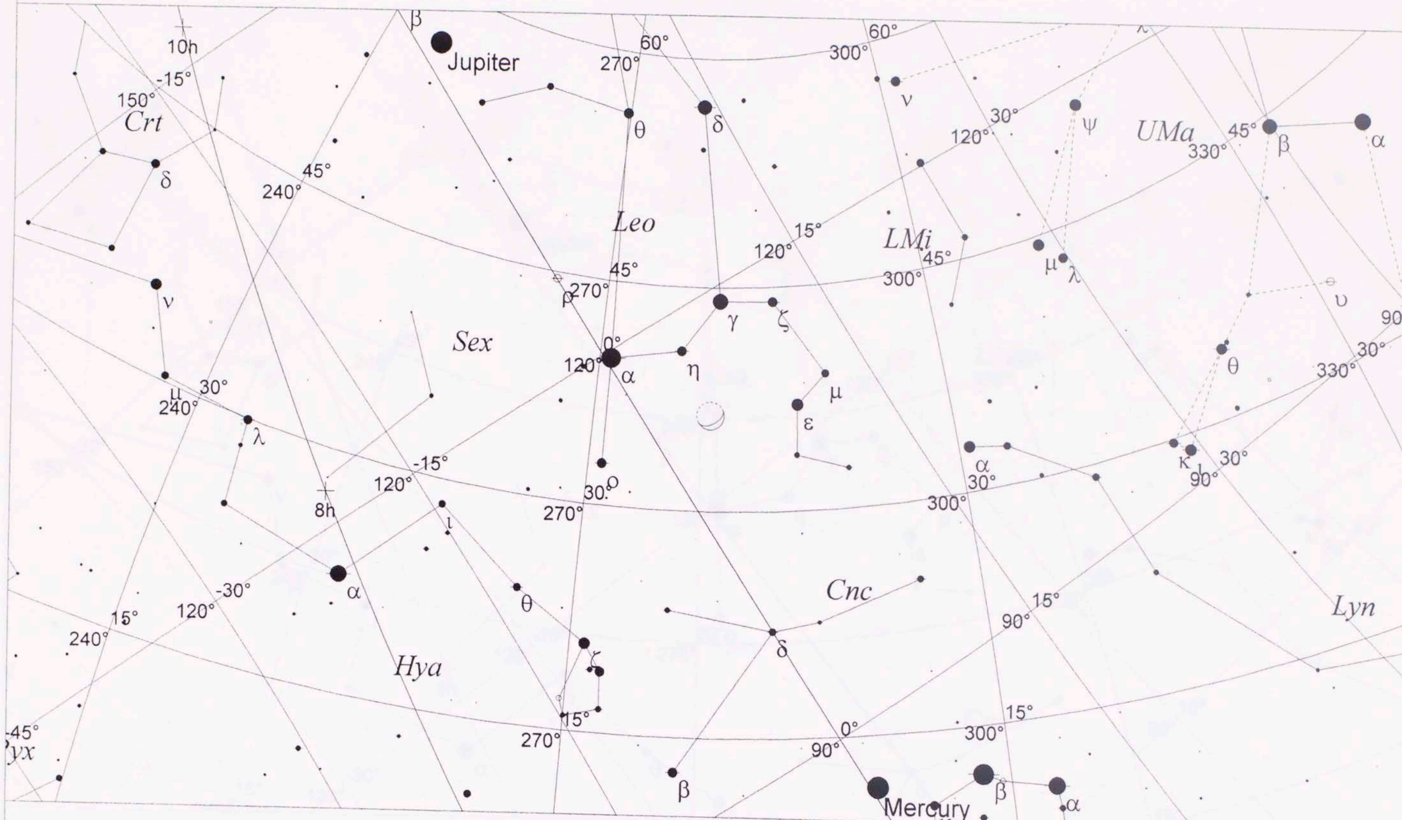


Local Time: 19:44:00 26-May-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:46:00 26-May-191BC
RA: 6h48m32s Dec: +27° 44' Field: 90.0°

Sidereal Time: 11:44:24
Julian Day: 1651806.1986

-190 III 4

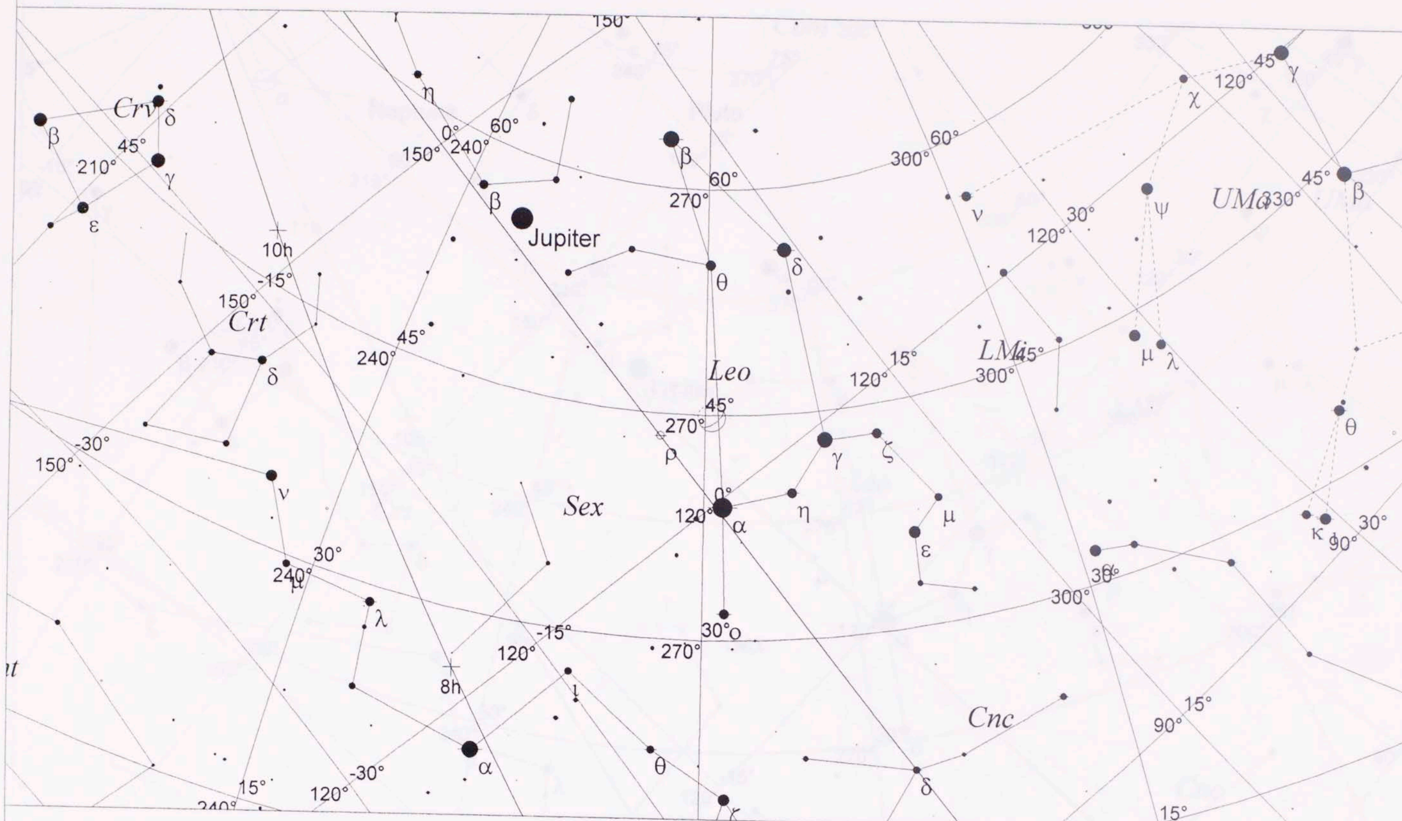


Local Time: 19:44:00 27-May-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:46:00 27-May-191BC
RA: 7h41m21s Dec: +25° 49' Field: 90.0°

Sidereal Time: 11:48:21
Julian Day: 1651807.1986

-190 III 5

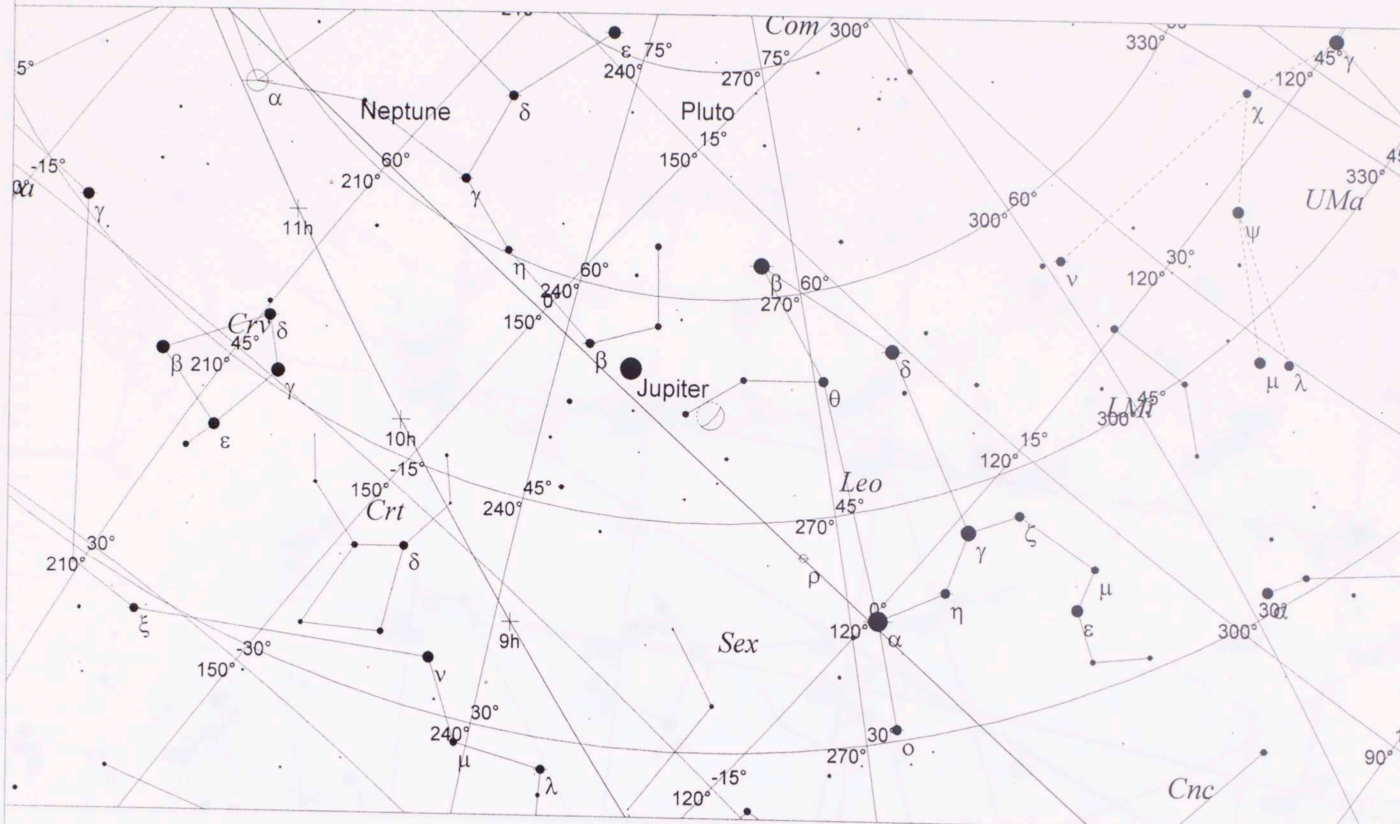


Local Time: 19:45:00 28-May-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:47:00 28-May-191BC
RA: 8h32m29s Dec: +22° 41' Field: 90.0°

Sidereal Time: 11:53:18
Julian Day: 1651808.1993

-190 III 6

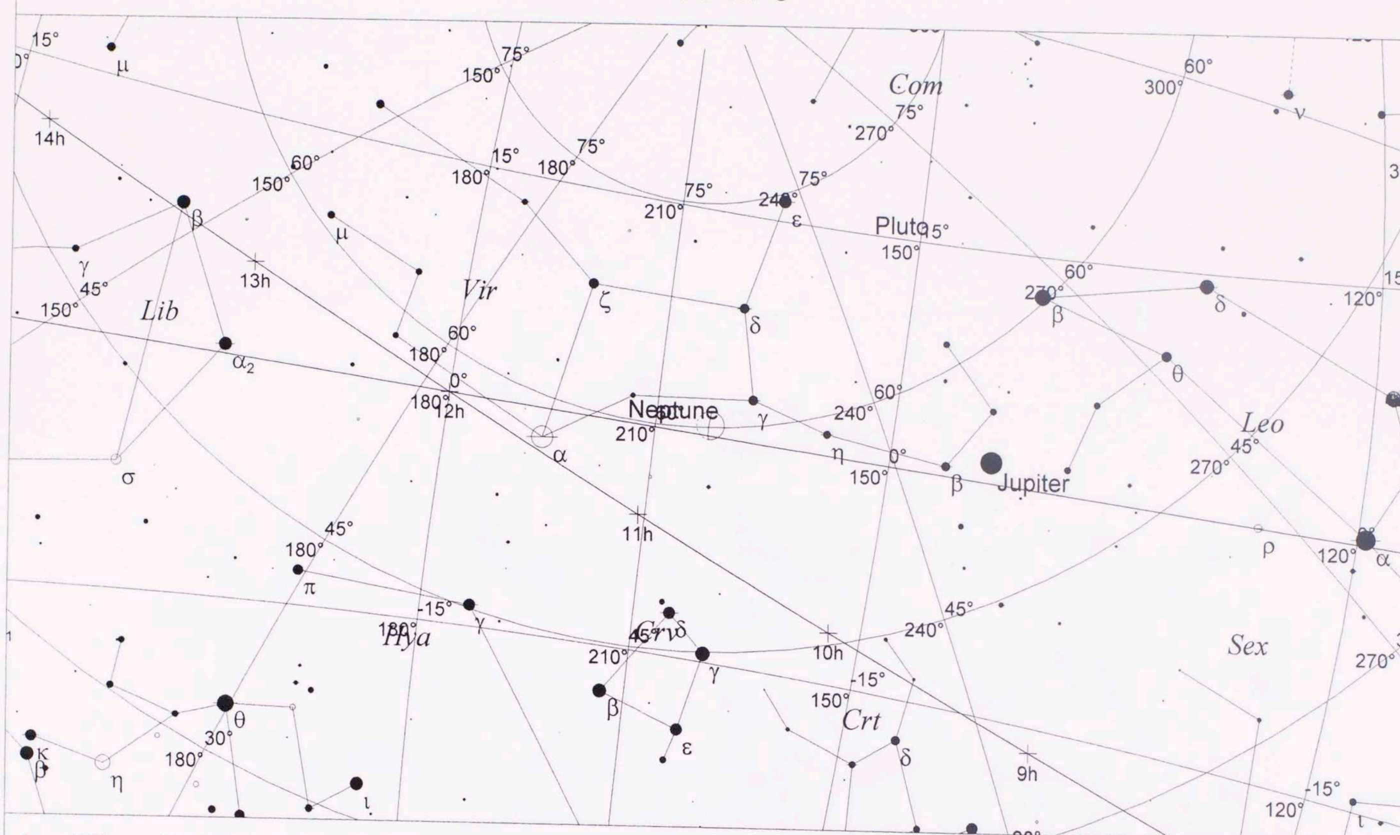


Local Time: 19:46:00 29-May-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:48:00 29-May-191BC
RA: 9h21m42s Dec: +18° 30' Field: 90.0°

Sidereal Time: 11:58:14
Julian Day: 1651809.2000

-190 III 8

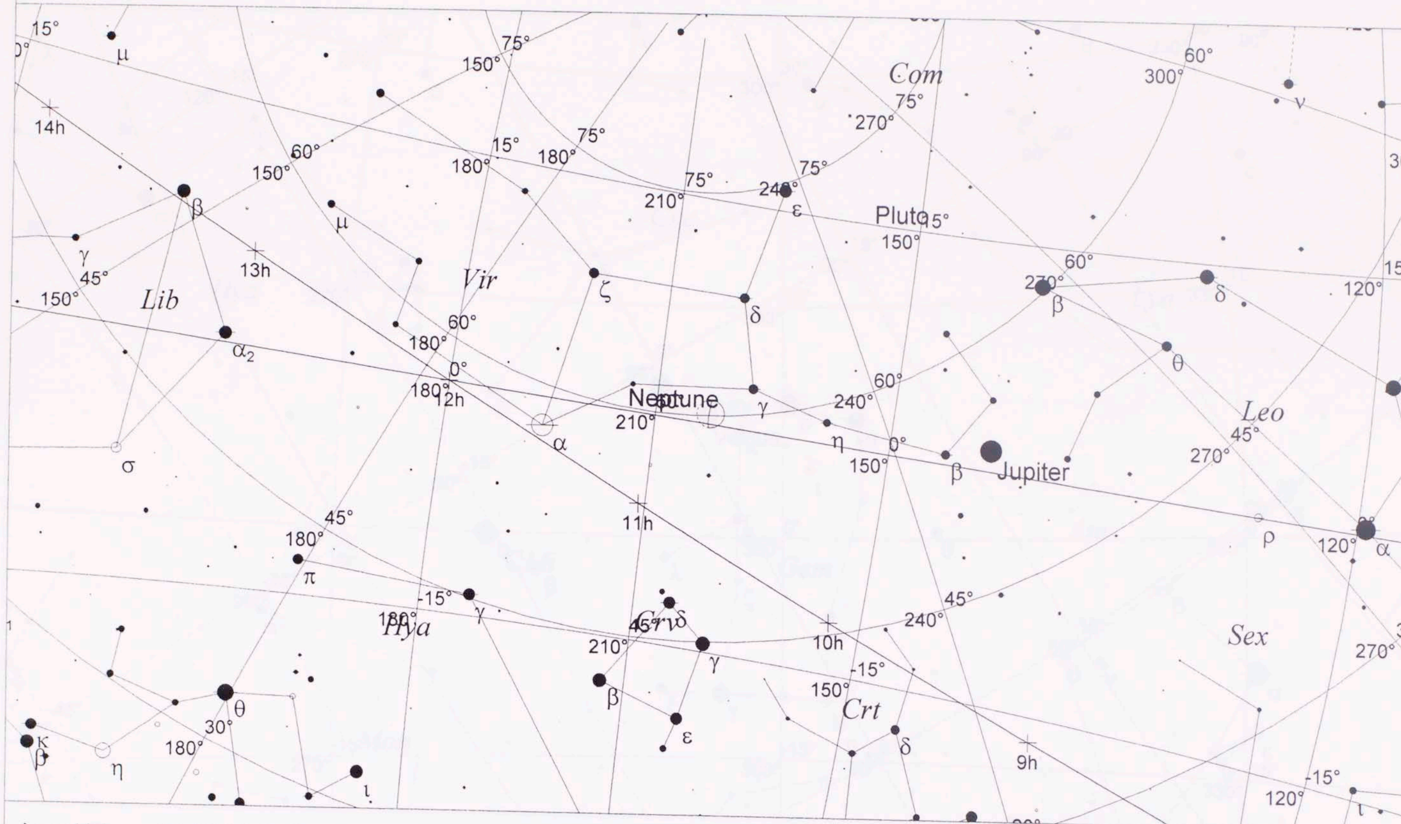


Local Time: 19:47:00 31-May-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:49:00 31-May-191BC
RA: 10h55m55s Dec: +7° 41' Field: 90.0°

Sidereal Time: 12:07:08
Julian Day: 1651811.2007

-190 III 8

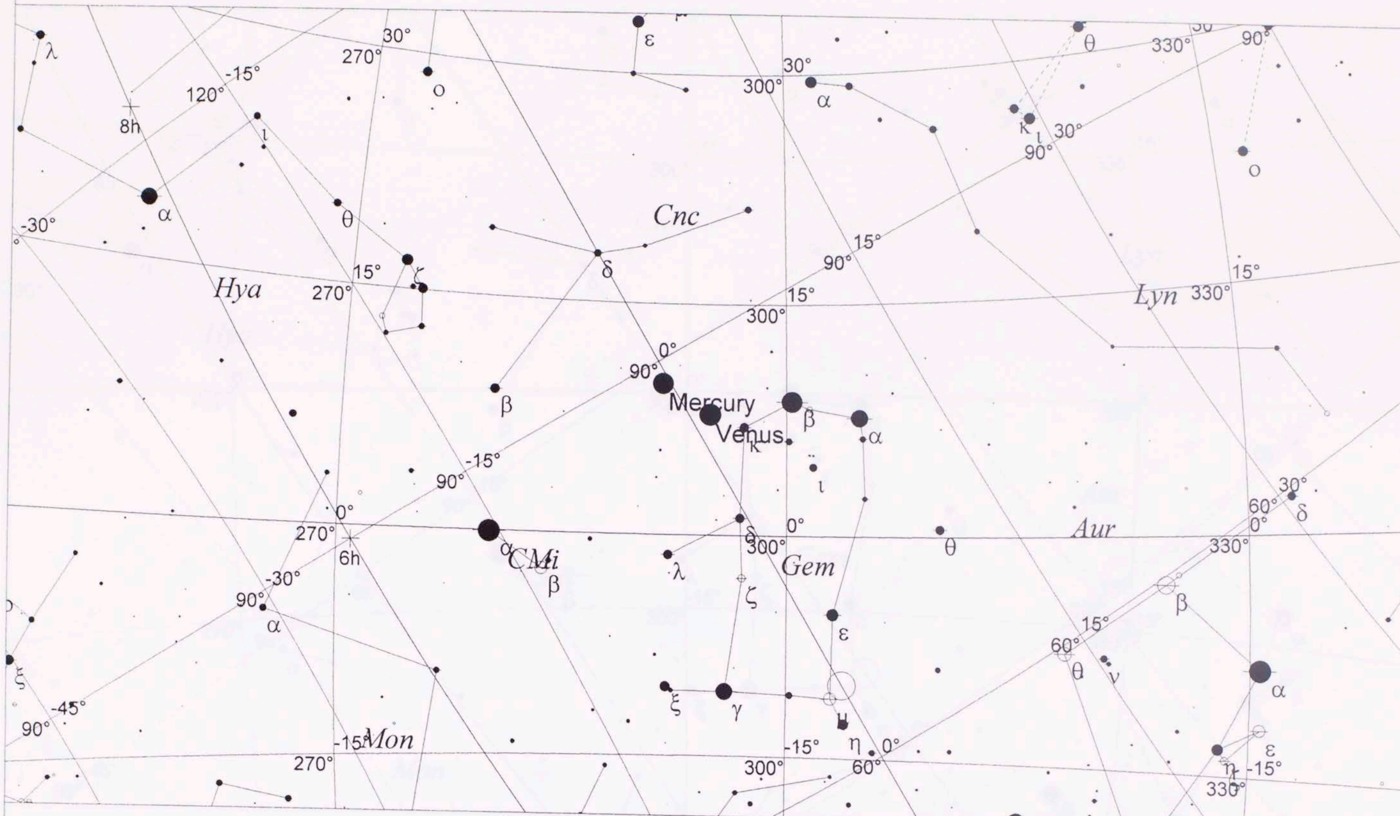


Local Time: 19:47:00 31-May-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:49:00 31-May-191BC
RA: 10h55m55s Dec: +7° 41' Field: 90.0°

Sidereal Time: 12:07:08
Julian Day: 1651811.2007

-190 III 8

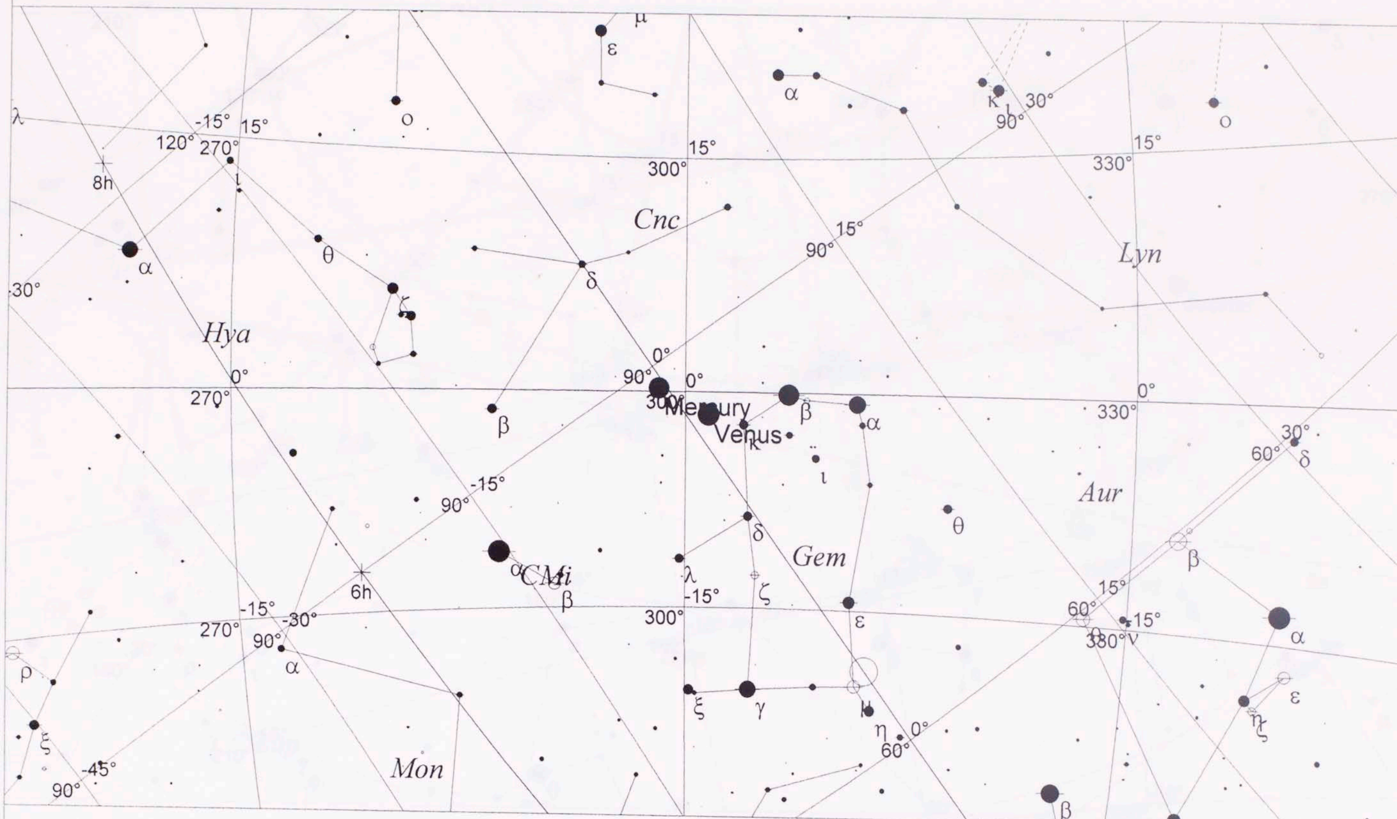


Local Time: 19:47:00 31-May-191BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 16:49:00 31-May-191BC
RA: 5h38m30s Dec: +24° 54' Field: 90.0°

Sidereal Time: 12:07:08
Julian Day: 1651811.2007

-190 III 8

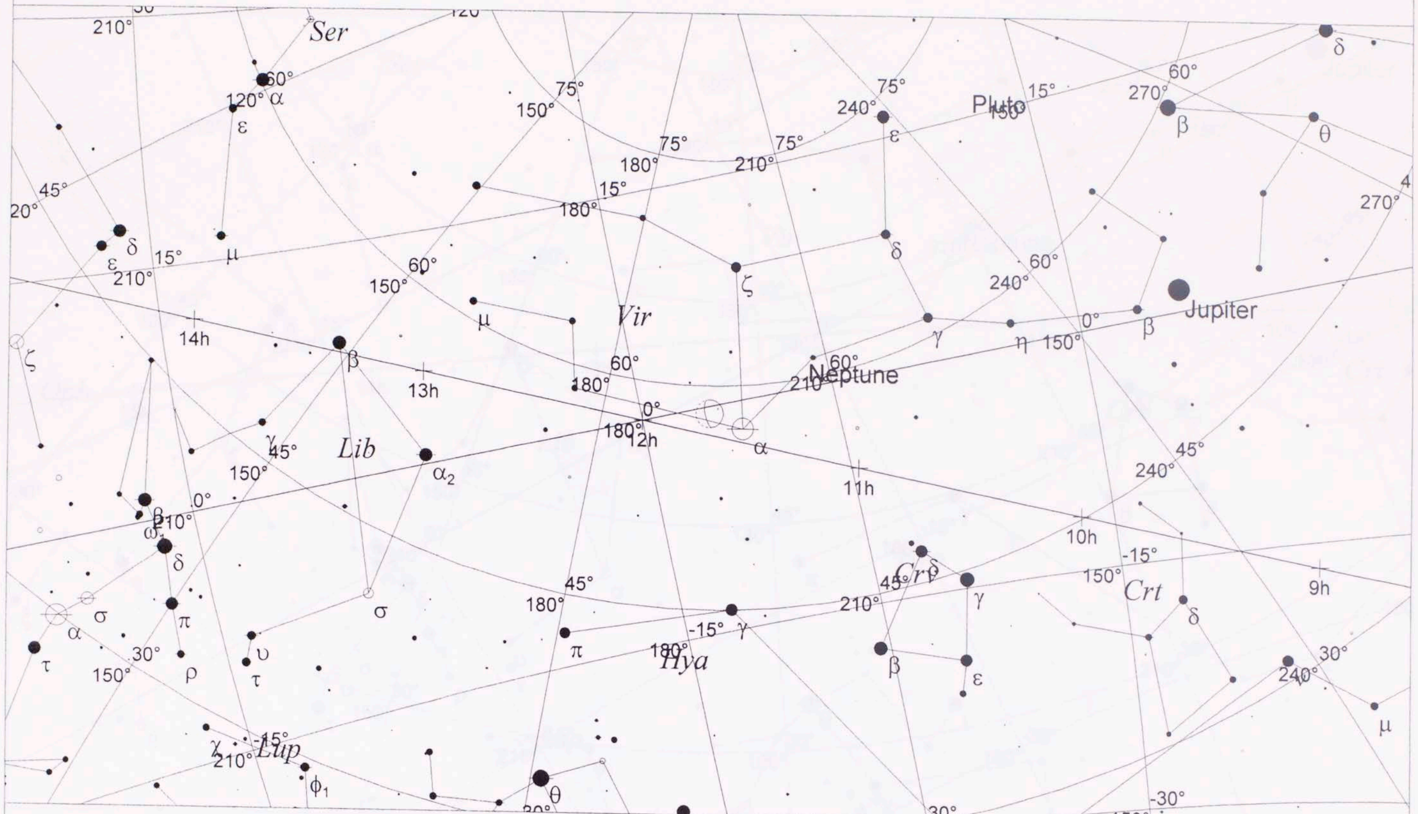


Local Time: 20:39:00 31-May-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 17:41:00 31-May-191BC
RA: 5h38m41s Dec: +24° 54' Field: 90.0°

Sidereal Time: 12:59:16
Julian Day: 1651811.2368

-190 III 9

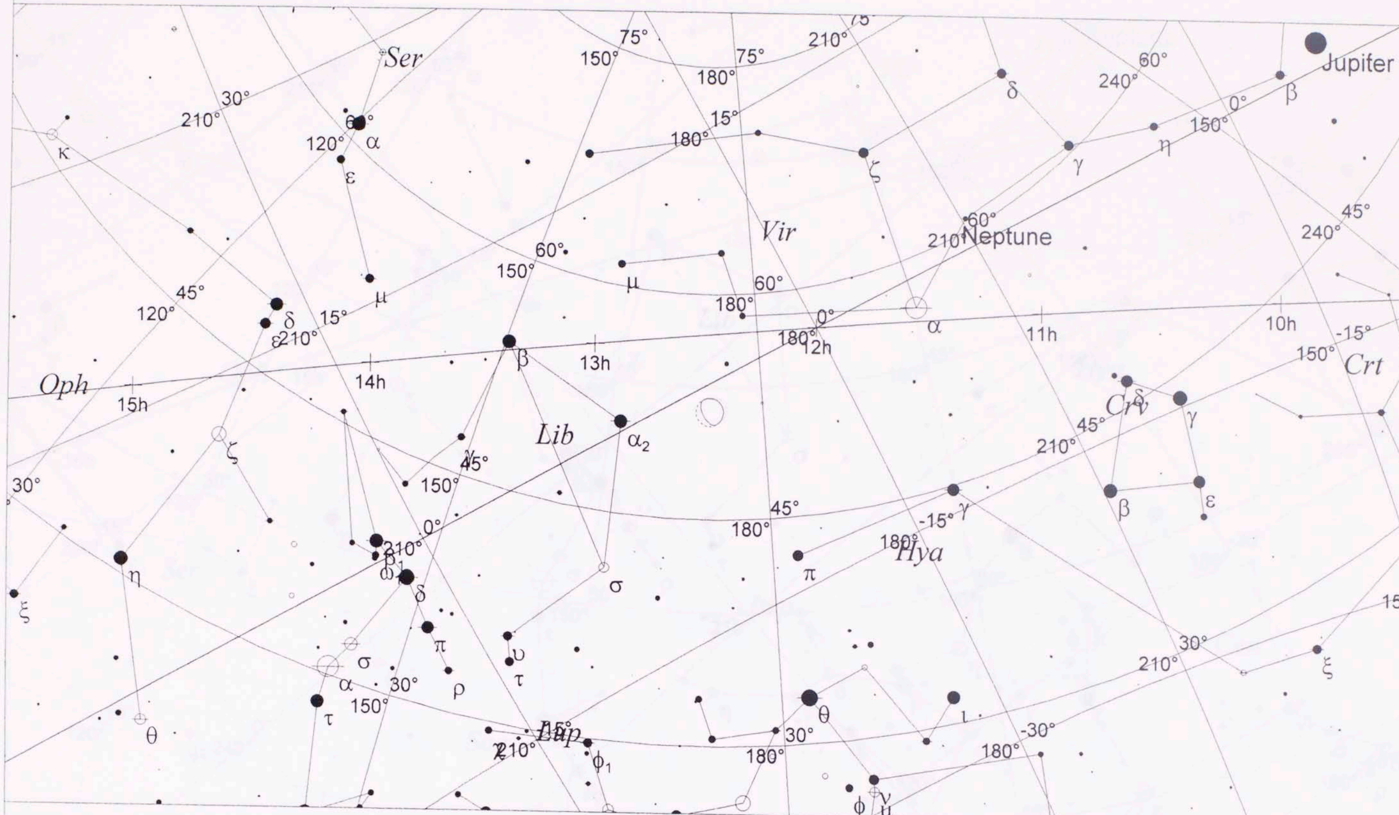


Local Time: 19:47:00 1-Jun-191BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 16:49:00 1-Jun-191BC
RA: 11h42m37s Dec: +1° 24' Field: 90.0°

Sidereal Time: 12:11:04
Julian Day: 1651812.2007

-190 III 10

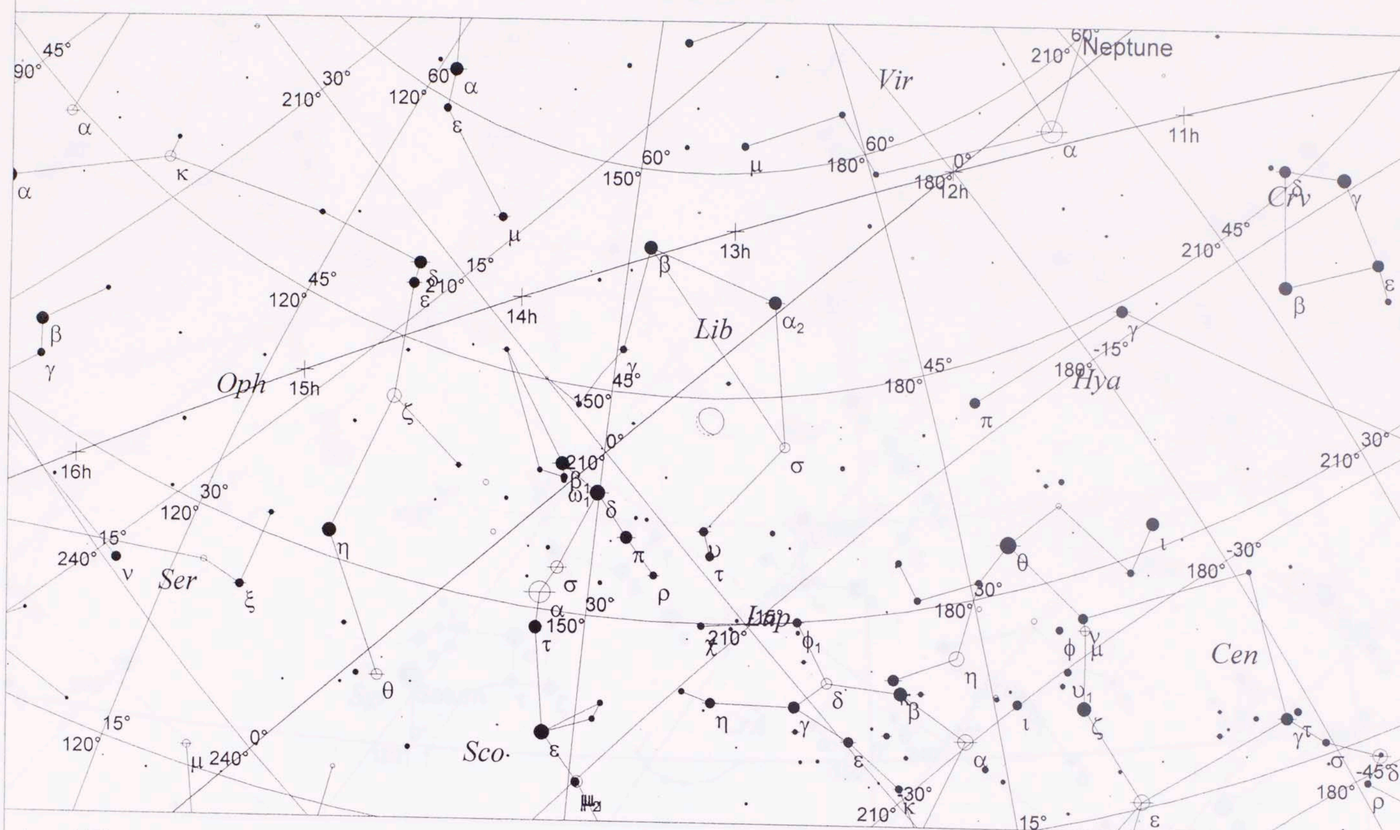


Local Time: 19:48:00 2-Jun-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:50:00 2-Jun-191BC
RA: 12h30m37s Dec: -5° 09' Field: 90.0°

Sidereal Time: 12:16:01
Julian Day: 1651813.2014

-190 III 11

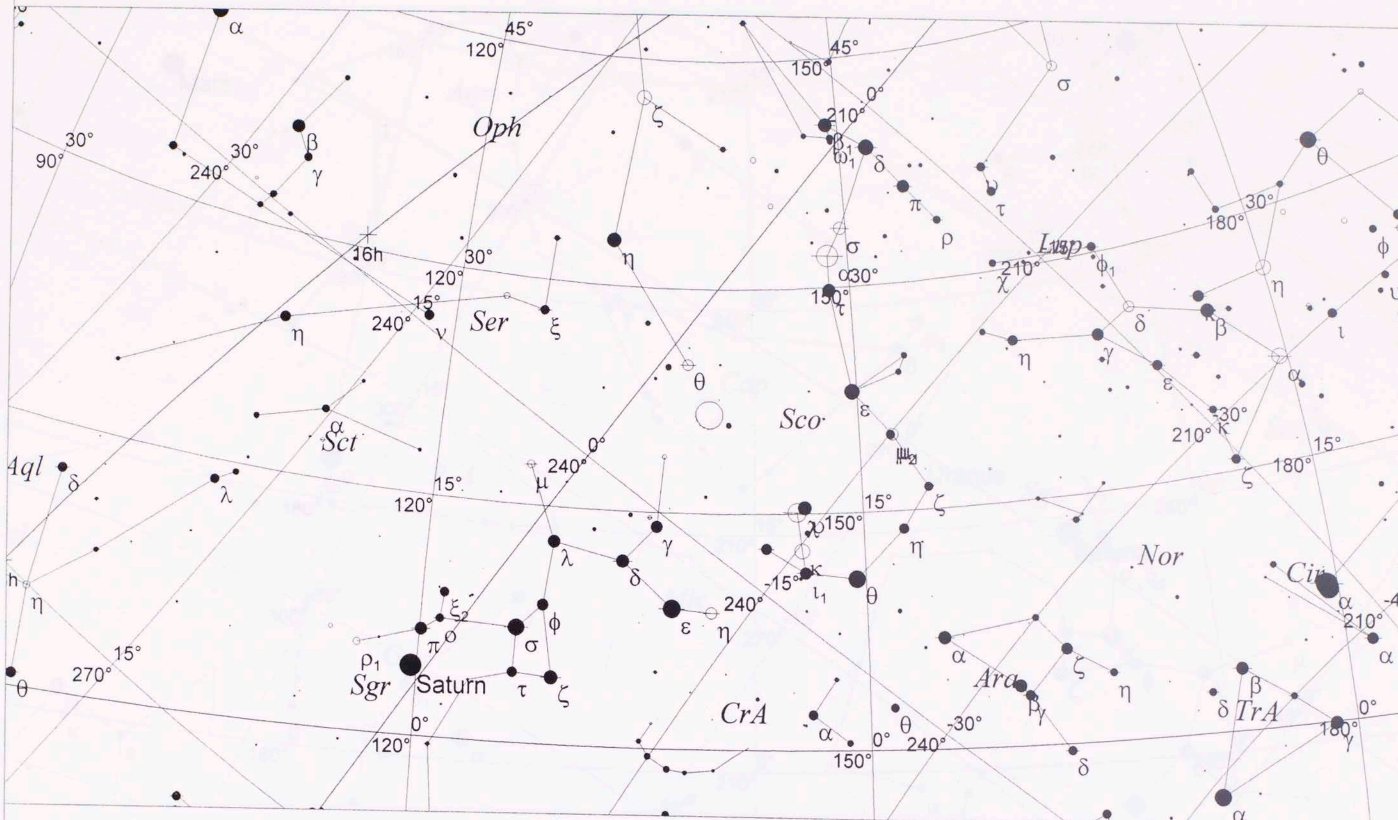


Local Time: 19:49:00 3-Jun-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:51:00 3-Jun-191BC
RA: 13h21m15s Dec: -11° 44' Field: 90.0°

Sidereal Time: 12:20:58
Julian Day: 1651814.2021

-190 III 13

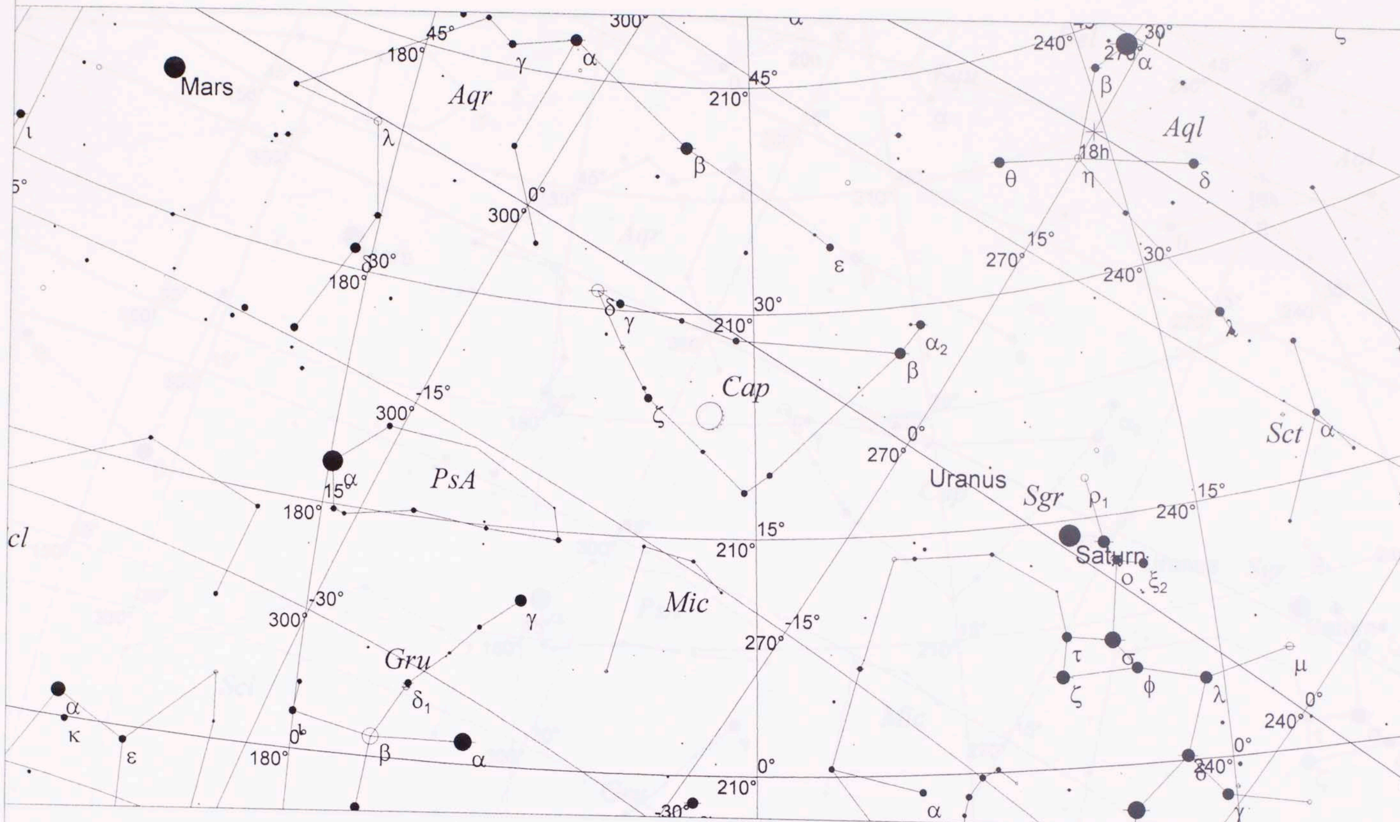


Local Time: 19:50:00 5-Jun-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:52:00 5-Jun-191BC
RA: 15h15m36s Dec: -23° 15' Field: 90.0°

Sidereal Time: 12:29:51
Julian Day: 1651816.2028

-190 III 16

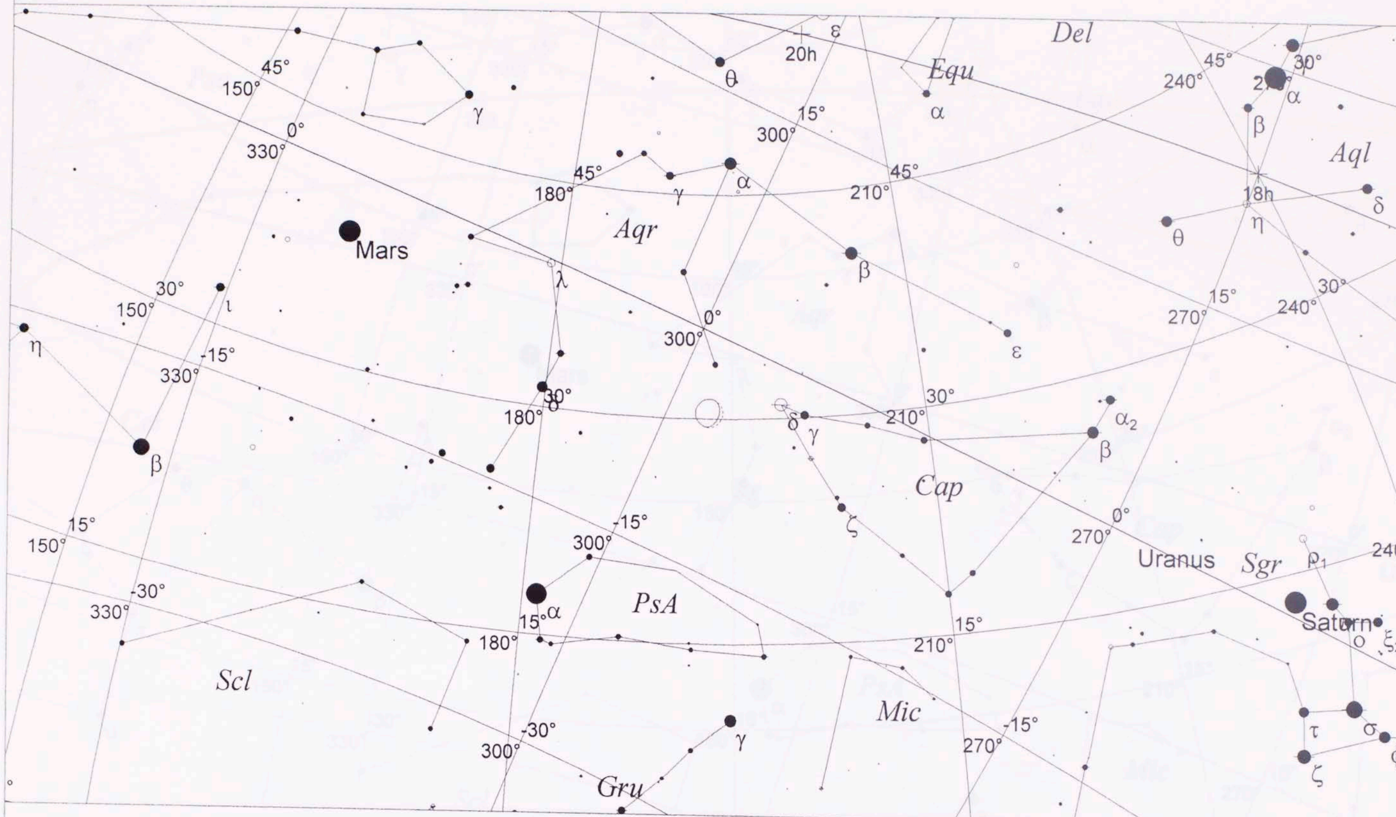


Local Time: 03:55:00 9-Jun-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 00:57:00 9-Jun-191BC
RA: 18h55m42s Dec: -28° 41' Field: 90.0°

Sidereal Time: 20:48:00
Julian Day: 1651819.5396

-190 III 17

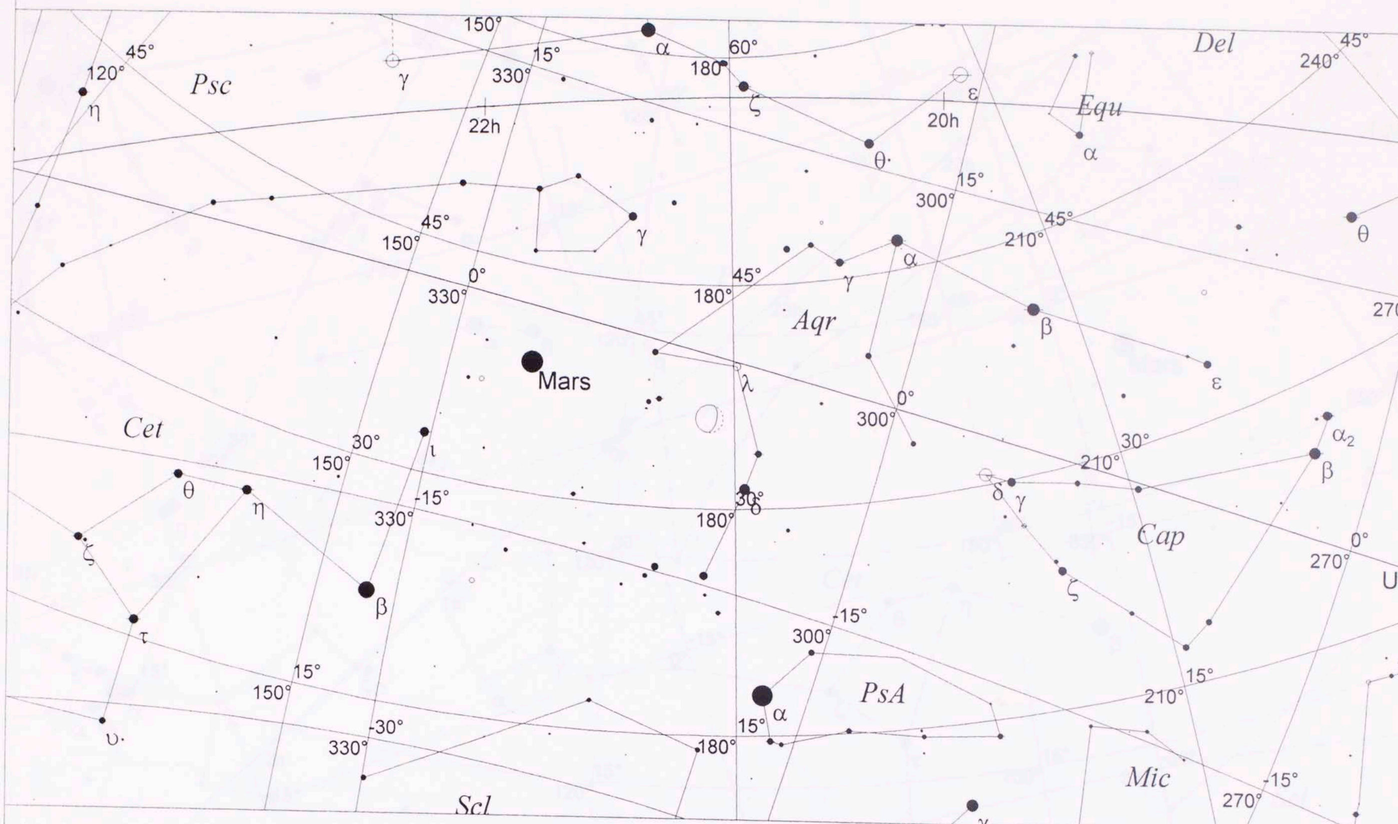


Local Time: 03:55:00 10-Jun-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 00:57:00 10-Jun-191BC
RA: 20h02m04s Dec: -25° 51' Field: 90.0°

Sidereal Time: 20:51:57
Julian Day: 1651820.5396

-190 III 18

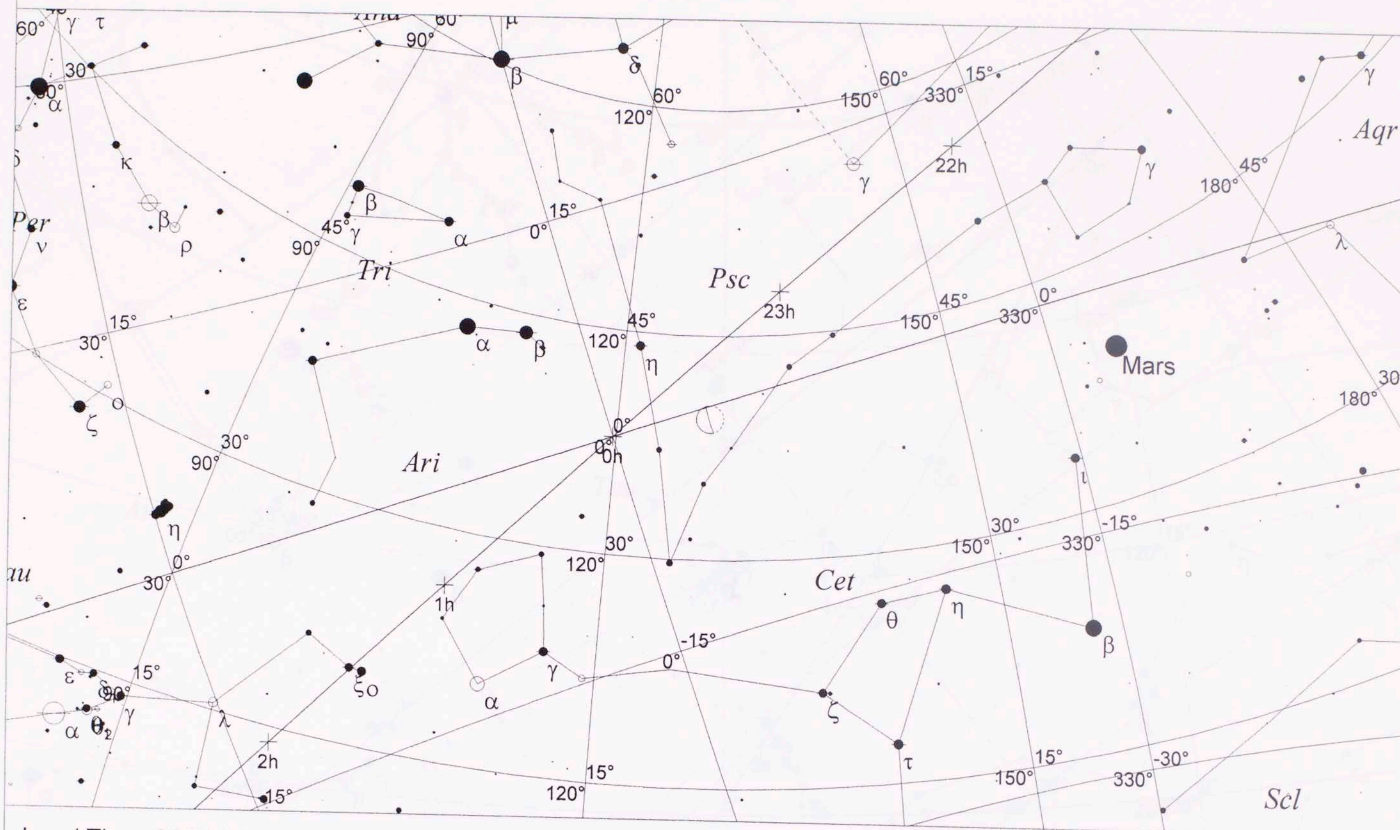


Local Time: 03:55:00 11-Jun-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 00:57:00 11-Jun-191BC
RA: 21h03m07s Dec: -21° 24' Field: 90.0°

Sidereal Time: 20:55:53
Julian Day: 1651821.5396

-190 III 21

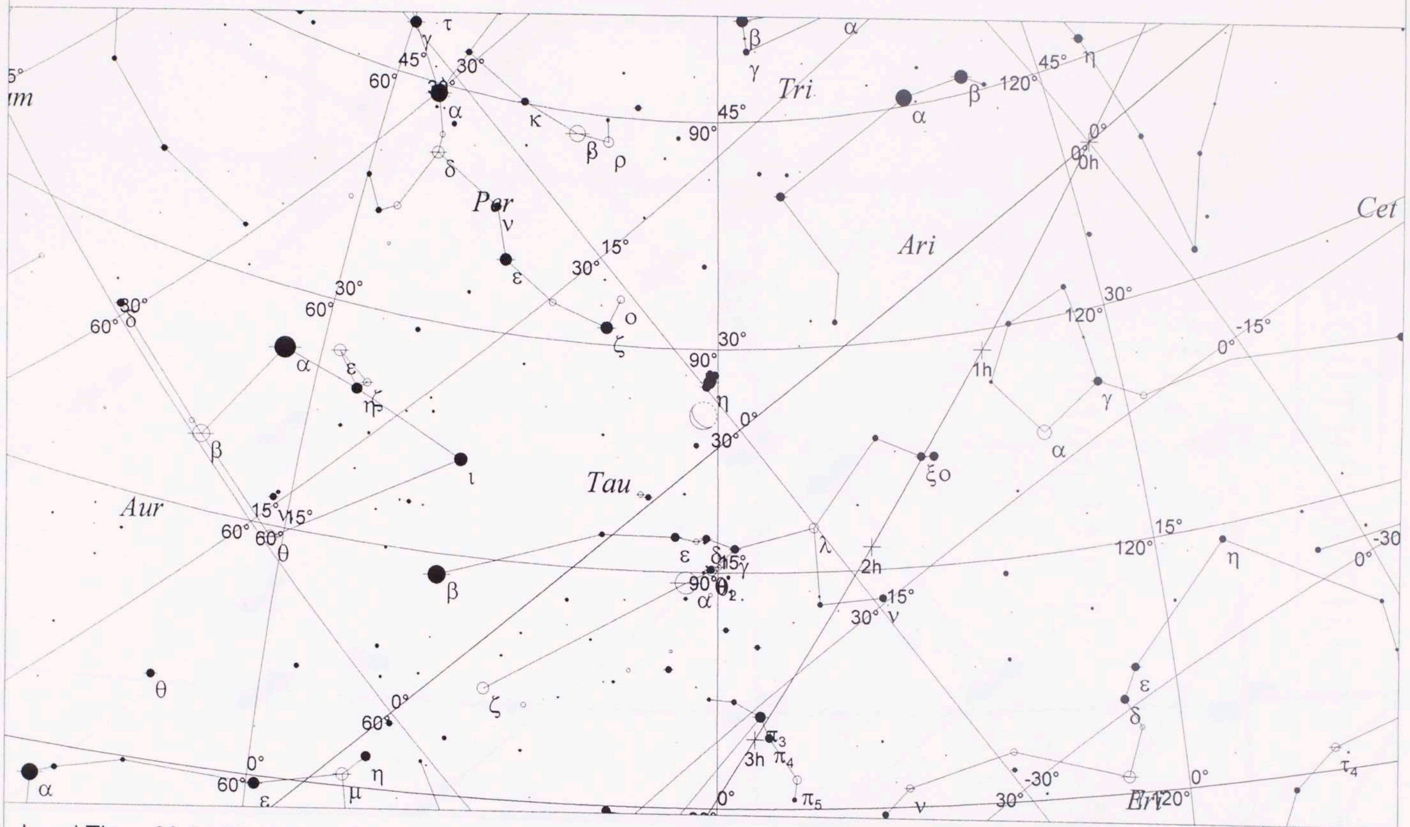


Local Time: 03:54:00 14-Jun-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 00:56:00 14-Jun-191BC
RA: 23h36m56s Dec: -3° 26' Field: 90.0°

Sidereal Time: 21:06:43
Julian Day: 1651824.5389

-190 III 24

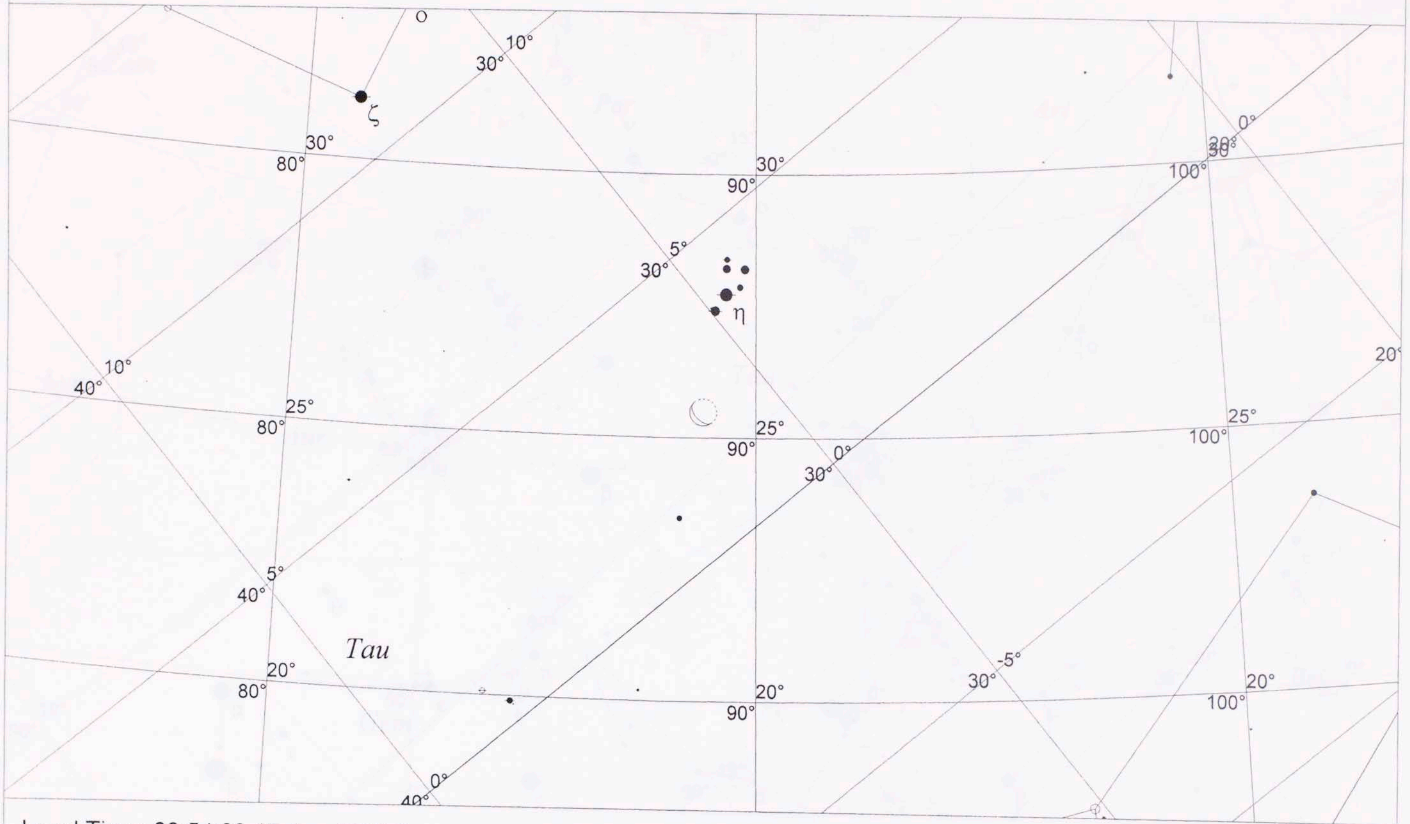


Local Time: 03:54:00 17-Jun-191BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 00:56:00 17-Jun-191BC
RA: 1h53m09s Dec: +14° 15' Field: 90.0°

Sidereal Time: 21:18:33
Julian Day: 1651827.5389

-190 III 24

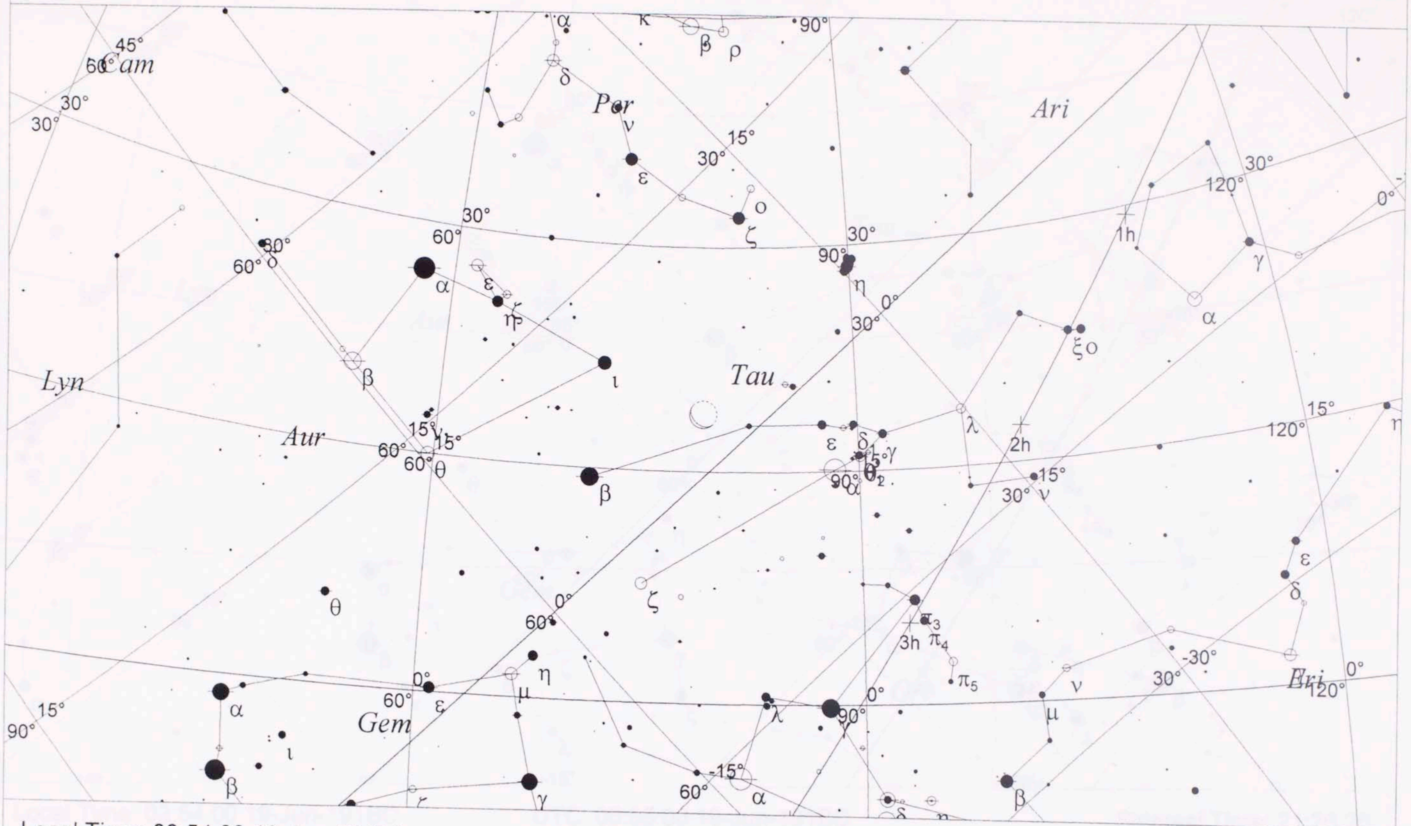


Local Time: 03:54:00 17-Jun-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 00:56:00 17-Jun-191BC
RA: 1h53m09s Dec: +14° 15' Field: 26.7°

Sidereal Time: 21:18:33
Julian Day: 1651827.5389

-190 III 25

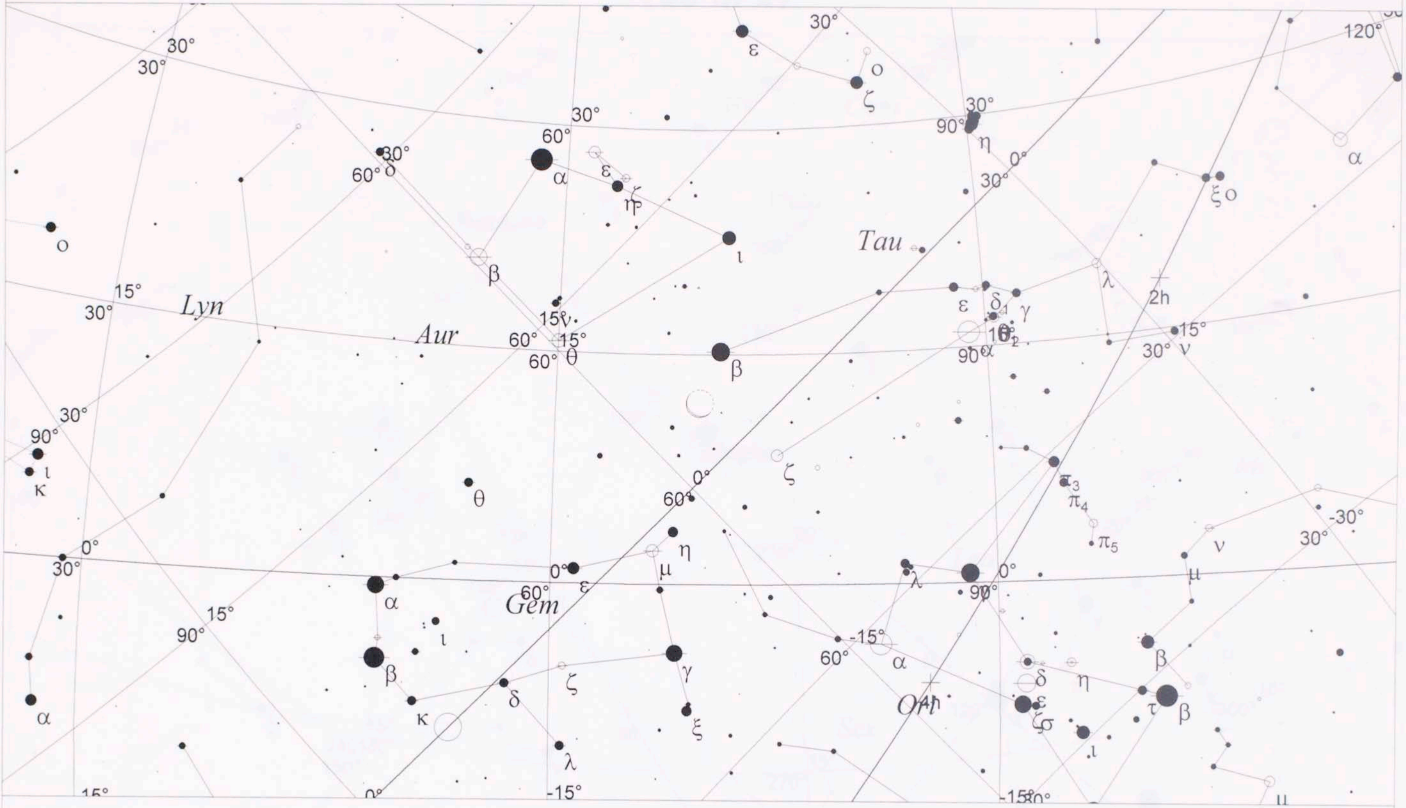


Local Time: 03:54:00 18-Jun-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 00:56:00 18-Jun-191BC
RA: 2h40m03s Dec: +19° 03' Field: 90.0°

Sidereal Time: 21:22:29
Julian Day: 1651828.5389

-190 III 26

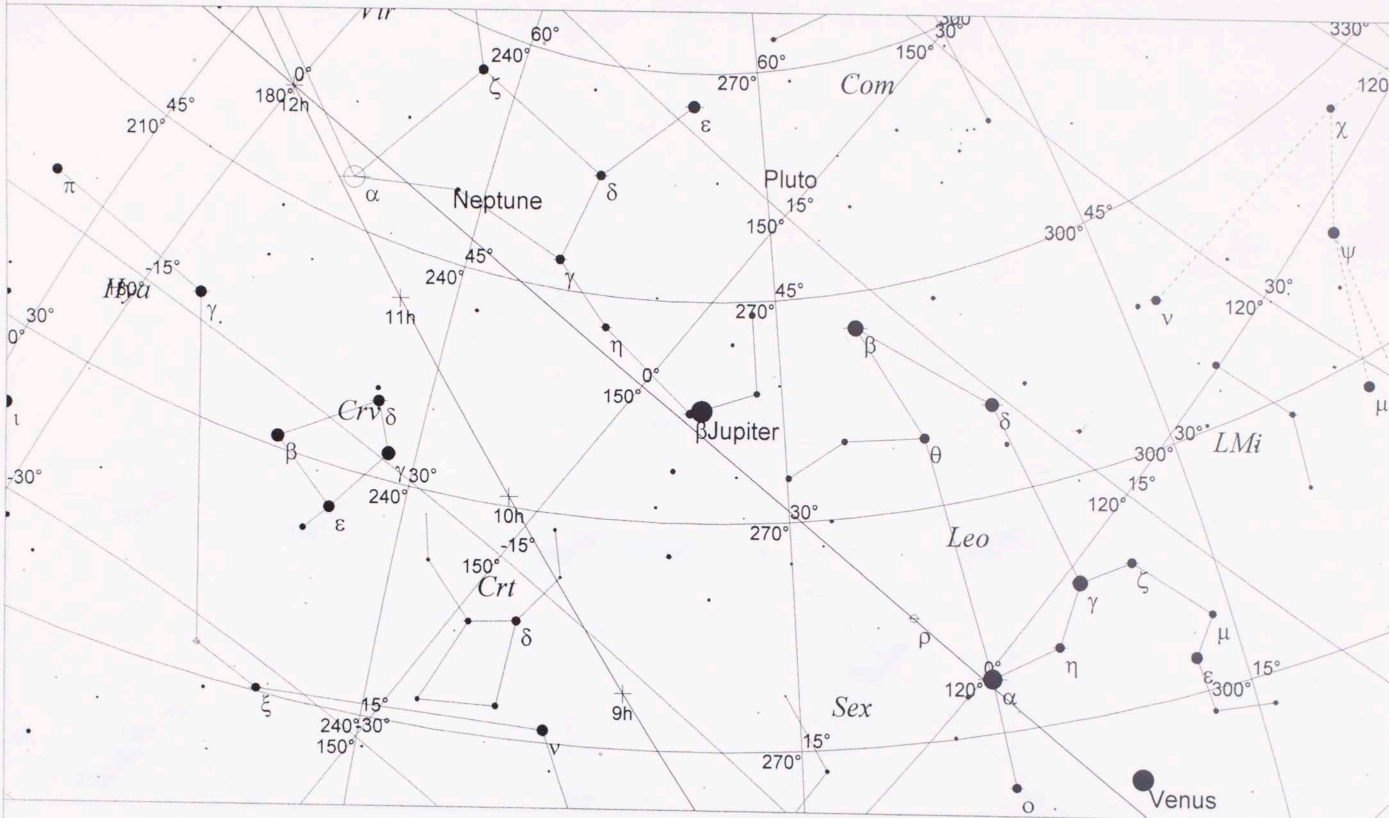


Local Time: 03:54:00 19-Jun-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 00:56:00 19-Jun-191BC
RA: 3h28m52s Dec: +23° 00' Field: 90.0°

Sidereal Time: 21:26:26
Julian Day: 1651829.5389

-190 III 27

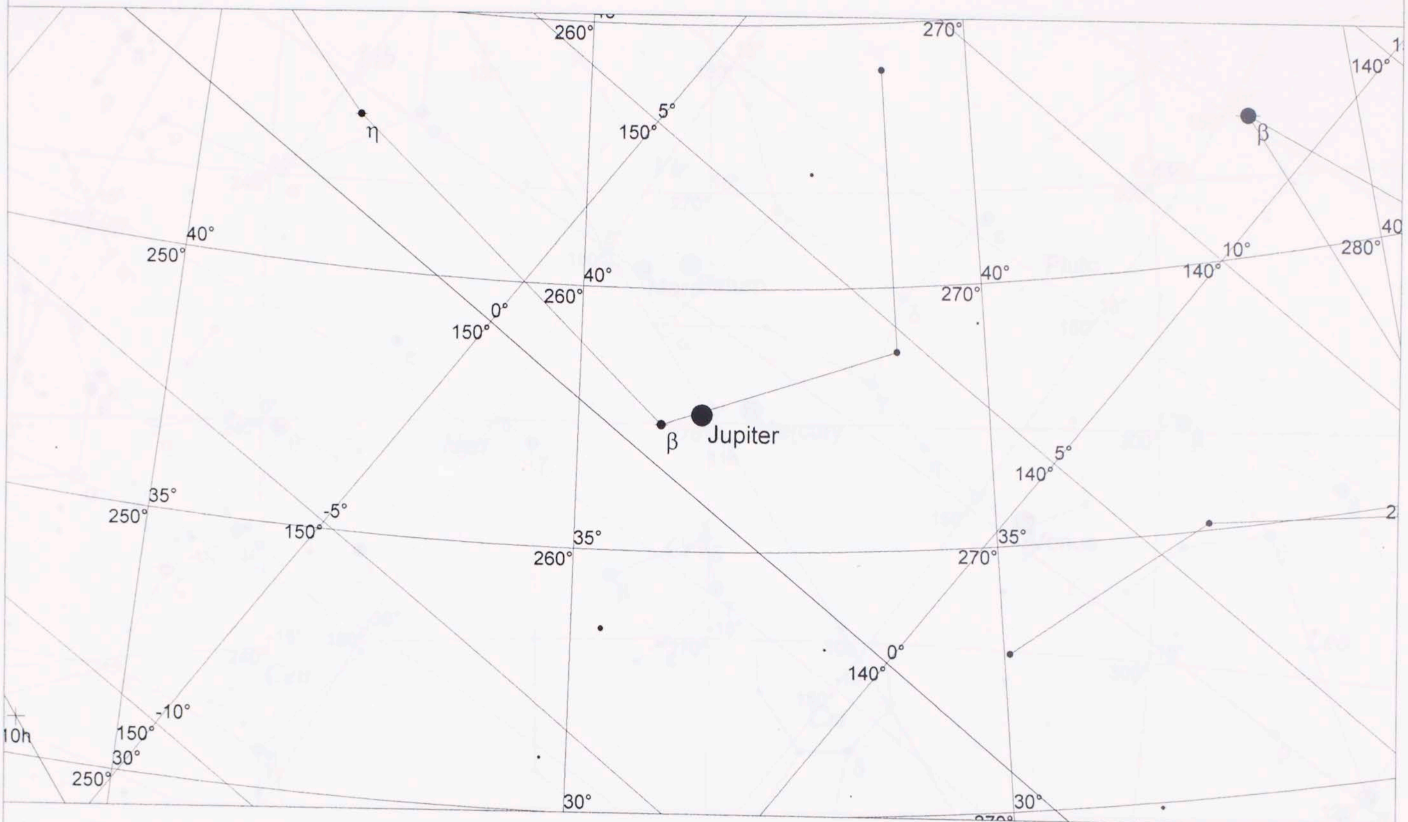


Local Time: 19:56:00 19-Jun-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:58:00 19-Jun-191BC
RA: 9h54m07s Dec: +14° 17' Field: 90.0°

Sidereal Time: 13:31:04
Julian Day: 1651830.2069

-190 III 27

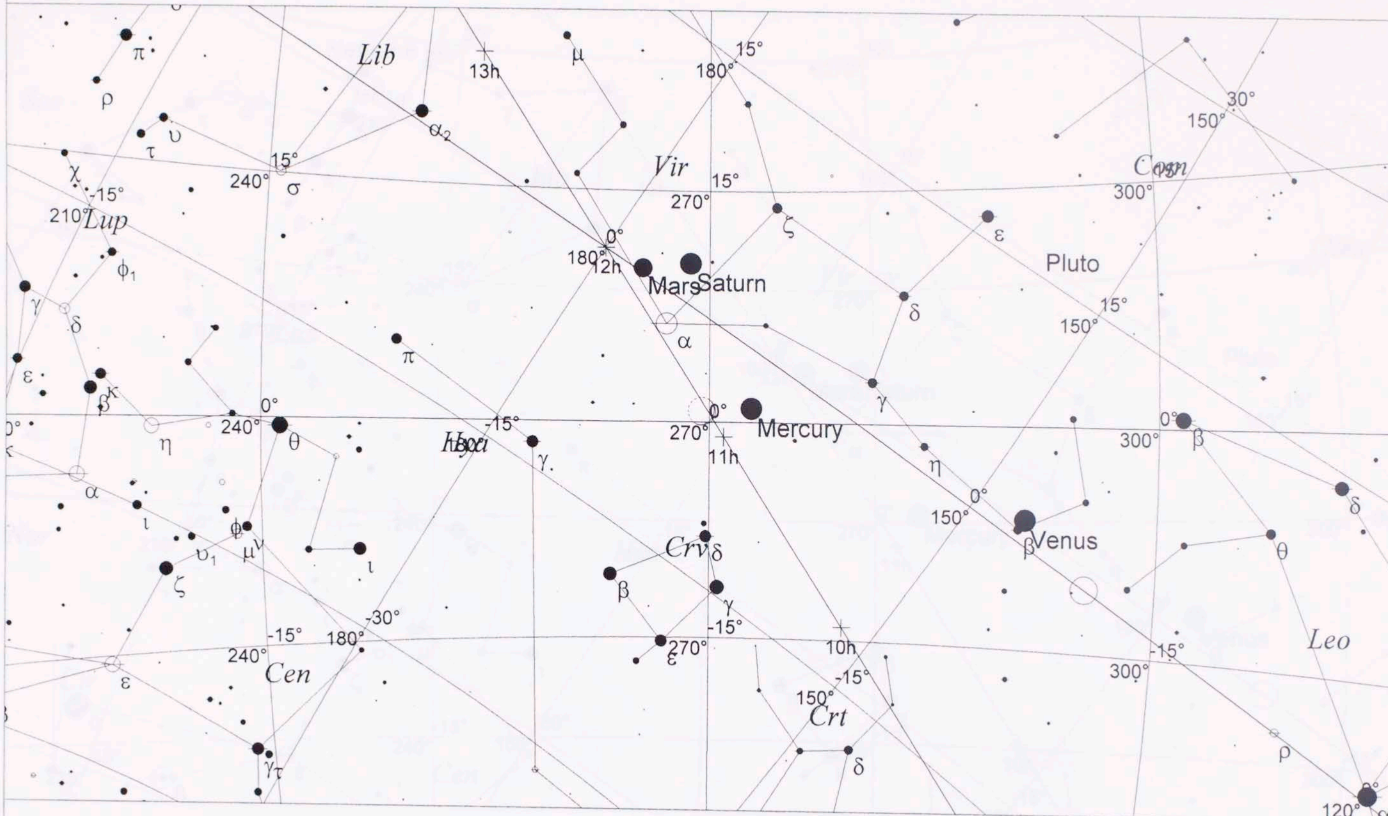


Local Time: 19:56:00 19-Jun-191BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:58:00 19-Jun-191BC
RA: 9h54m07s Dec: +14° 17' Field: 26.7°

Sidereal Time: 13:31:04
Julian Day: 1651830.2069

-168 V 1

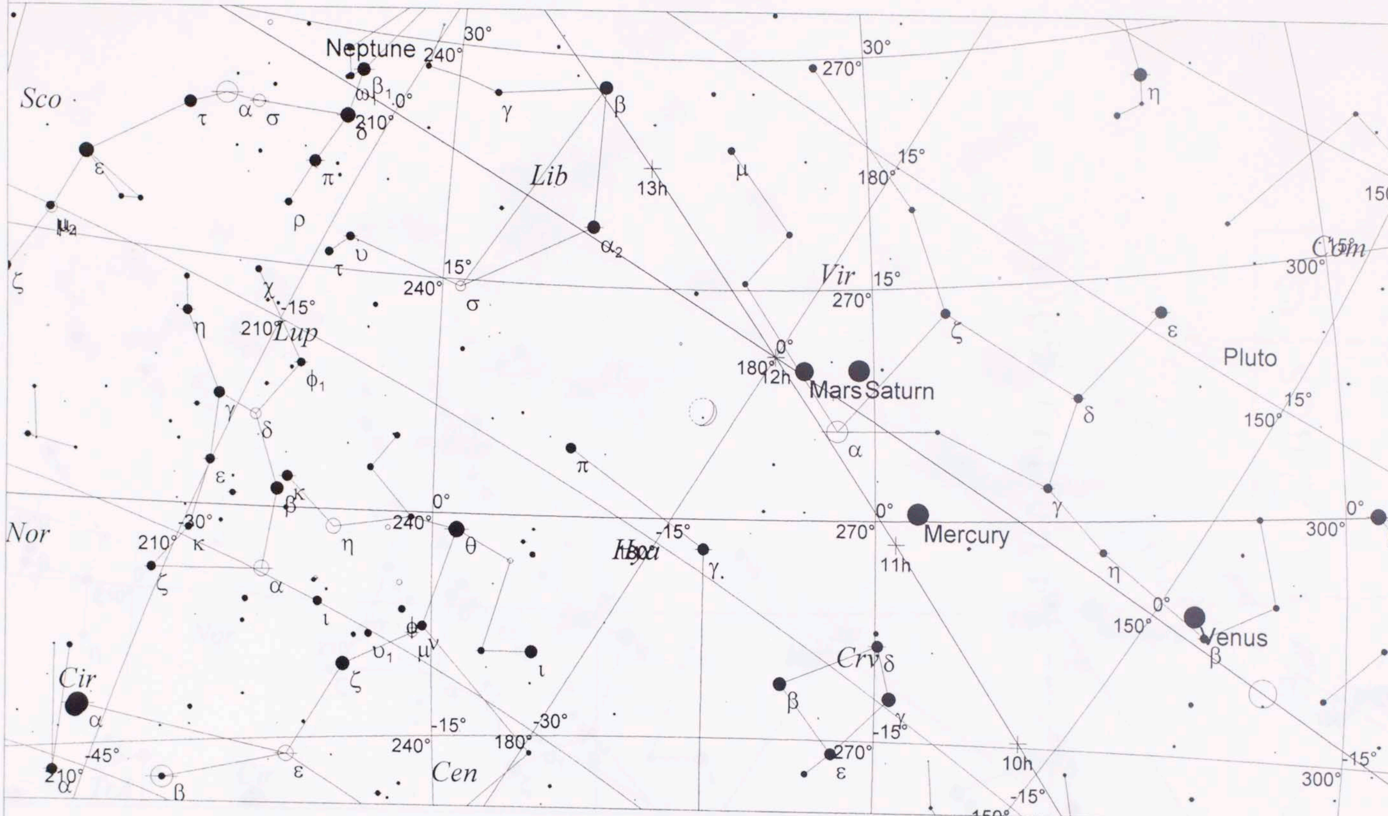


Local Time: 19:37:00 17-Aug-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:39:00 17-Aug-169BC
RA: 11h08m58s Dec: -0° 20' Field: 90.0°

Sidereal Time: 17:07:16
Julian Day: 1659925.1937

-168 V 2

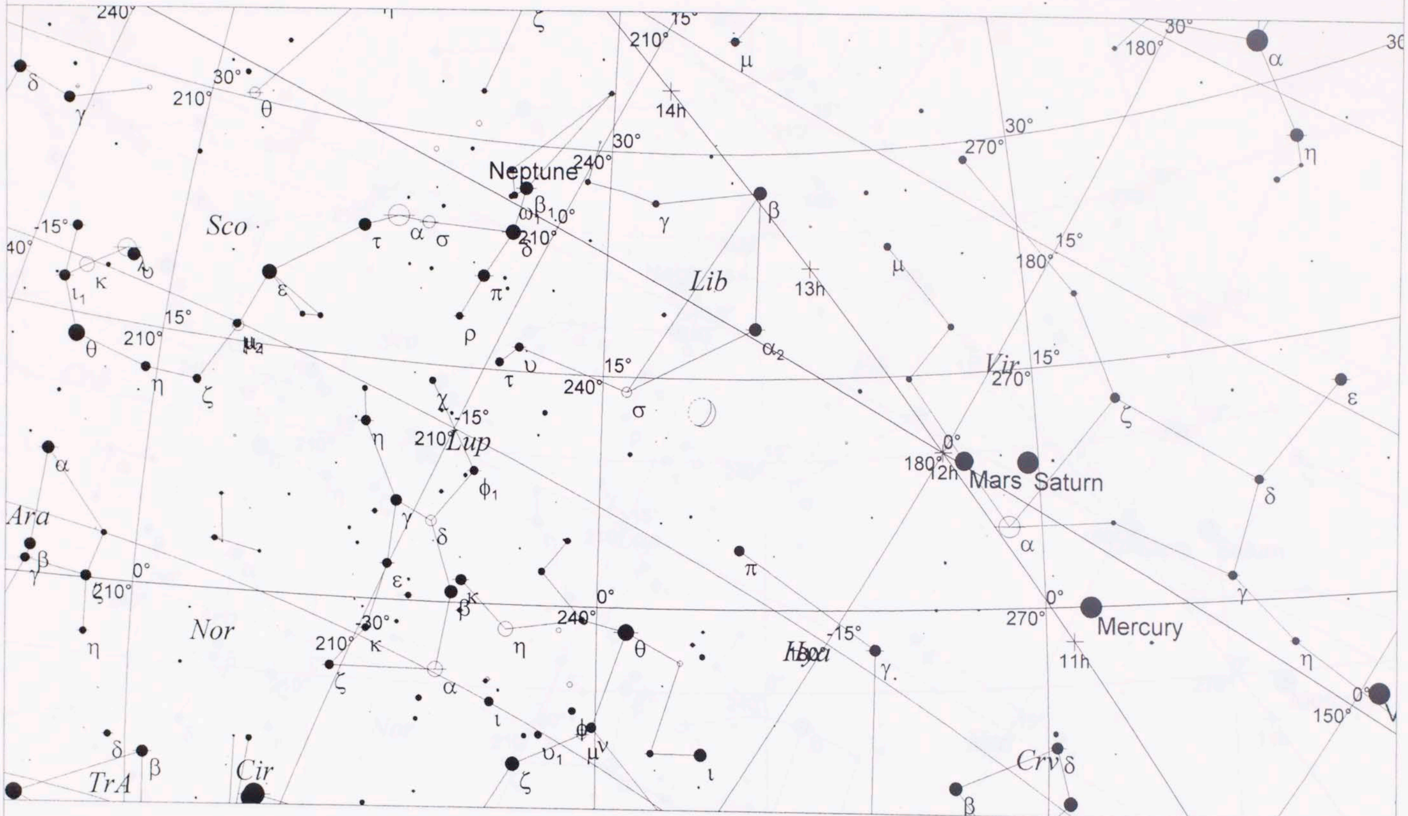


Local Time: 19:36:00 18-Aug-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:38:00 18-Aug-169BC
RA: 11h58m27s Dec: -6° 12' Field: 90.0°

Sidereal Time: 17:10:13
Julian Day: 1659926.1931

-168 V 3

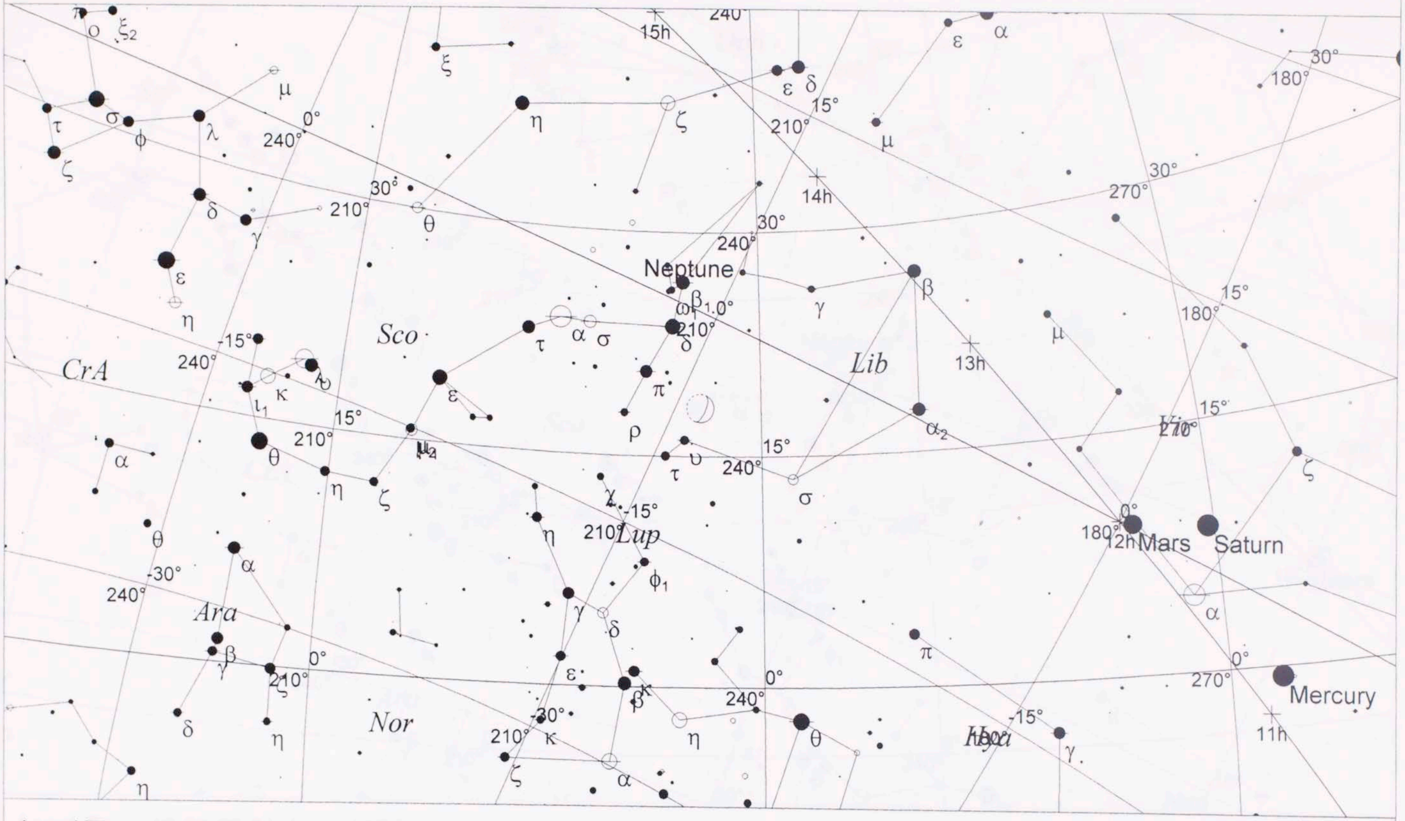


Local Time: 19:35:00 19-Aug-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:37:00 19-Aug-169BC
RA: 12h47m25s Dec: -11° 40' Field: 90.0°

Sidereal Time: 17:13:09
Julian Day: 1659927.1924

-168 V 4

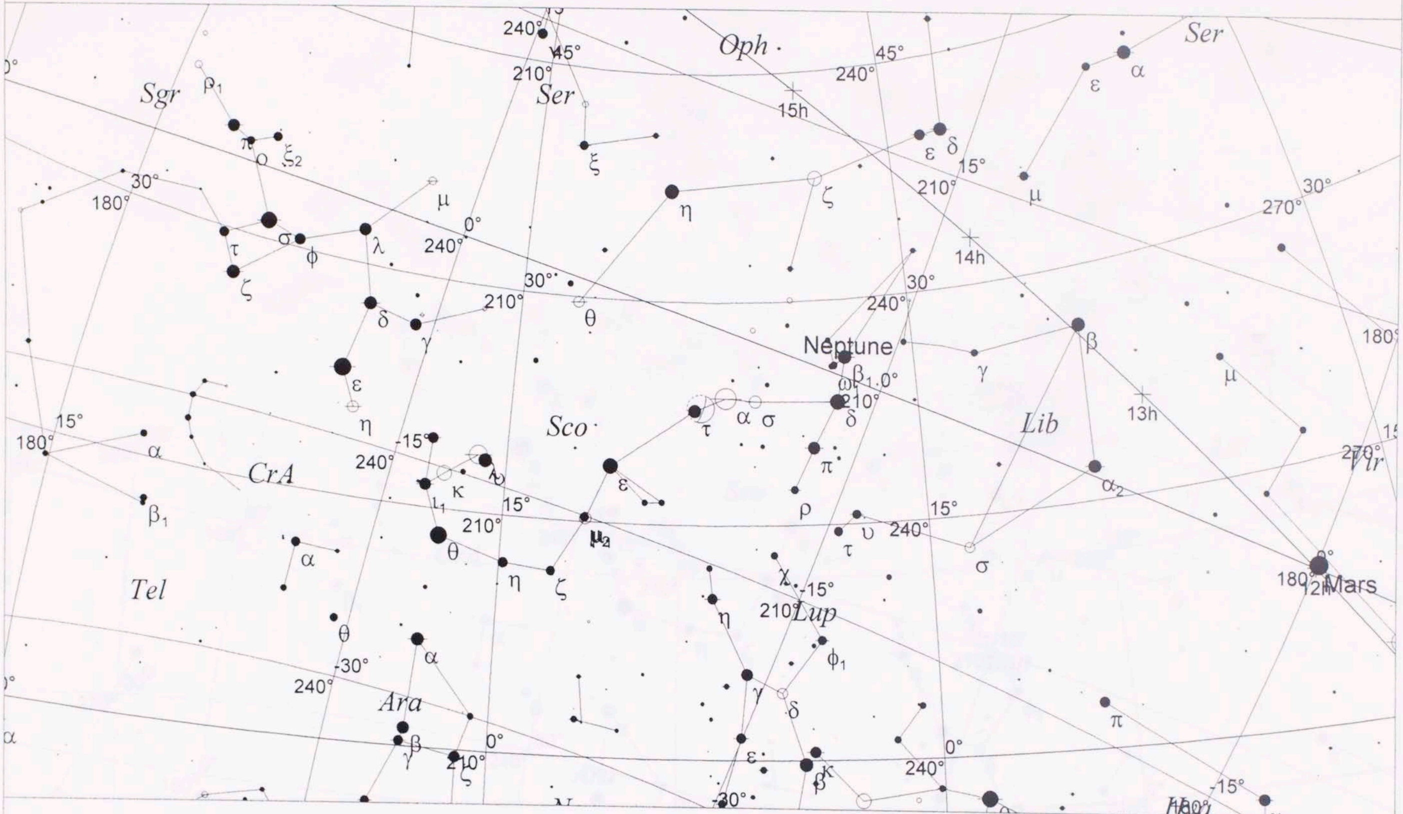


Local Time: 19:34:00 20-Aug-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:36:00 20-Aug-169BC
RA: 13h36m41s Dec: -16° 30' Field: 90.0°

Sidereal Time: 17:16:06
Julian Day: 1659928.1917

-168 V 5

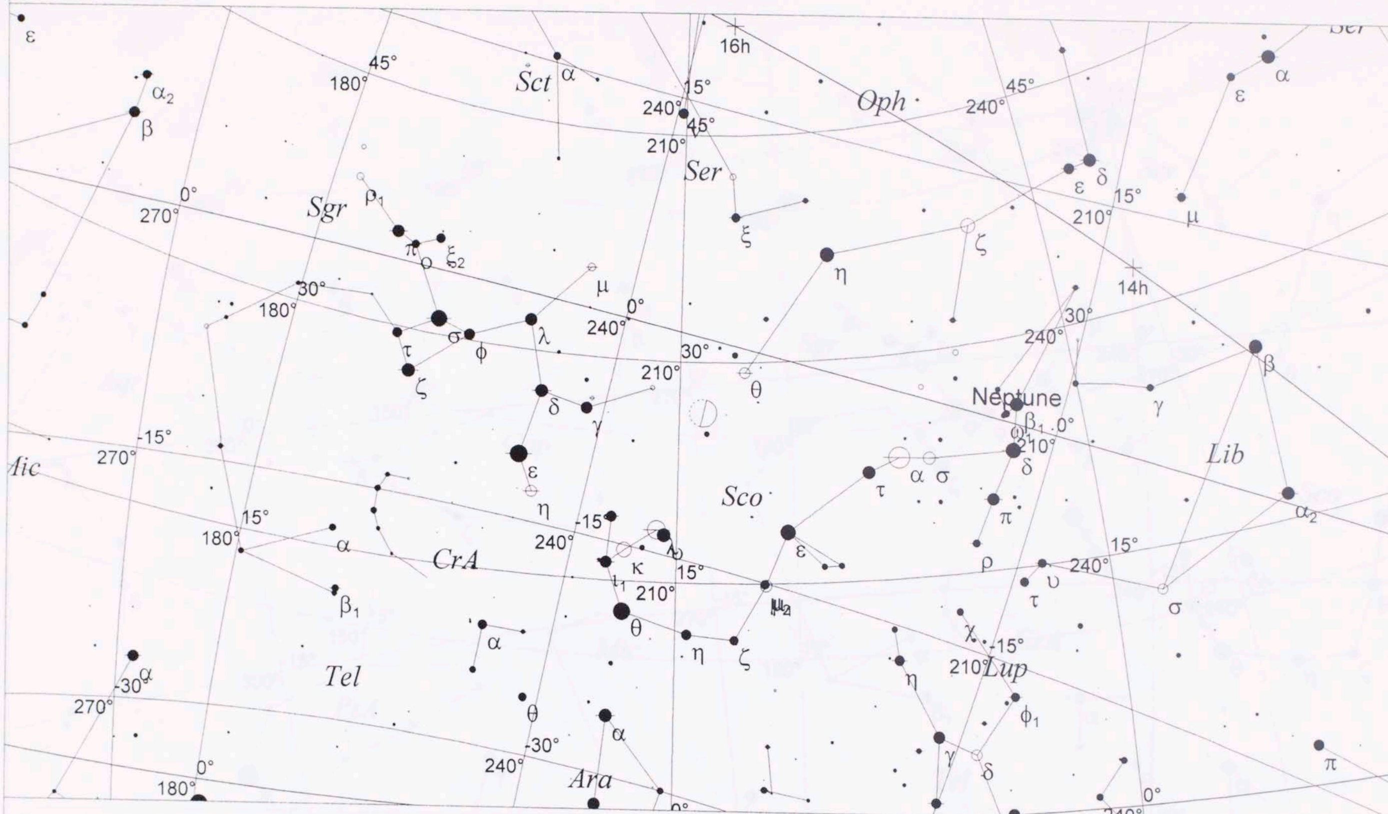


Local Time: 19:33:00 21-Aug-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:35:00 21-Aug-169BC
RA: 14h26m49s Dec: -20° 32' Field: 90.0°

Sidereal Time: 17:19:02
Julian Day: 1659929.1910

-168 V 6

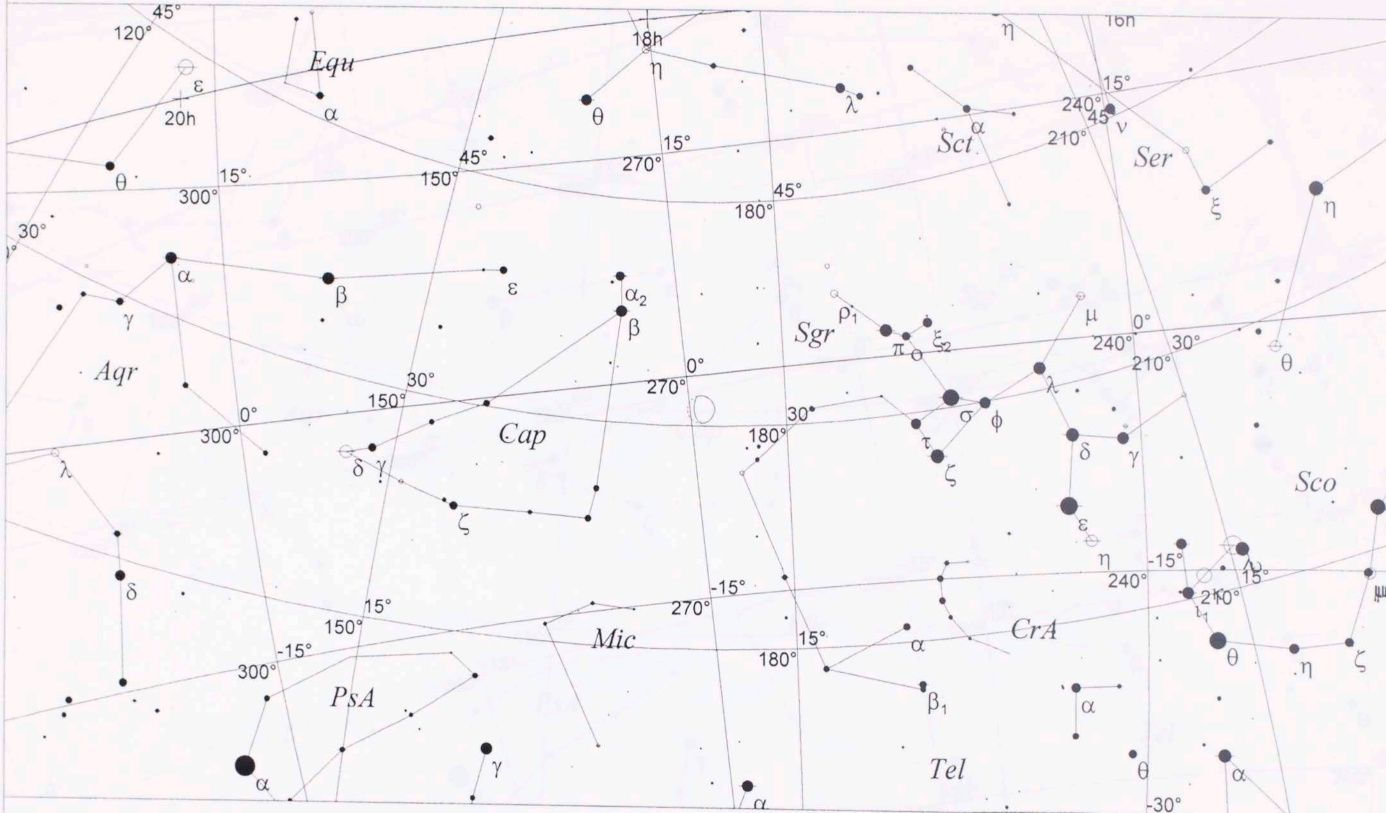


Local Time: 19:32:00 22-Aug-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:34:00 22-Aug-169BC
RA: 15h18m06s Dec: -23° 35' Field: 90.0°

Sidereal Time: 17:21:58
Julian Day: 1659930.1903

-168 V 9

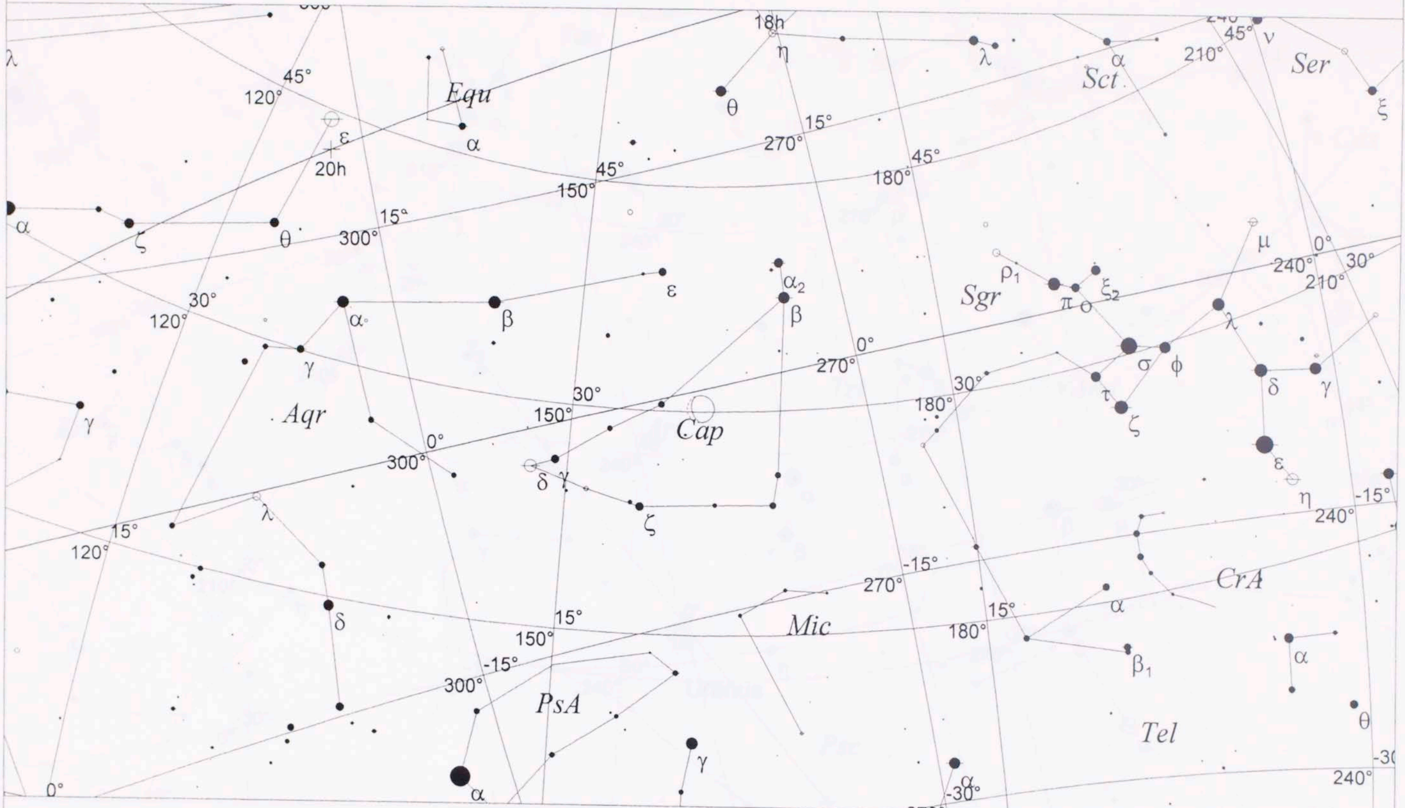


Local Time: 19:29:00 25-Aug-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:31:00 25-Aug-169BC
RA: 17h56m42s Dec: -26° 01' Field: 90.0°

Sidereal Time: 17:30:48
Julian Day: 1659933.1882

-168 V 10

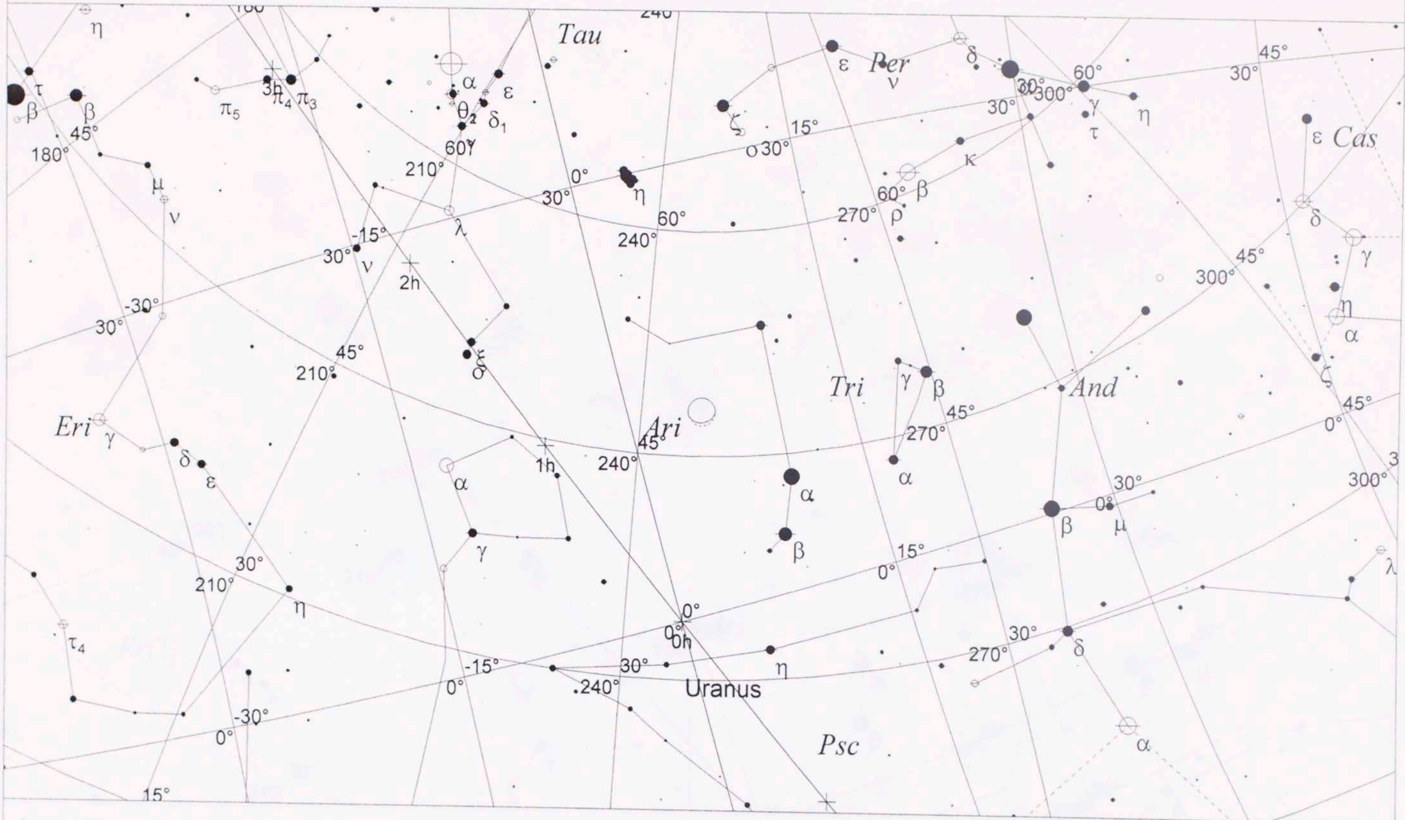


Local Time: 19:28:00 26-Aug-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:30:00 26-Aug-169BC
RA: 18h49m10s Dec: -24° 29' Field: 90.0°

Sidereal Time: 17:33:44
Julian Day: 1659934.1875

-168 V 17

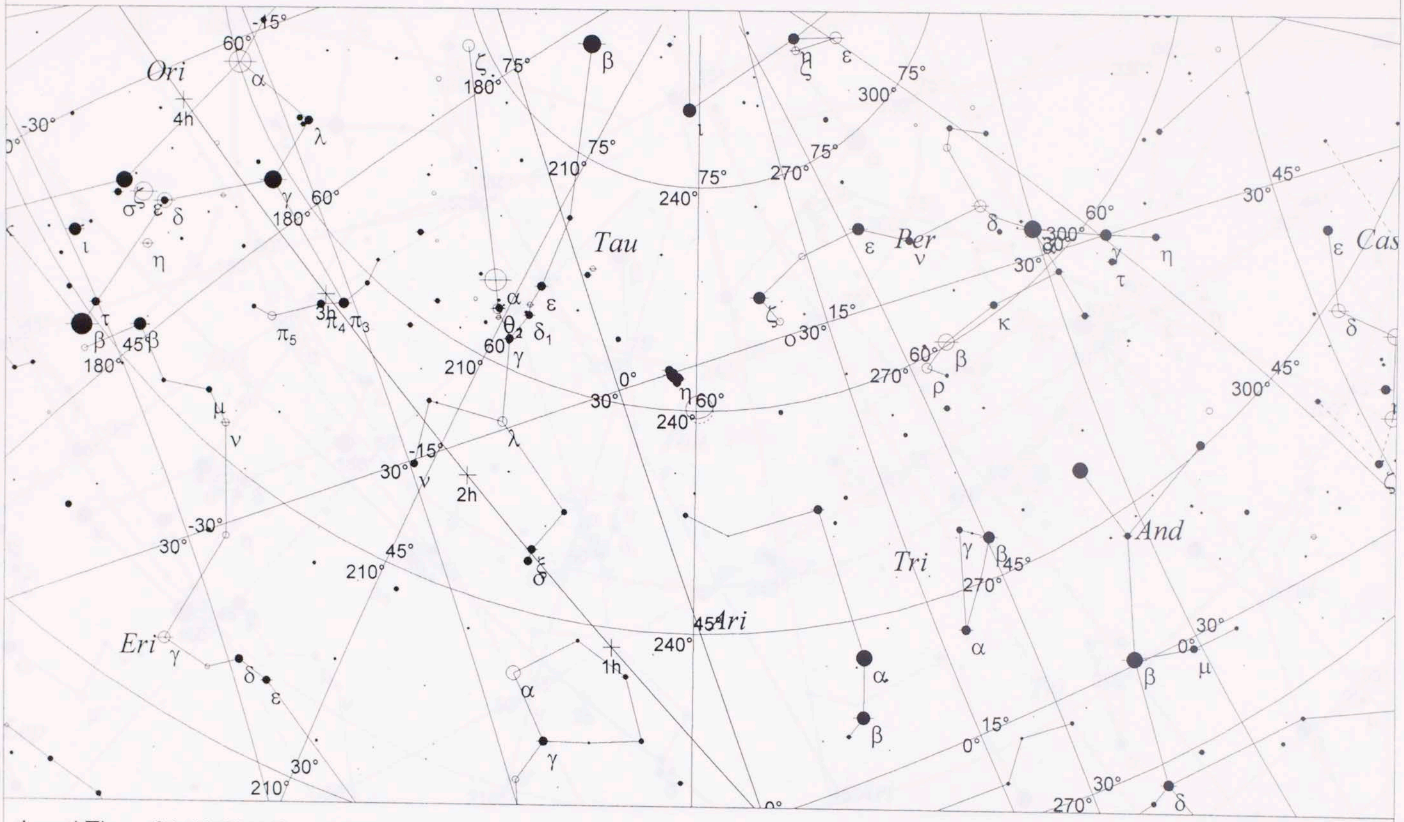


Local Time: 04:40:00 3-Sep-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:42:00 3-Sep-169BC
RA: 0h41m21s Dec: +9° 53' Field: 90.0°

Sidereal Time: 03:14:50
Julian Day: 1659941.5708

-168 V 18

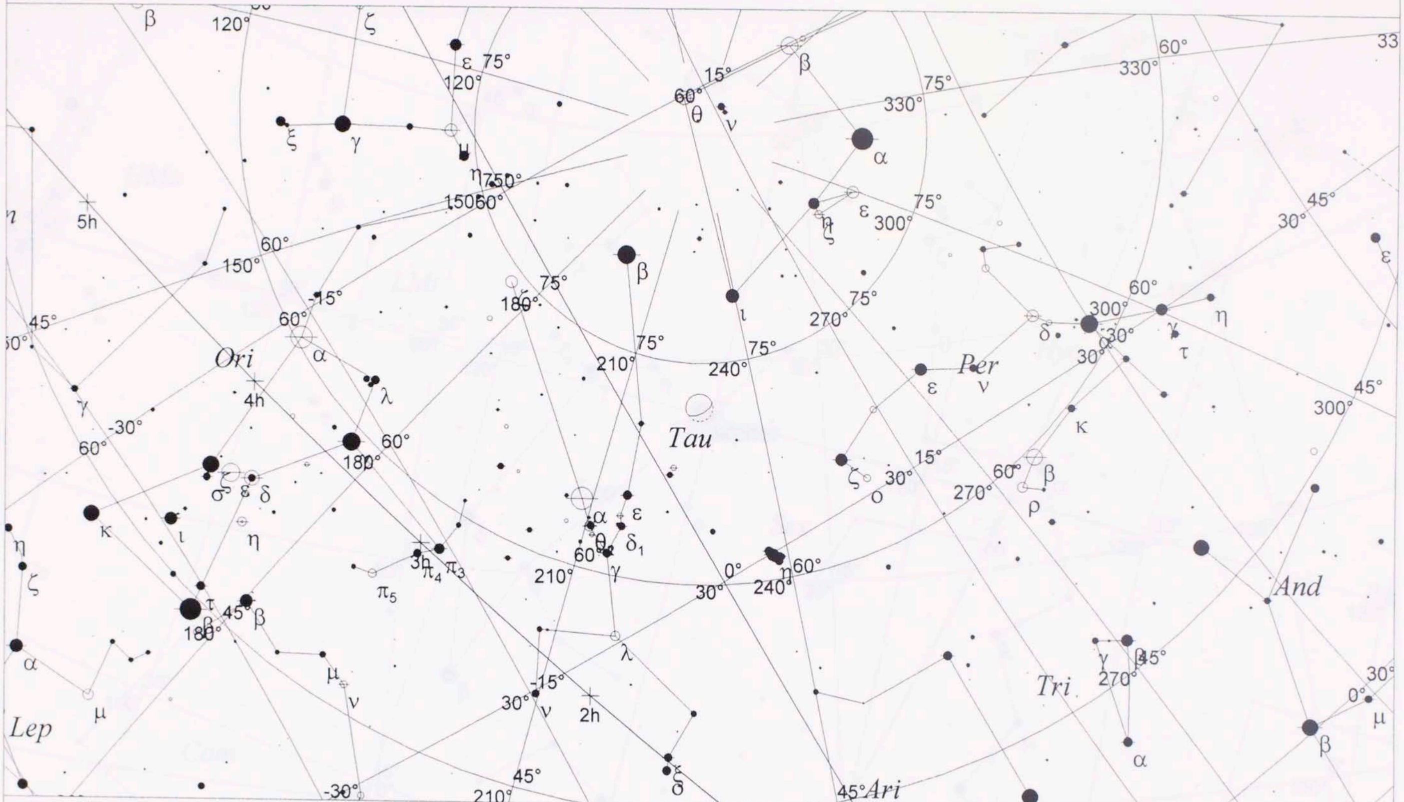


Local Time: 04:41:00 4-Sep-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:43:00 4-Sep-169BC
RA: 1h33m06s Dec: +15° 04' Field: 90.0°

Sidereal Time: 03:19:47
Julian Day: 1659942.5715

-168 V 19

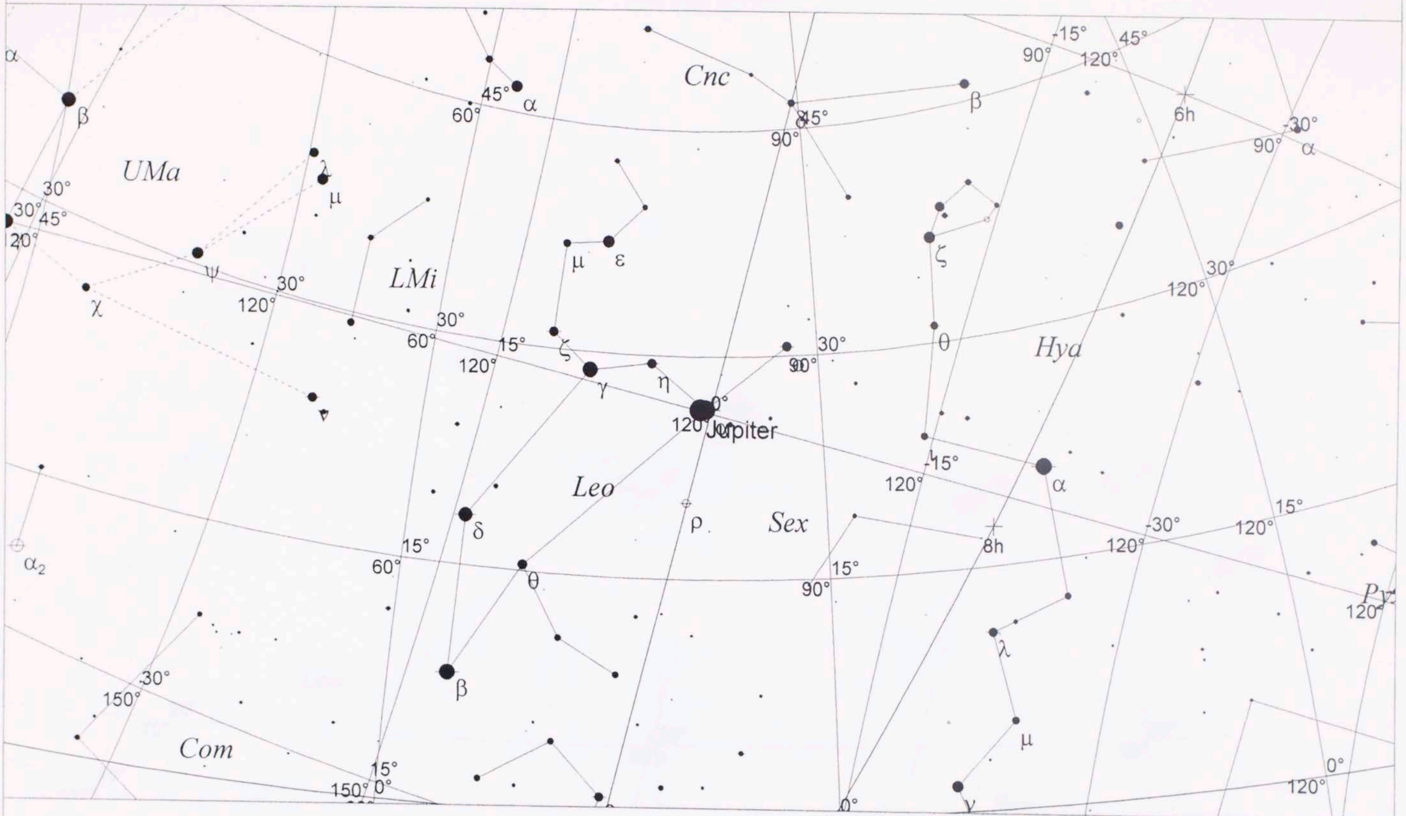


Local Time: 04:41:00 5-Sep-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:43:00 5-Sep-169BC
RA: 2h28m04s Dec: +19° 31' Field: 90.0°

Sidereal Time: 03:23:44
Julian Day: 1659943.5715

-168 V 19

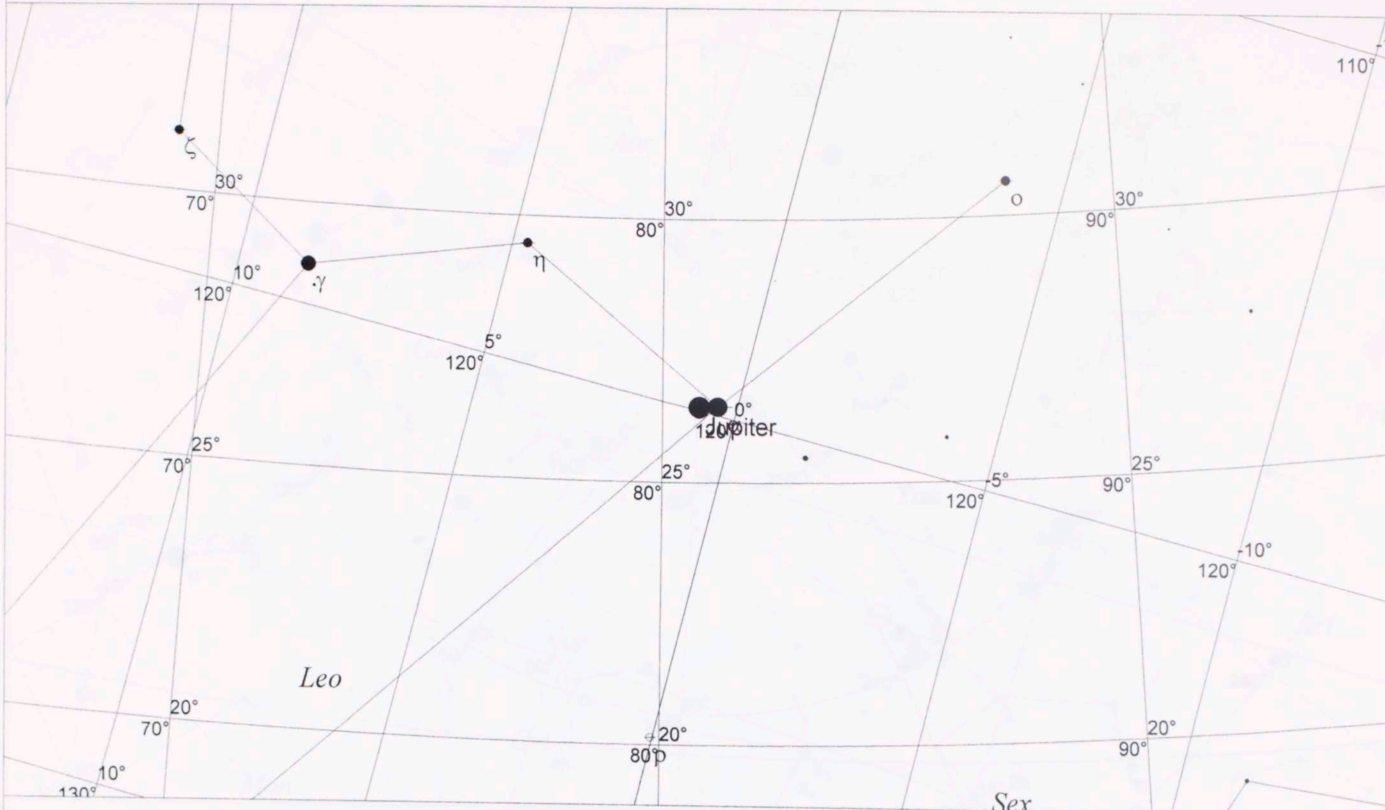


Local Time: 04:41:00 5-Sep-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:43:00 5-Sep-169BC
RA: 8h09m19s Dec: +21° 05' Field: 90.0°

Sidereal Time: 03:23:44
Julian Day: 1659943.5715

-168 V 19

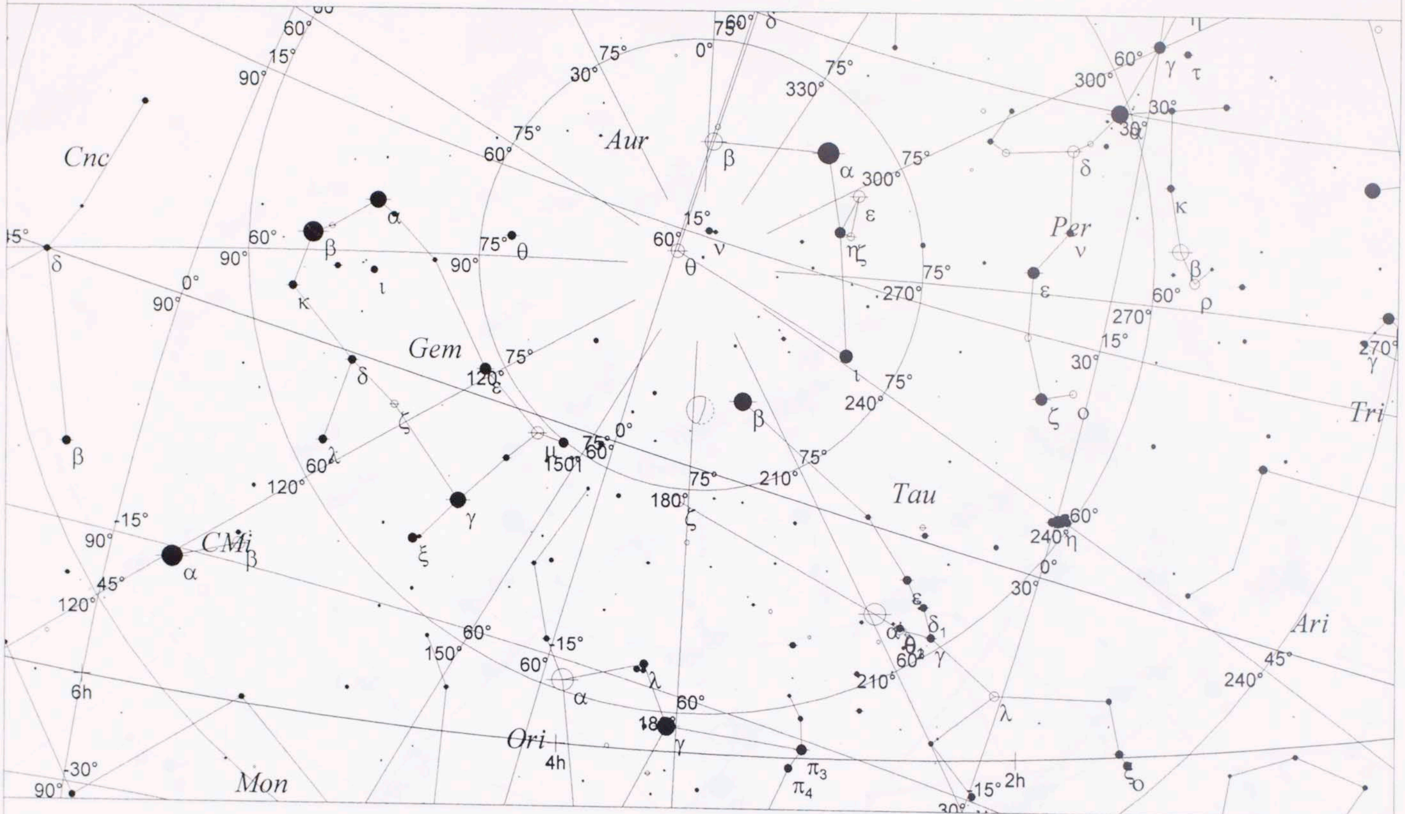


Local Time: 04:41:00 5-Sep-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:43:00 5-Sep-169BC
RA: 8h09m19s Dec: +21° 05' Field: 26.7°

Sidereal Time: 03:23:44
Julian Day: 1659943.5715

-168 V 20

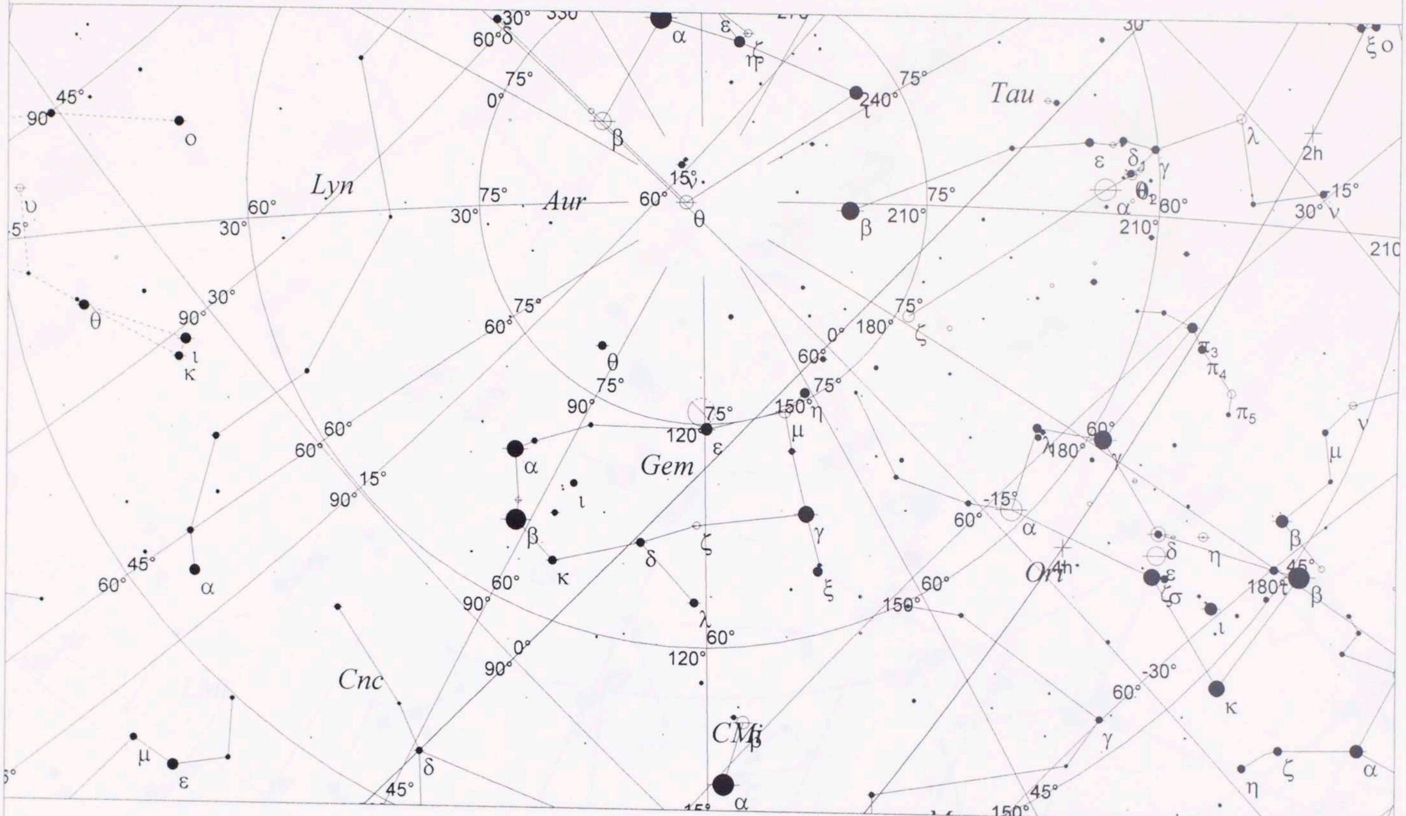


Local Time: 04:42:00 6-Sep-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:44:00 6-Sep-169BC
RA: 3h26m35s Dec: +22° 55' Field: 90.0°

Sidereal Time: 03:28:40
Julian Day: 1659944.5722

-168 V 21

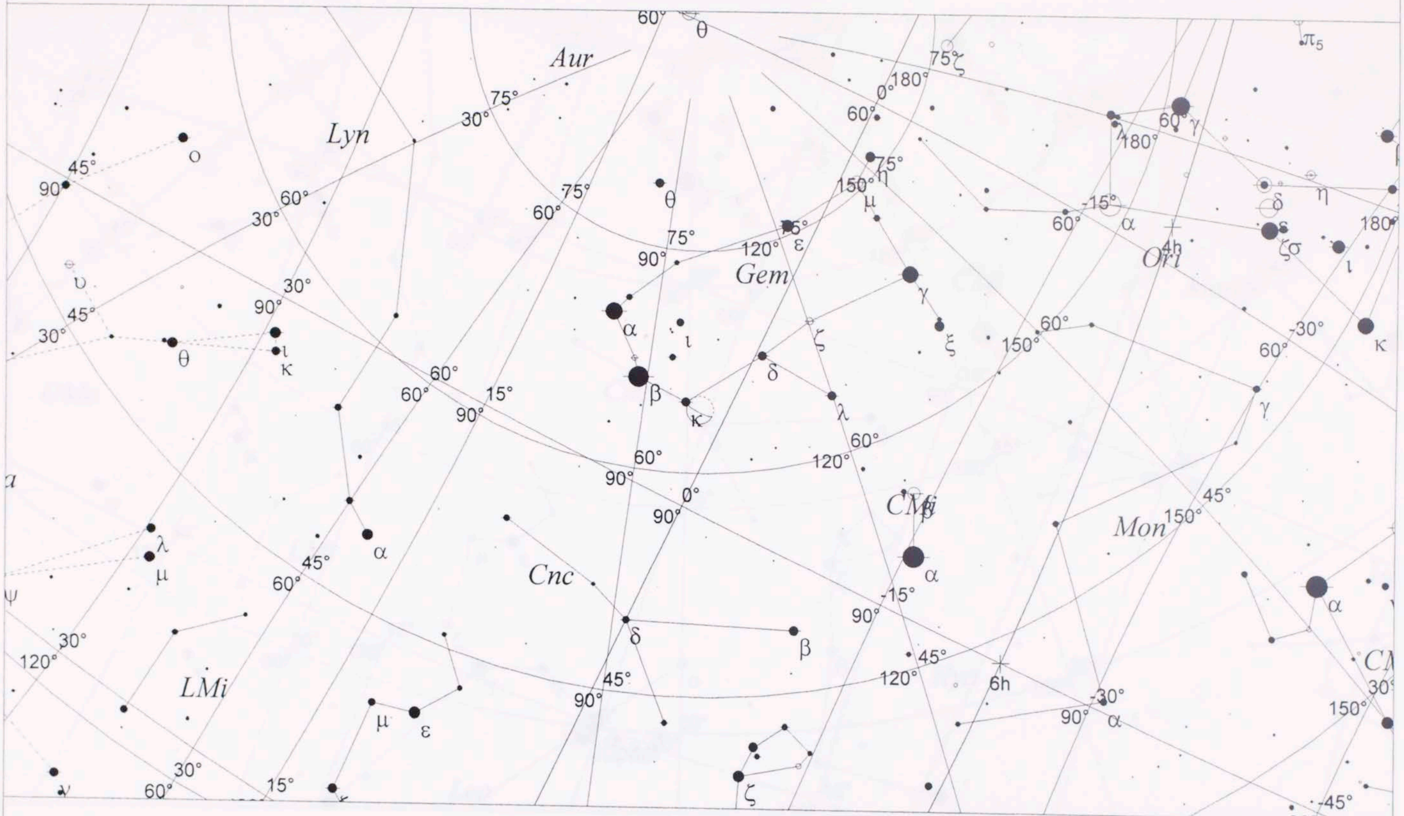


Local Time: 04:43:00 7-Sep-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:45:00 7-Sep-169BC
RA: 4h28m12s Dec: +24° 56' Field: 90.0°

Sidereal Time: 03:33:37
Julian Day: 1659945.5729

-168 V 22

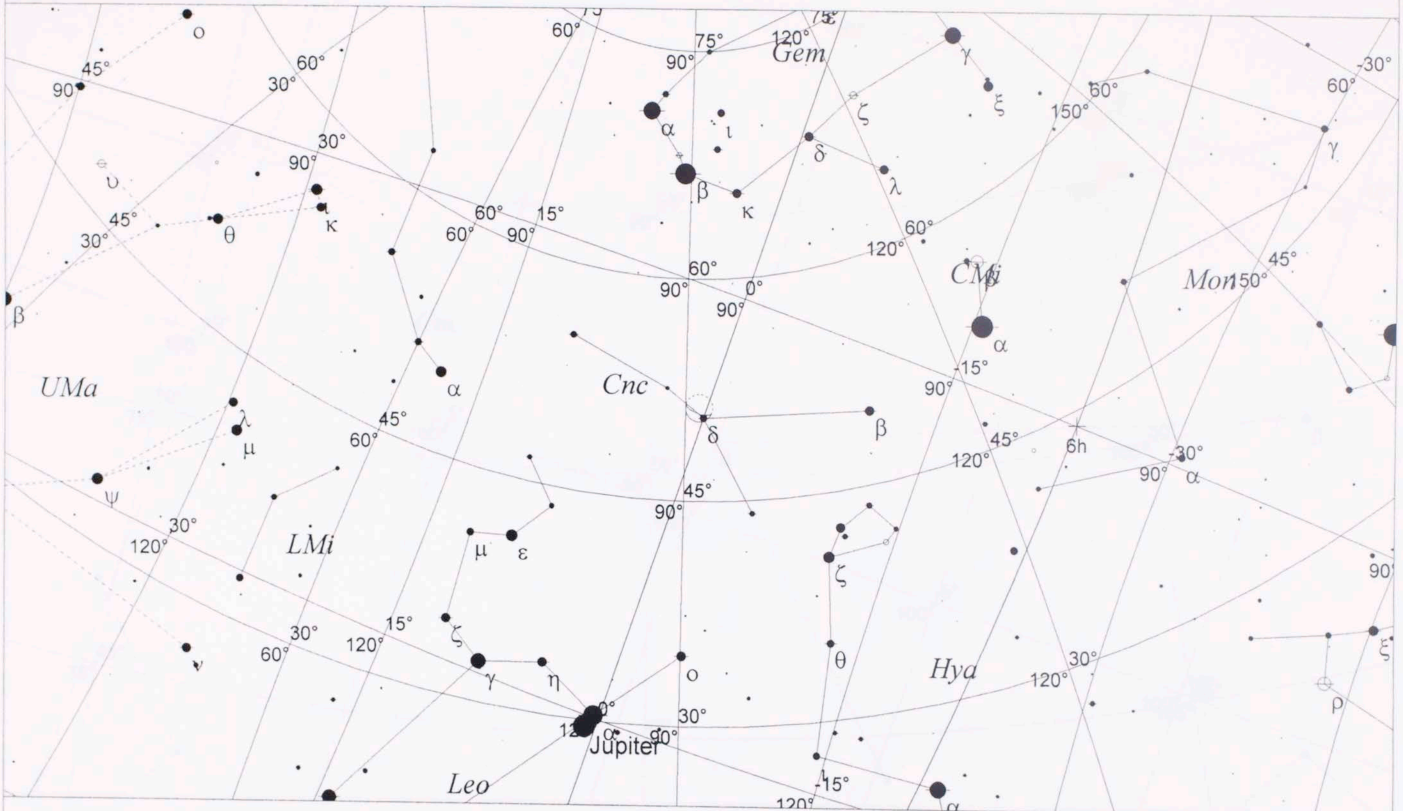


Local Time: 04:44:00 8-Sep-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:46:00 8-Sep-169BC
RA: 5h31m39s Dec: +25° 19' Field: 90.0°

Sidereal Time: 03:38:34
Julian Day: 1659946.5736

-168 V 23

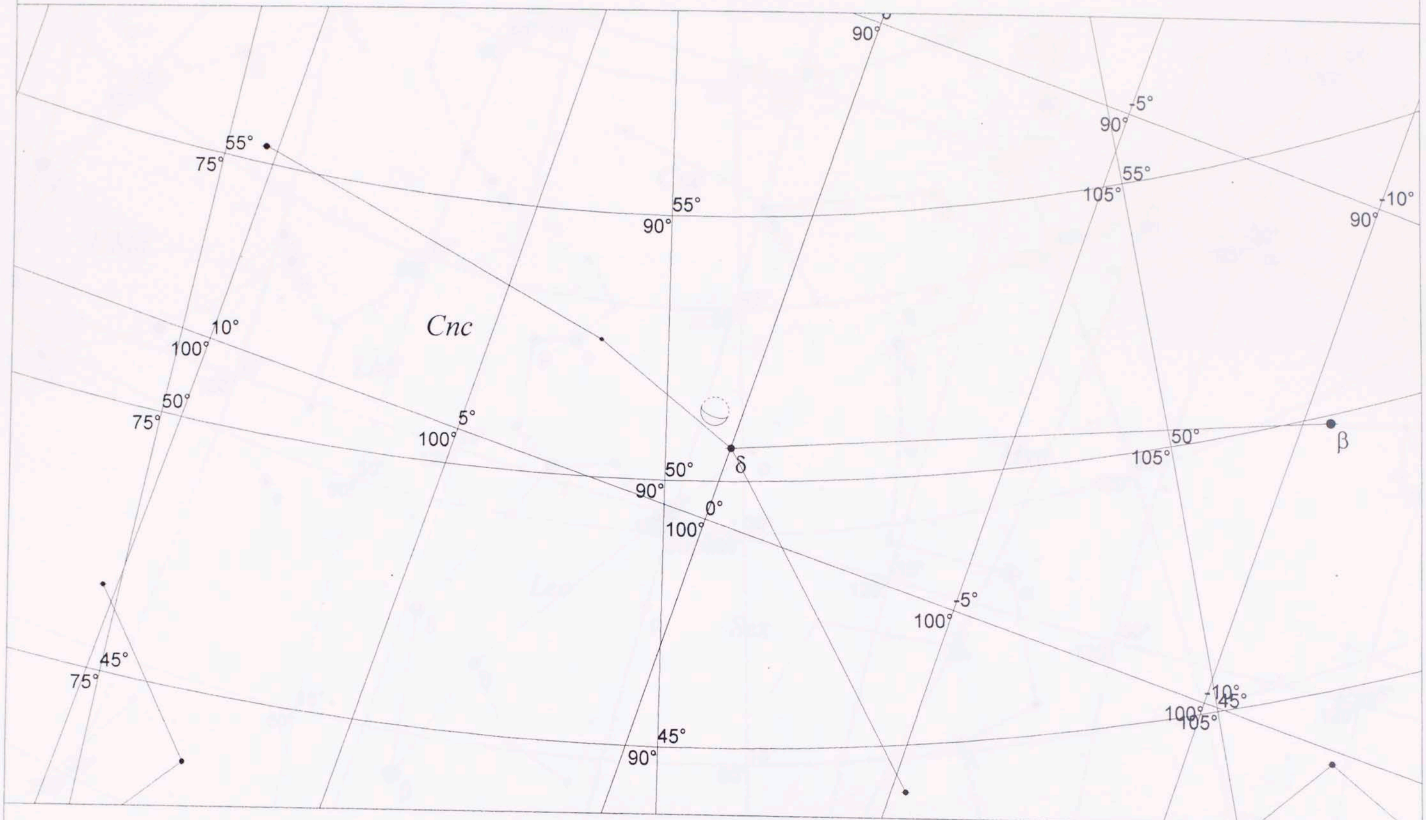


Local Time: 04:44:00 9-Sep-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:46:00 9-Sep-169BC
RA: 6h35m03s Dec: +23° 59' Field: 90.0°

Sidereal Time: 03:42:30
Julian Day: 1659947.5736

-168 V 23

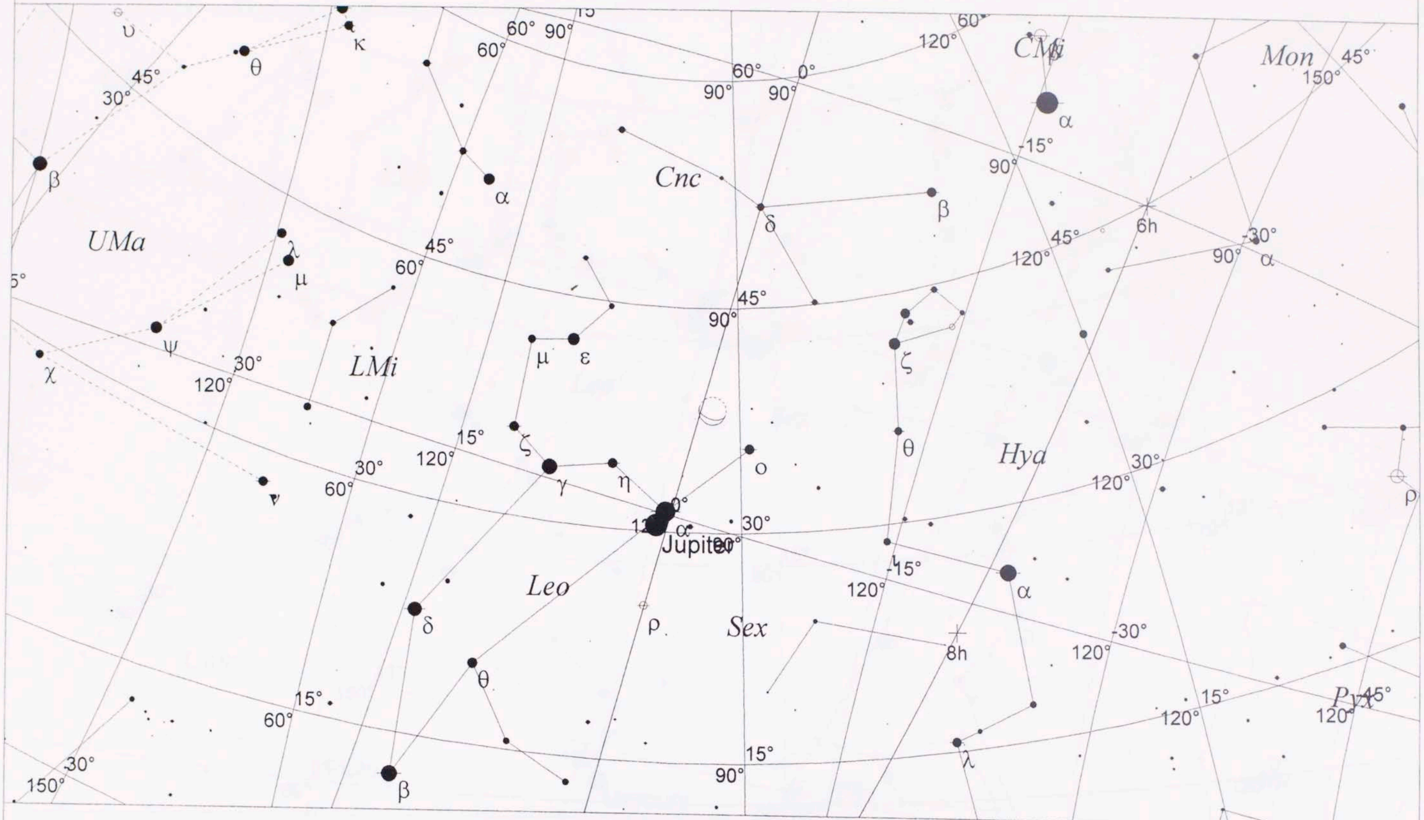


Local Time: 04:44:00 9-Sep-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:46:00 9-Sep-169BC
RA: 6h35m03s Dec: +23° 59' Field: 26.7°

Sidereal Time: 03:42:30
Julian Day: 1659947.5736

-168 V 24

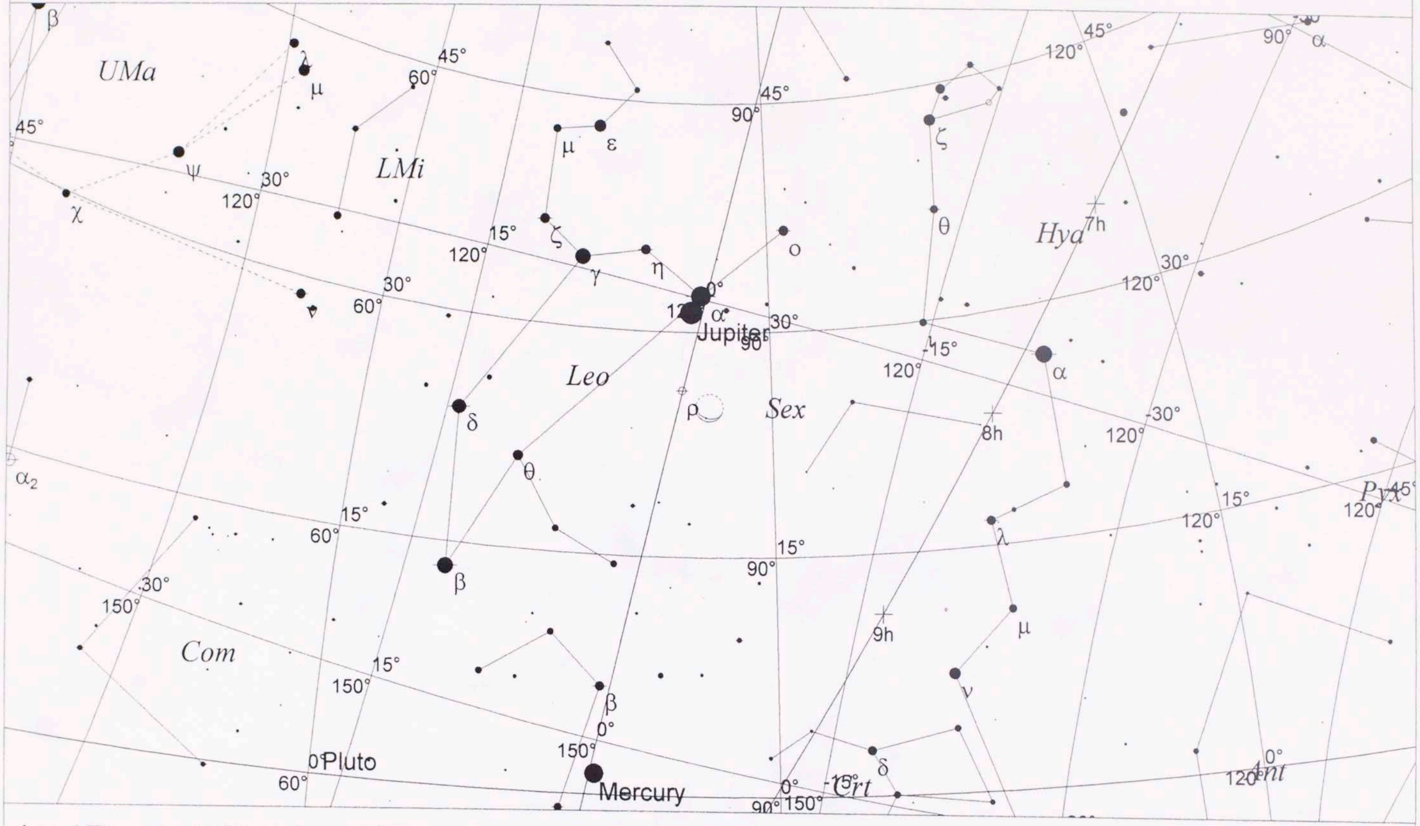


Local Time: 04:45:00 10-Sep-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:47:00 10-Sep-169BC
RA: 7h36m41s Dec: +21° 04' Field: 90.0°

Sidereal Time: 03:47:27
Julian Day: 1659948.5743

-168 V 25

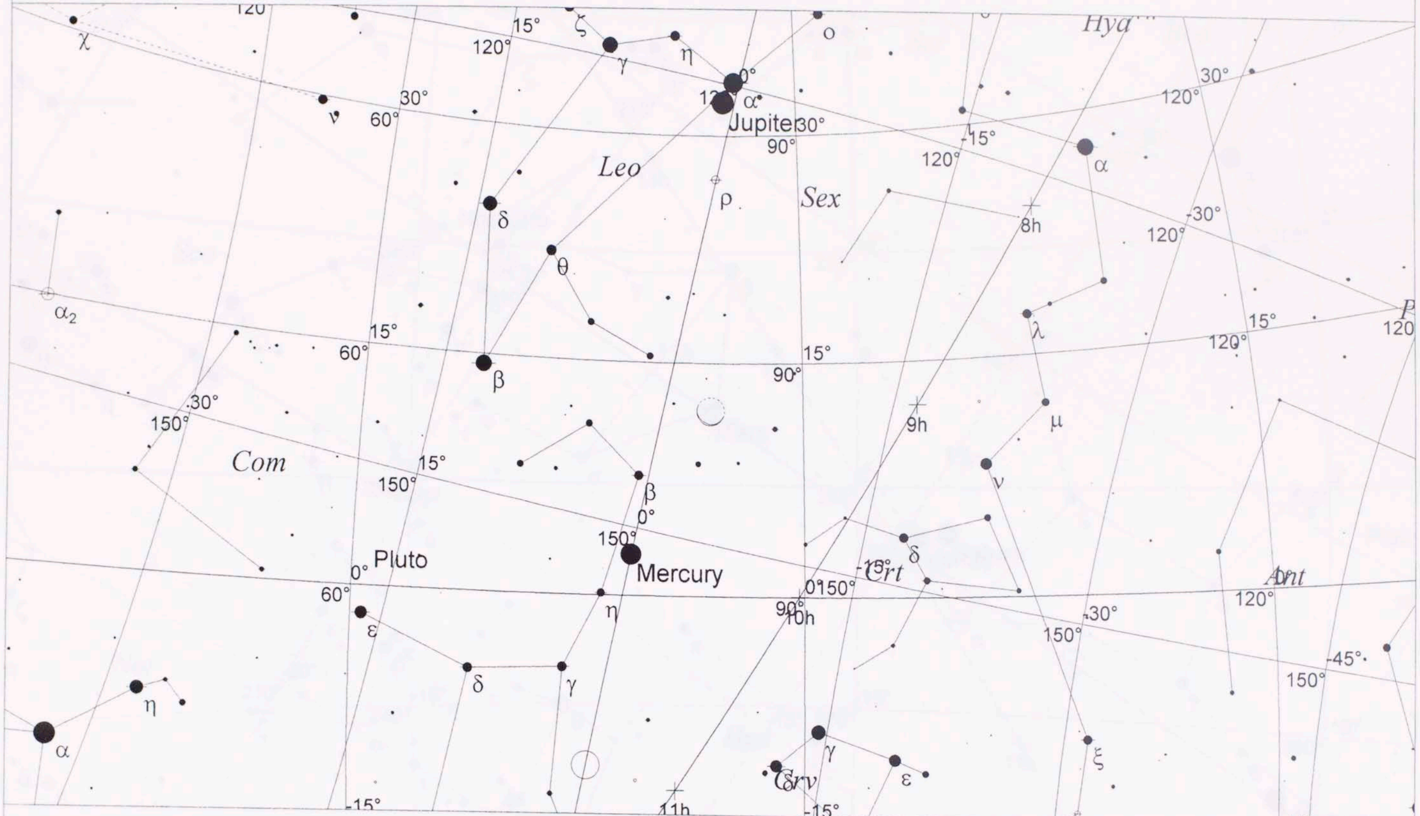


Local Time: 04:46:00 11-Sep-169BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 01:48:00 11-Sep-169BC
RA: 8h35m23s Dec: +16° 48' Field: 90.0°

Sidereal Time: 03:52:24
Julian Day: 1659949.5750

-168 V 26

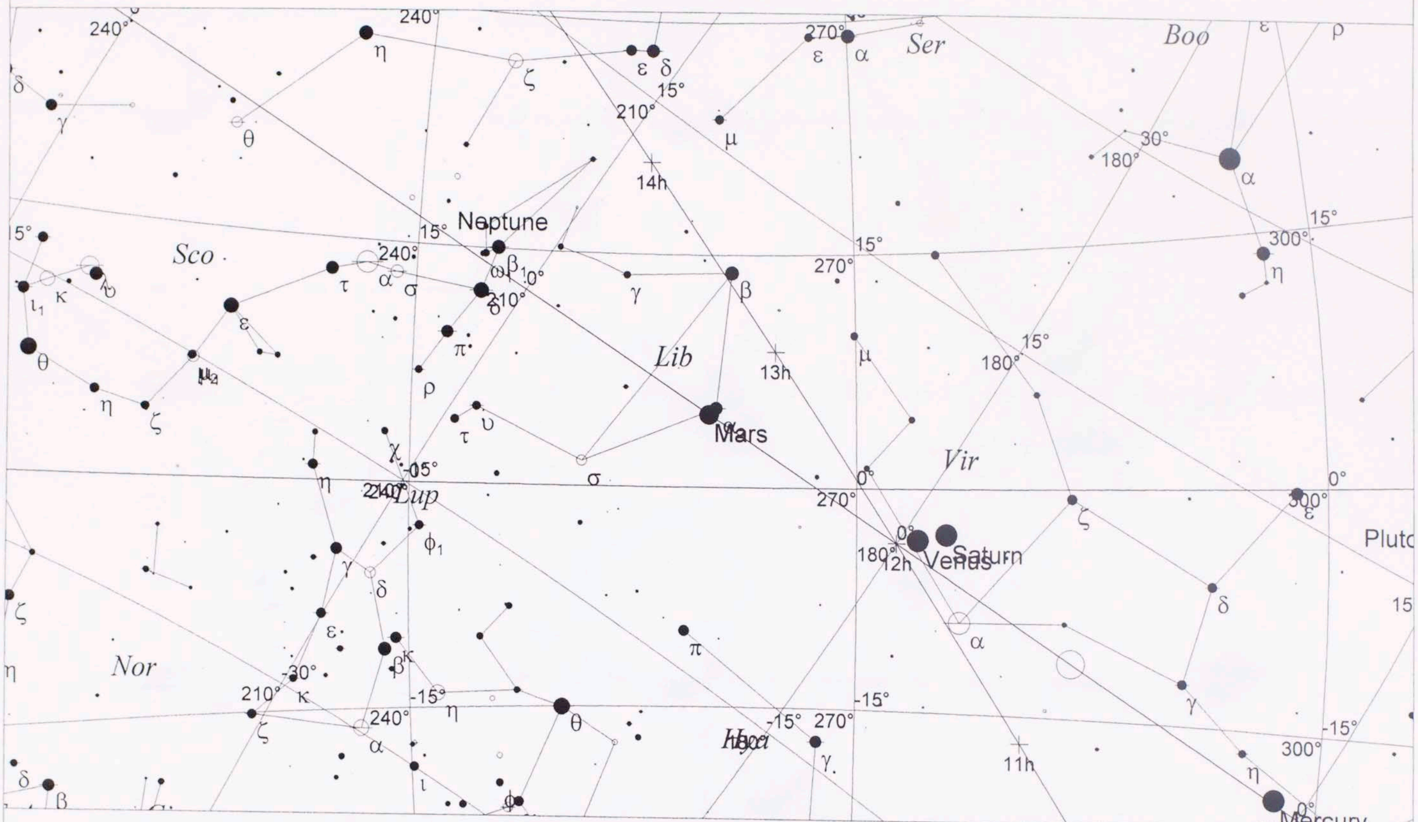


Local Time: 04:47:00 12-Sep-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:49:00 12-Sep-169BC
RA: 9h30m52s Dec: +11° 36' Field: 90.0°

Sidereal Time: 03:57:21
Julian Day: 1659950.5757

-168 V 27

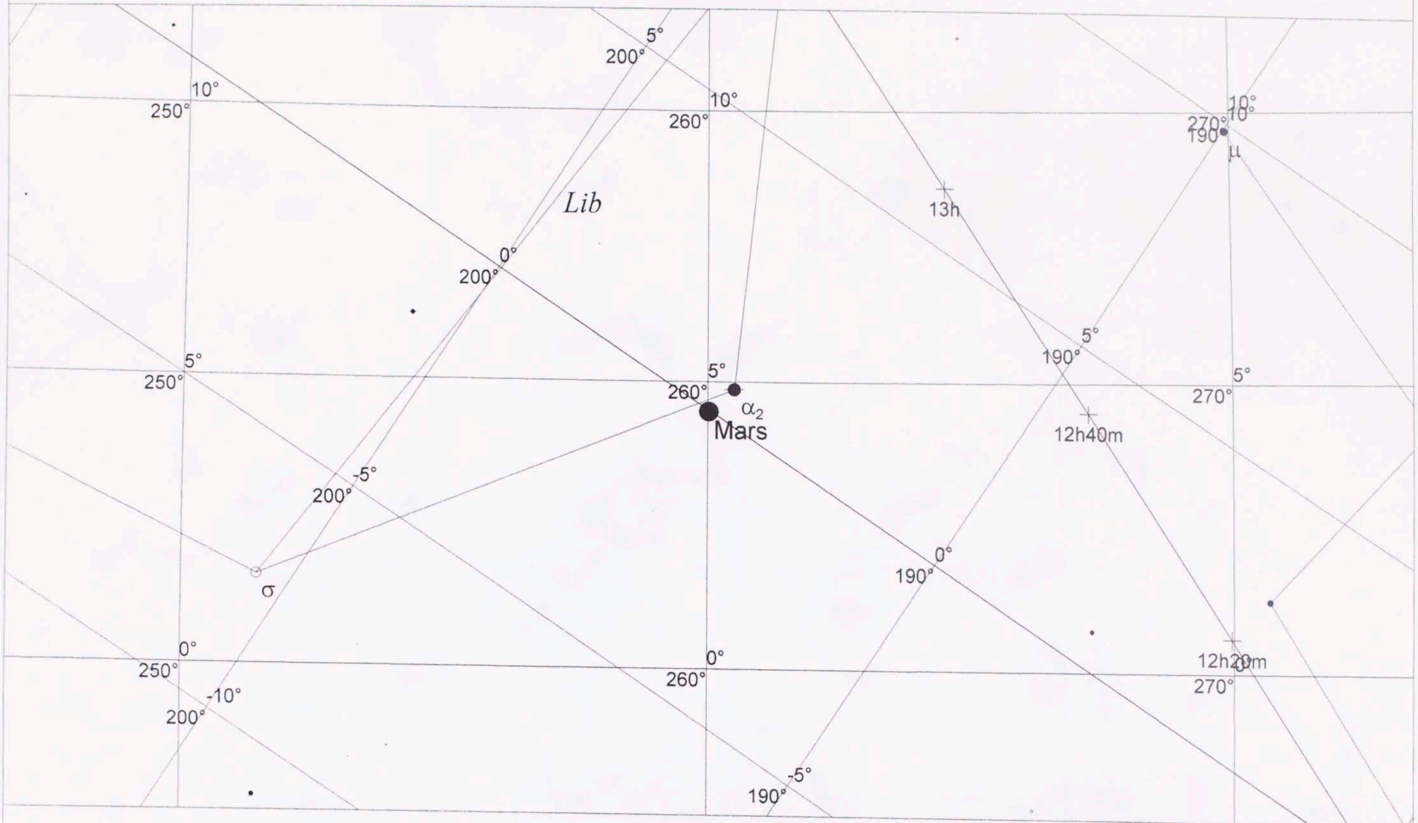


Local Time: 19:07:00 12-Sep-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:09:00 12-Sep-169BC
RA: 12h55m44s Dec: -6° 03' Field: 90.0°

Sidereal Time: 18:19:42
Julian Day: 1659951.1729

-168 V 27

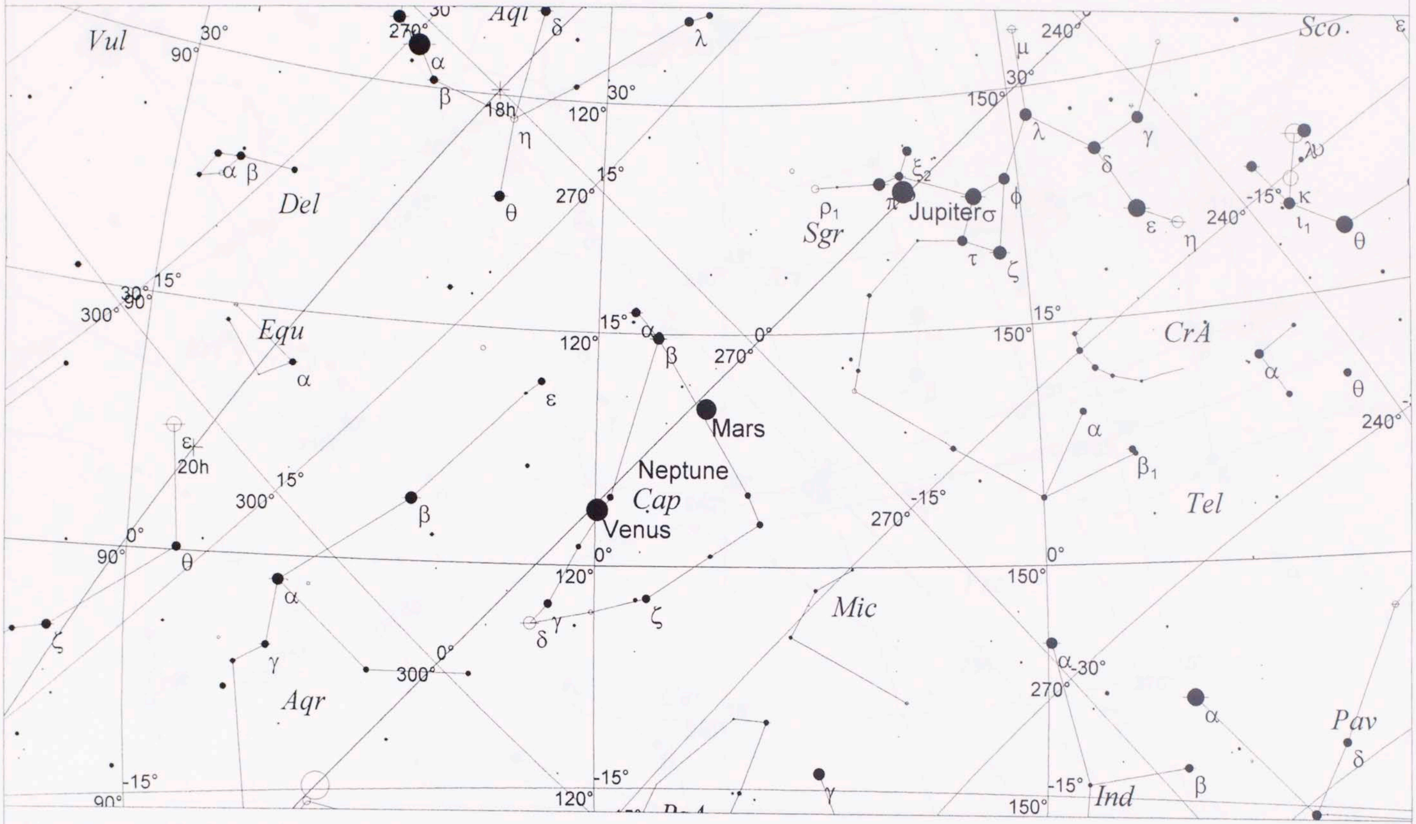


Local Time: 19:07:00 12-Sep-169BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:09:00 12-Sep-169BC
RA: 12h55m44s Dec: -6° 03' Field: 26.7°

Sidereal Time: 18:19:42
Julian Day: 1659951.1729

-140 XI 1

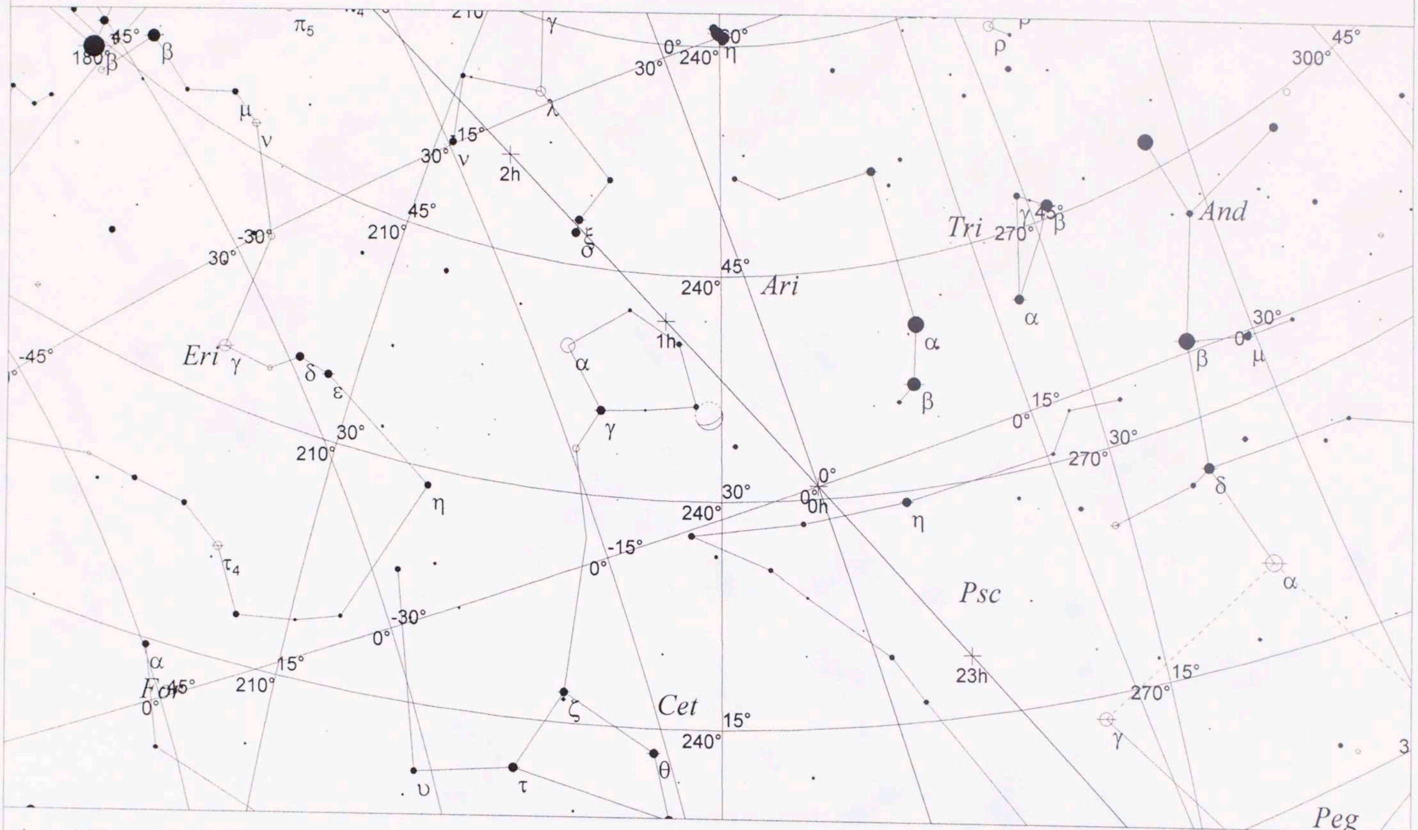


Local Time: 05:52:00 2-Feb-140BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:54:00 2-Feb-140BC
RA: 18h23m24s Dec: -24° 23' Field: 90.0°

Sidereal Time: 14:27:07
Julian Day: 1670320.6208

-140 XI 4

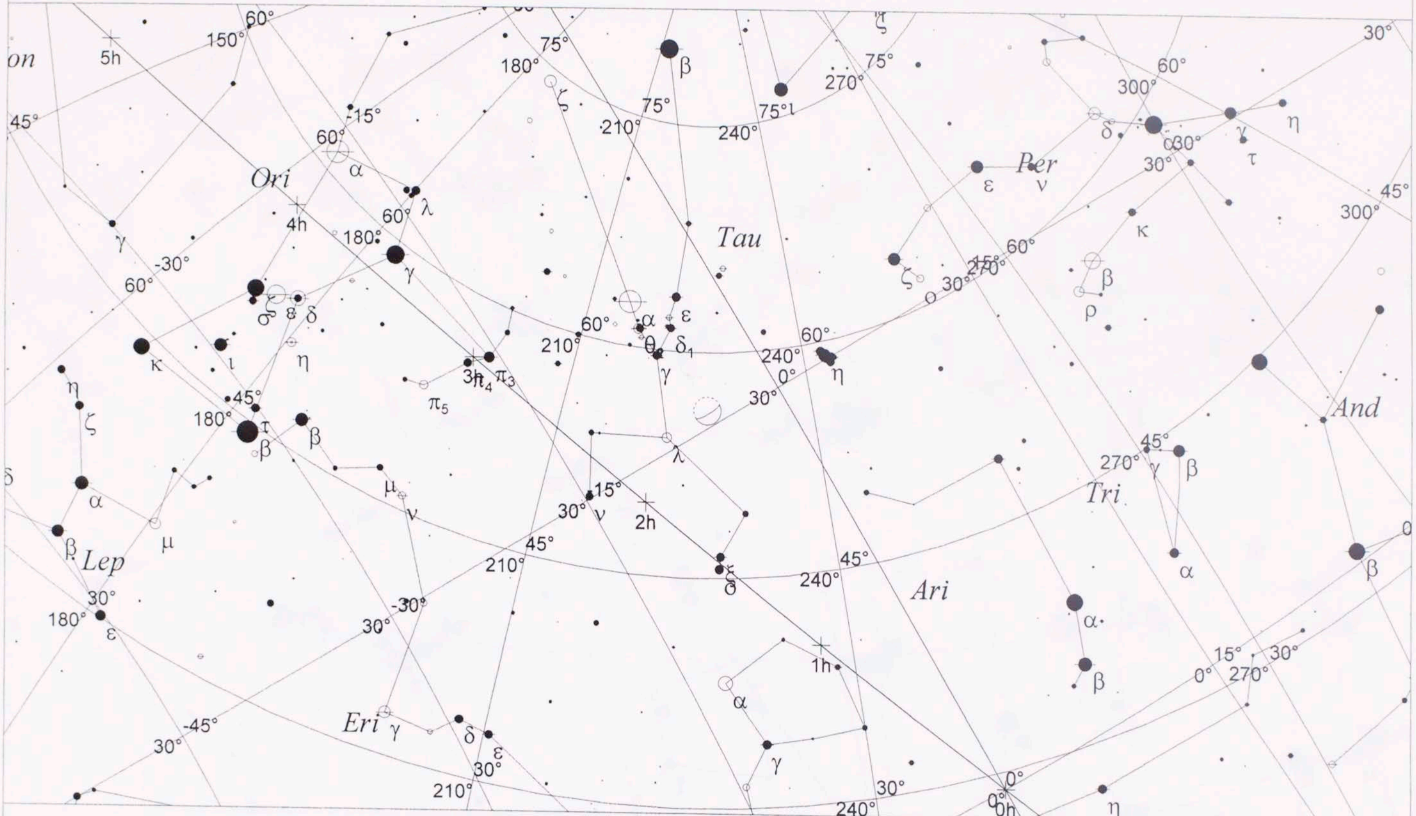


Local Time: 18:45:00 4-Feb-140BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 15:47:00 4-Feb-140BC
RA: 0h33m43s Dec: -2° 13' Field: 90.0°

Sidereal Time: 03:30:07
Julian Day: 1670323.1576

-140 XI 6

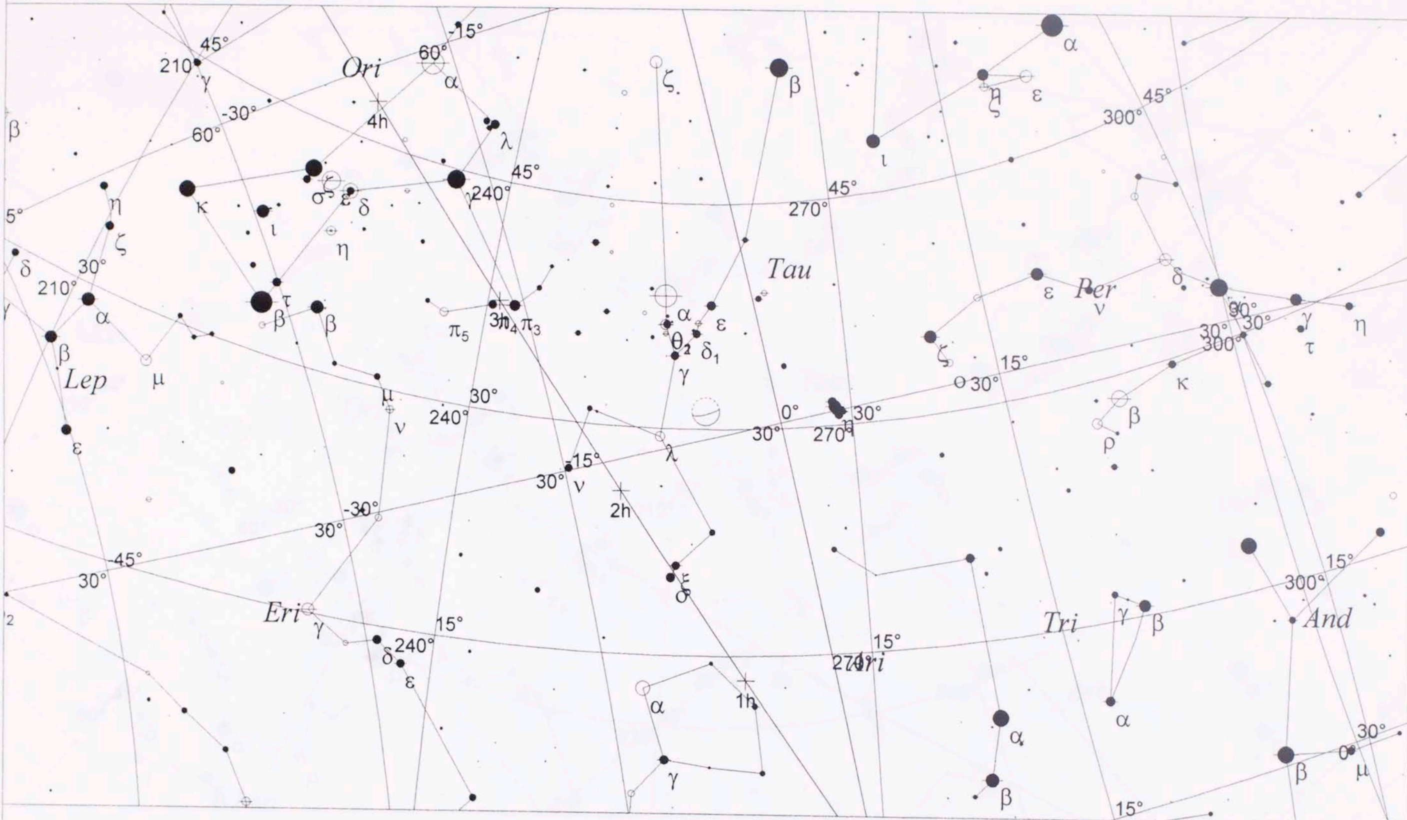


Local Time: 18:47:00 6-Feb-140BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 15:49:00 6-Feb-140BC
RA: 2h02m22s Dec: +7° 21' Field: 90.0°

Sidereal Time: 03:40:01
Julian Day: 1670325.1590

-140 XI 6

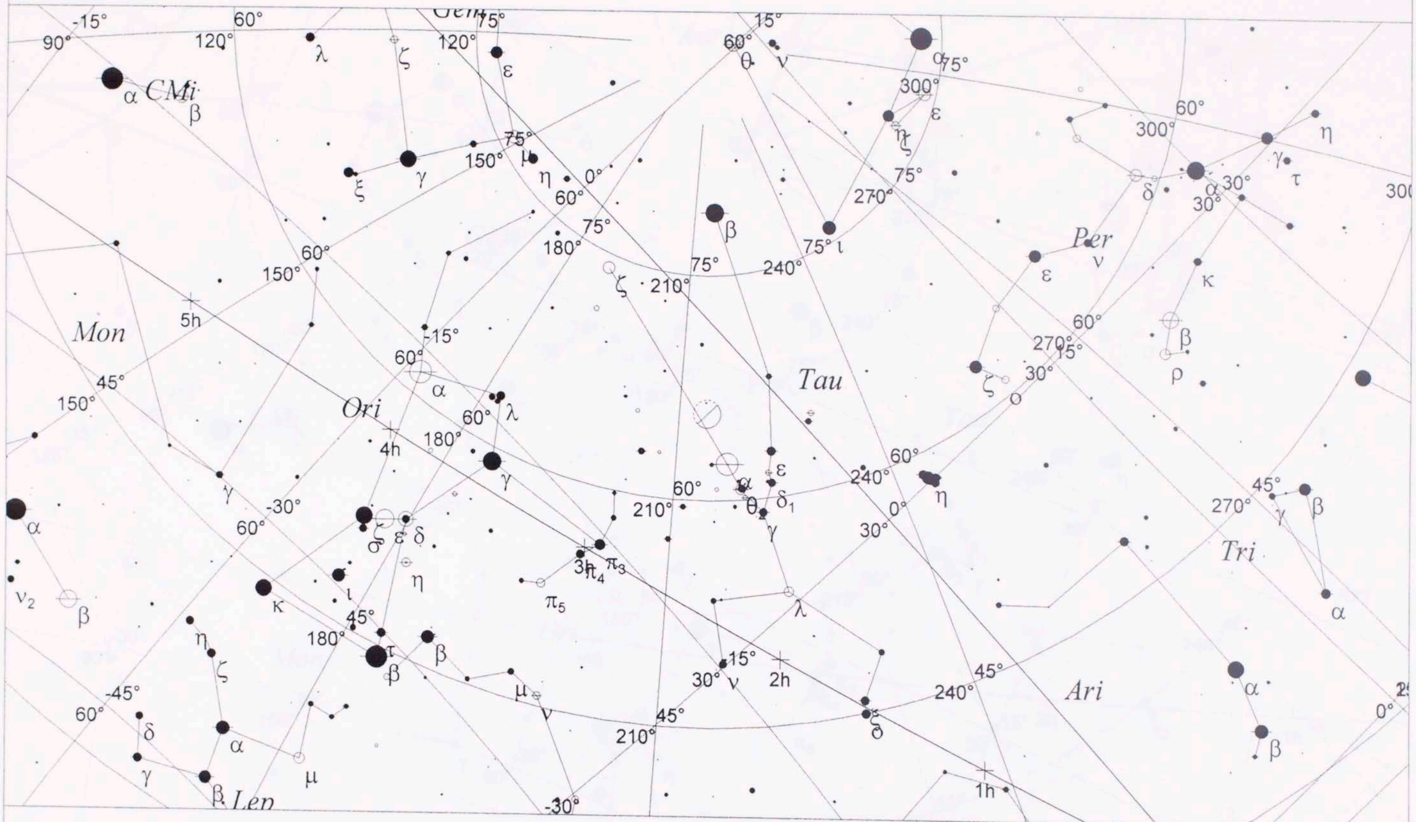


Local Time: 21:03:00 6-Feb-140BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 18:05:00 6-Feb-140BC
RA: 2h05m16s Dec: +7° 45' Field: 90.0°

Sidereal Time: 05:56:23
Julian Day: 1670325.2535

-140 XI 7

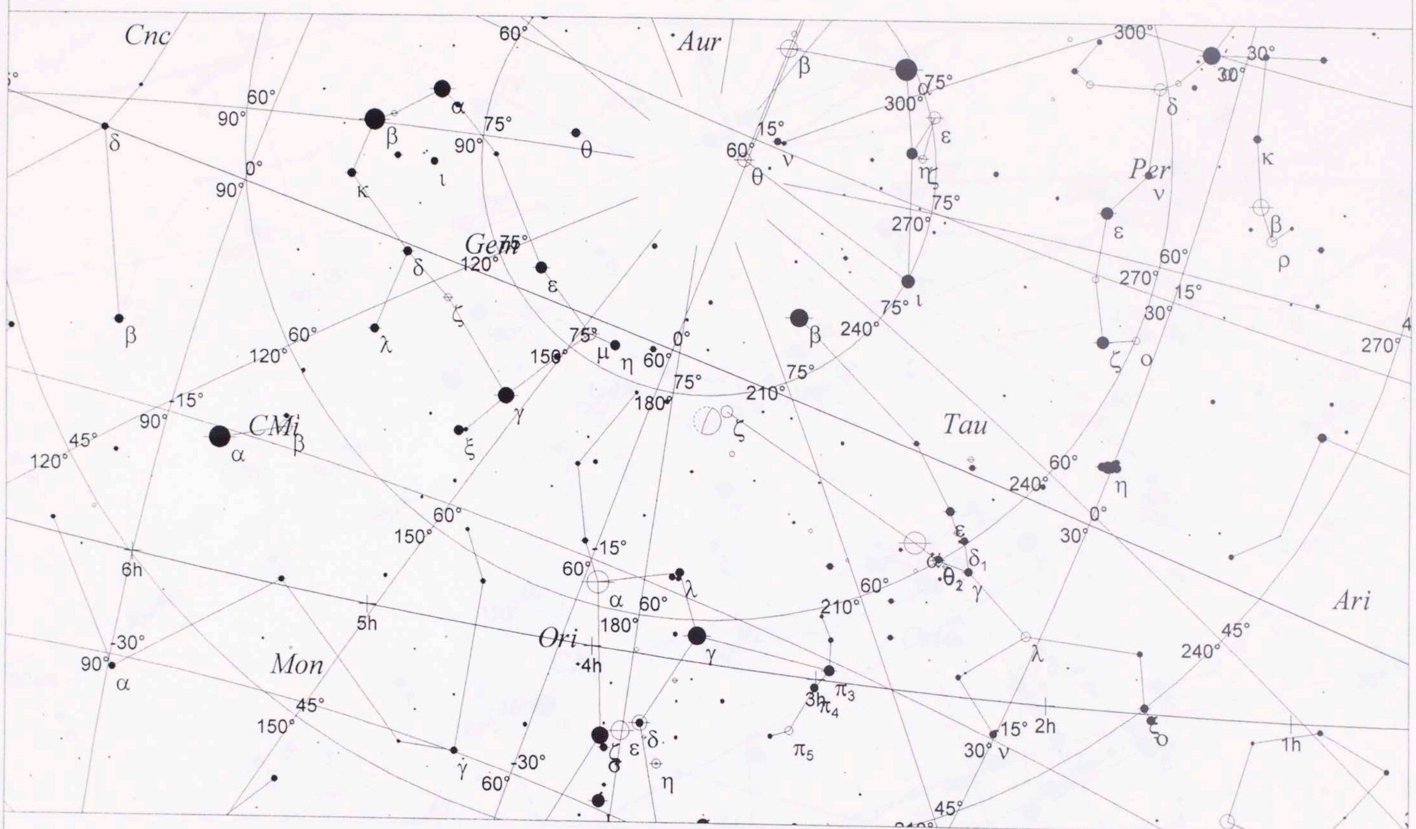


Local Time: 18:47:00 7-Feb-140BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 15:49:00 7-Feb-140BC
RA: 2h48m55s Dec: +11° 54' Field: 90.0°

Sidereal Time: 03:43:57
Julian Day: 1670326.1590

-140 XI 8

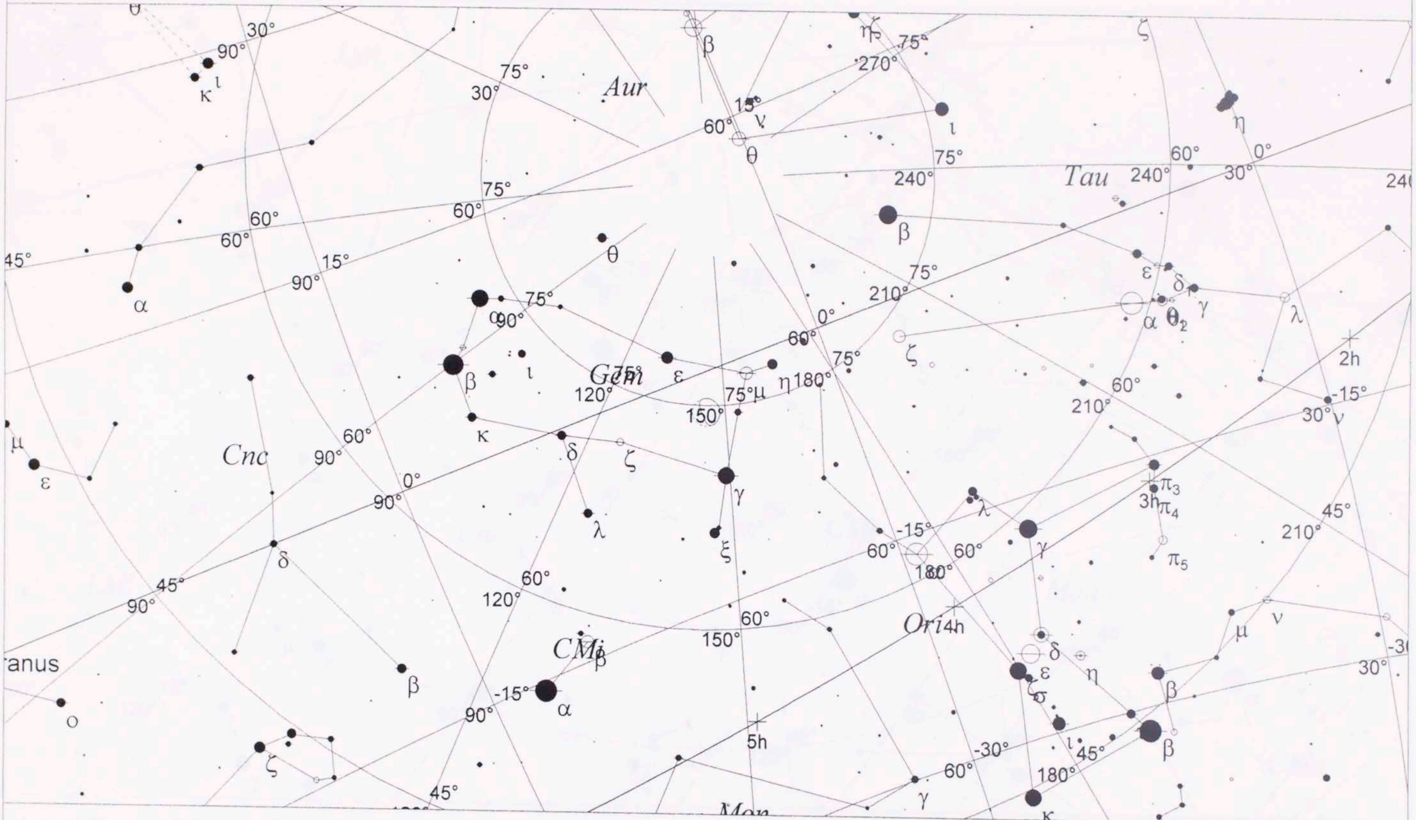


Local Time: 18:48:00 8-Feb-140BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 15:50:00 8-Feb-140BC
RA: 3h38m13s Dec: +16° 02' Field: 90.0°

Sidereal Time: 03:48:54
Julian Day: 1670327.1597

-140 XI 9

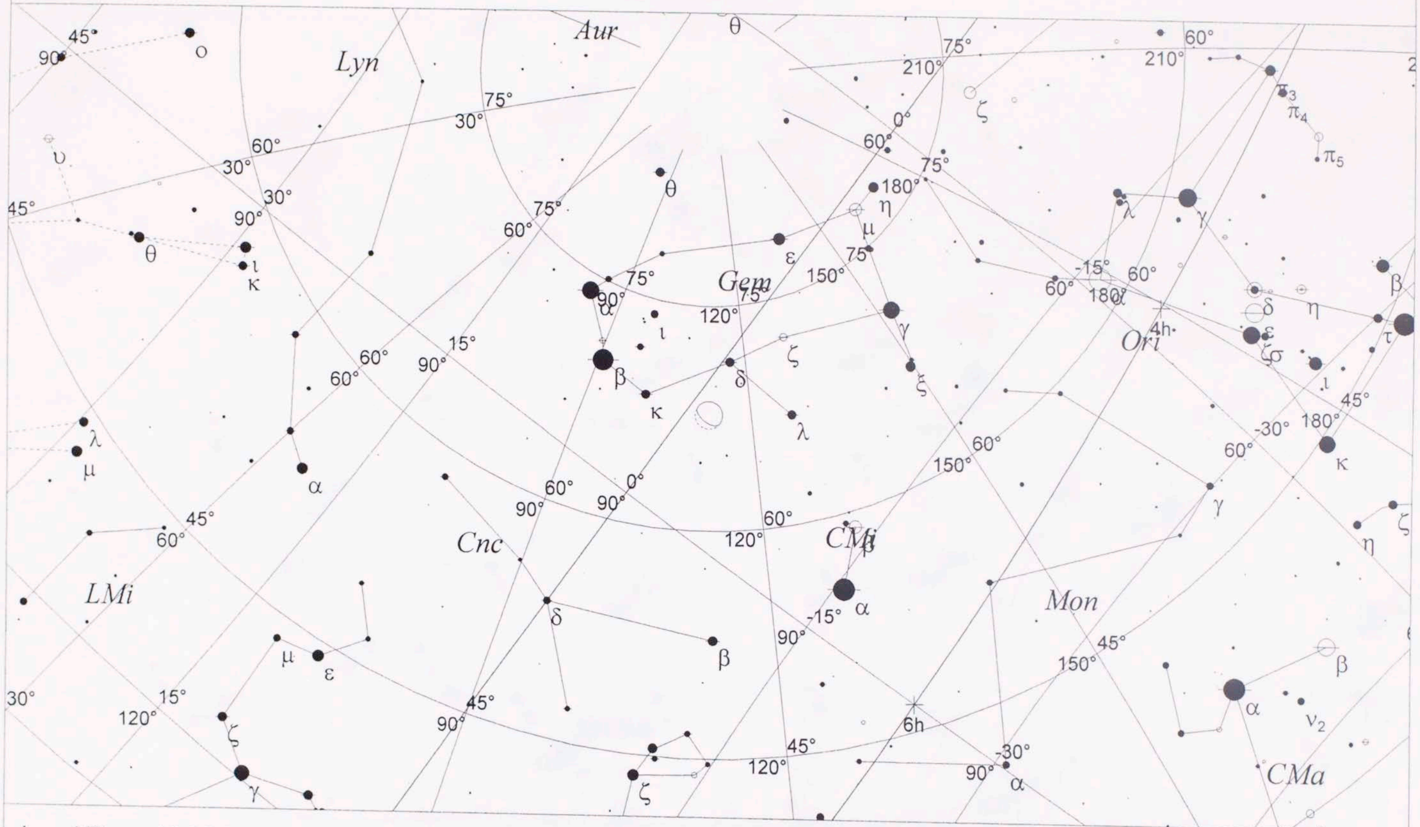


Local Time: 18:49:00 9-Feb-140BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 15:51:00 9-Feb-140BC
RA: 4h30m59s Dec: +19° 31' Field: 90.0°

Sidereal Time: 03:53:51
Julian Day: 1670328.1604

-140 XI 10

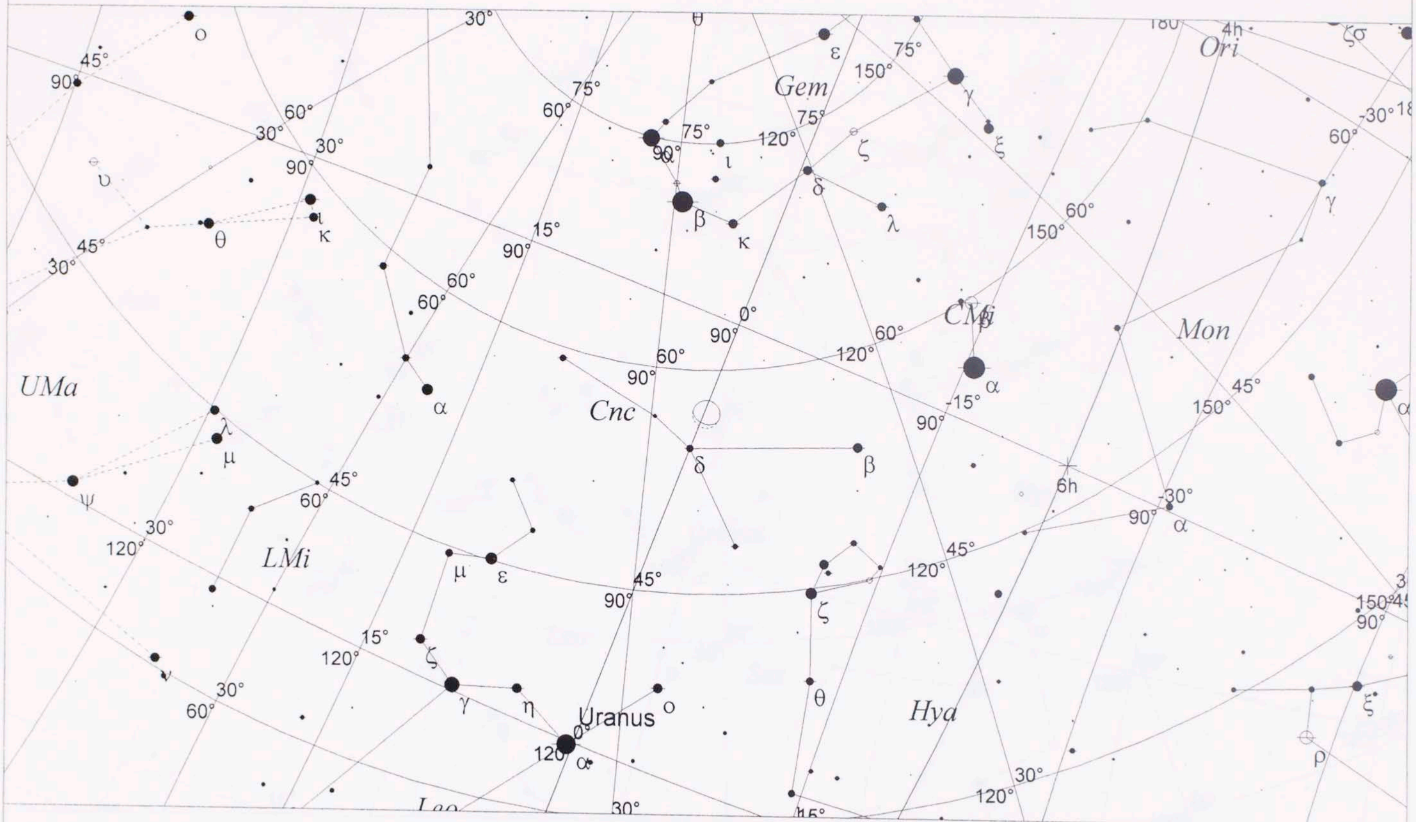


Local Time: 18:50:00 10-Feb-140BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 15:52:00 10-Feb-140BC
RA: 5h27m37s Dec: +22° 04' Field: 90.0°

Sidereal Time: 03:58:48
Julian Day: 1670329.1611

-140 XI 11

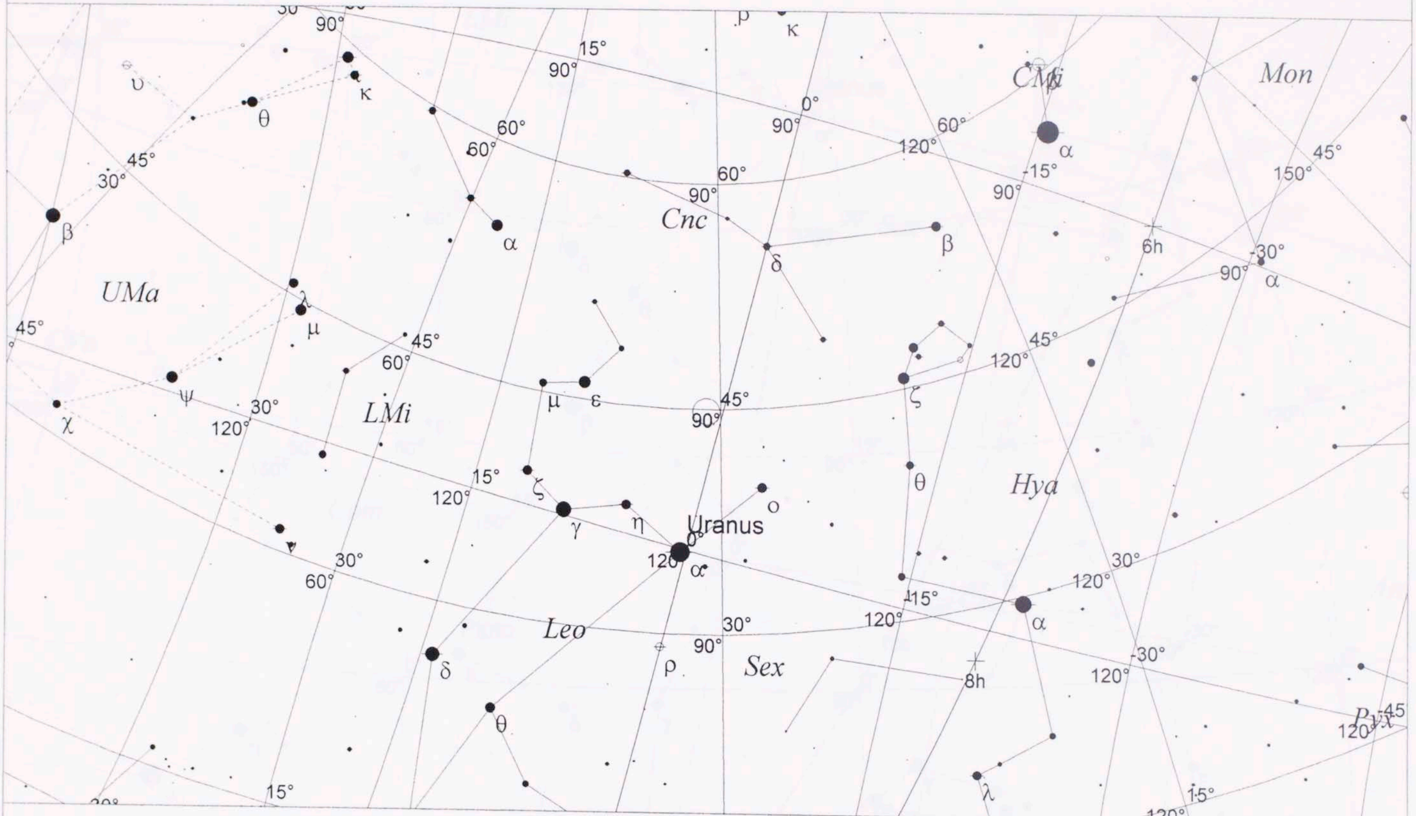


Local Time: 18:51:00 11-Feb-140BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 15:53:00 11-Feb-140BC
RA: 6h27m51s Dec: +23° 22' Field: 90.0°

Sidereal Time: 04:03:44
Julian Day: 1670330.1618

-140 XI 12

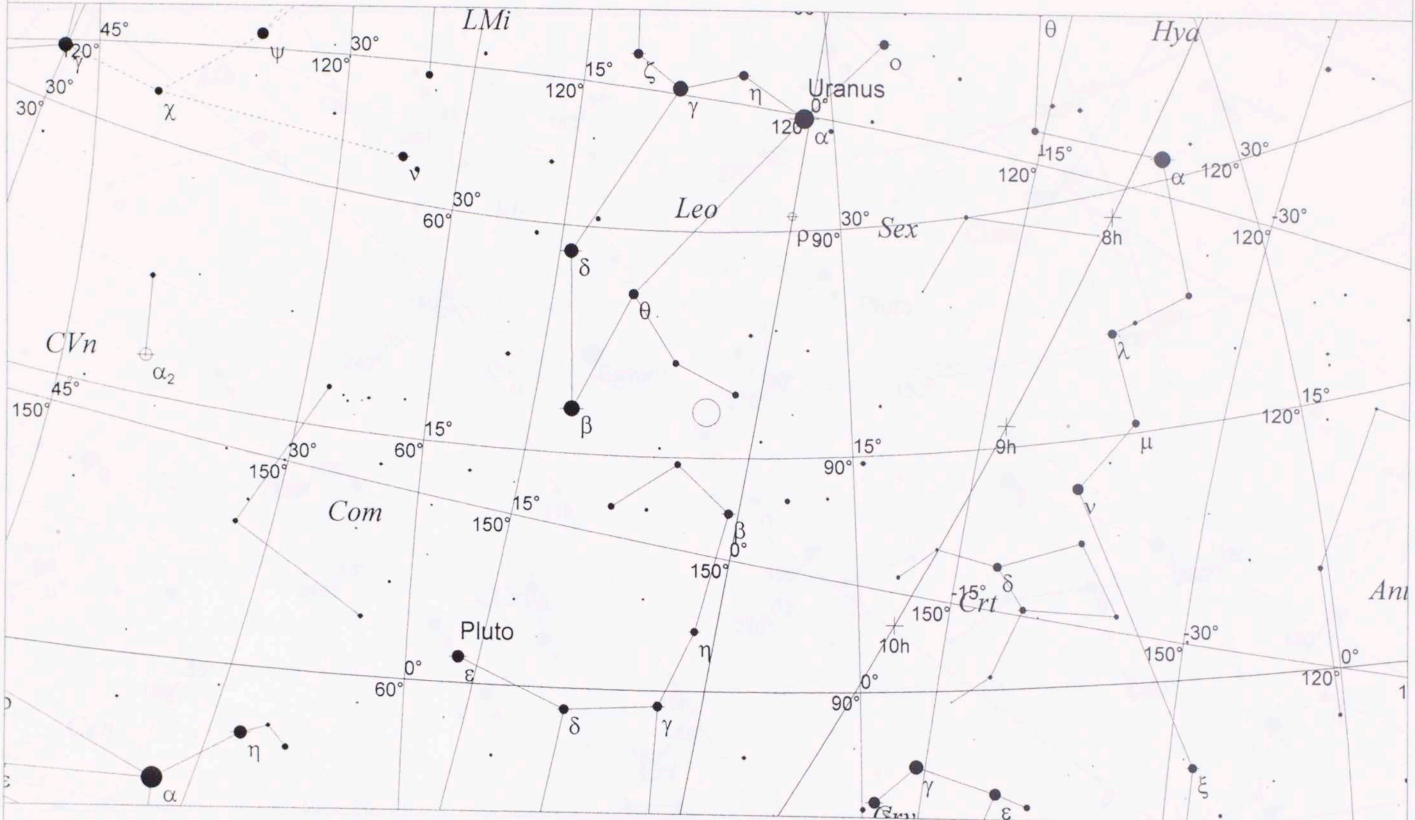


Local Time: 18:52:00 12-Feb-140BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 15:54:00 12-Feb-140BC
RA: 7h30m36s Dec: +23° 10' Field: 90.0°

Sidereal Time: 04:08:41
Julian Day: 1670331.1625

-140 XI 14

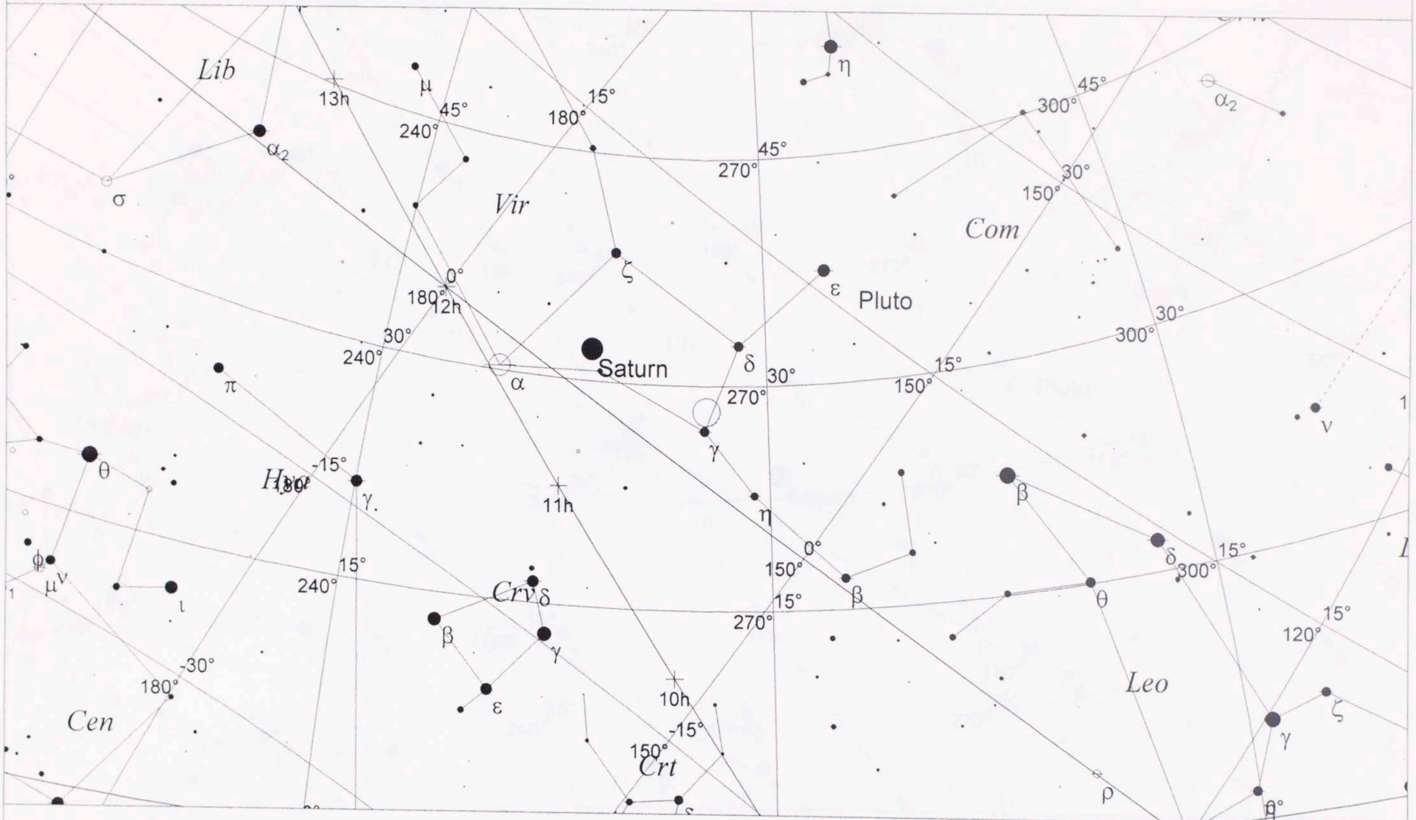


Local Time: 18:53:00 14-Feb-140BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 15:55:00 14-Feb-140BC
RA: 9h36m36s Dec: +18° 01' Field: 90.0°

Sidereal Time: 04:17:34
Julian Day: 1670333.1632

-140 XI 15

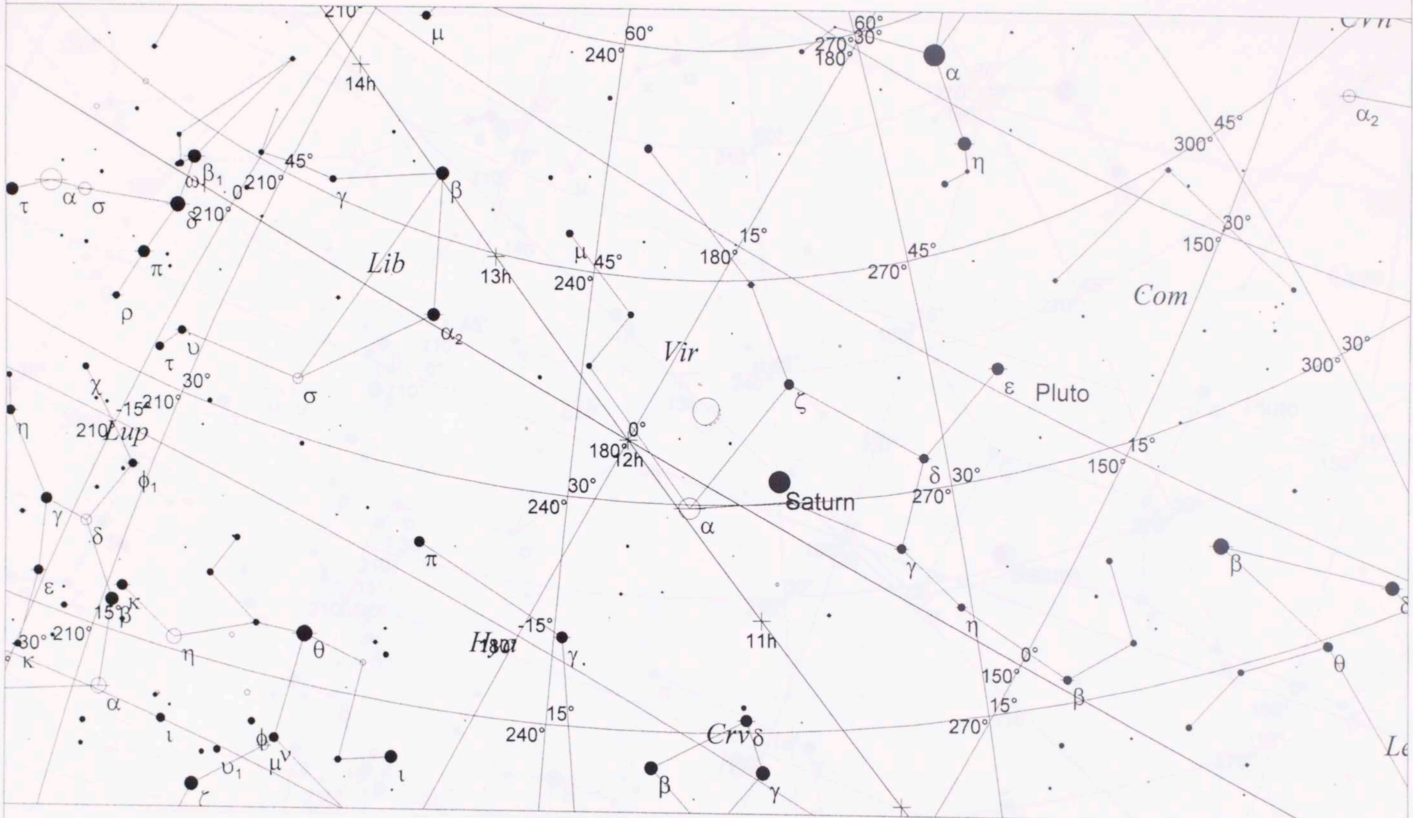


Local Time: 05:40:00 16-Feb-140BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:42:00 16-Feb-140BC
RA: 10h56m25s Dec: +11° 09' Field: 90.0°

Sidereal Time: 15:10:17
Julian Day: 1670334.6125

-140 XI 16

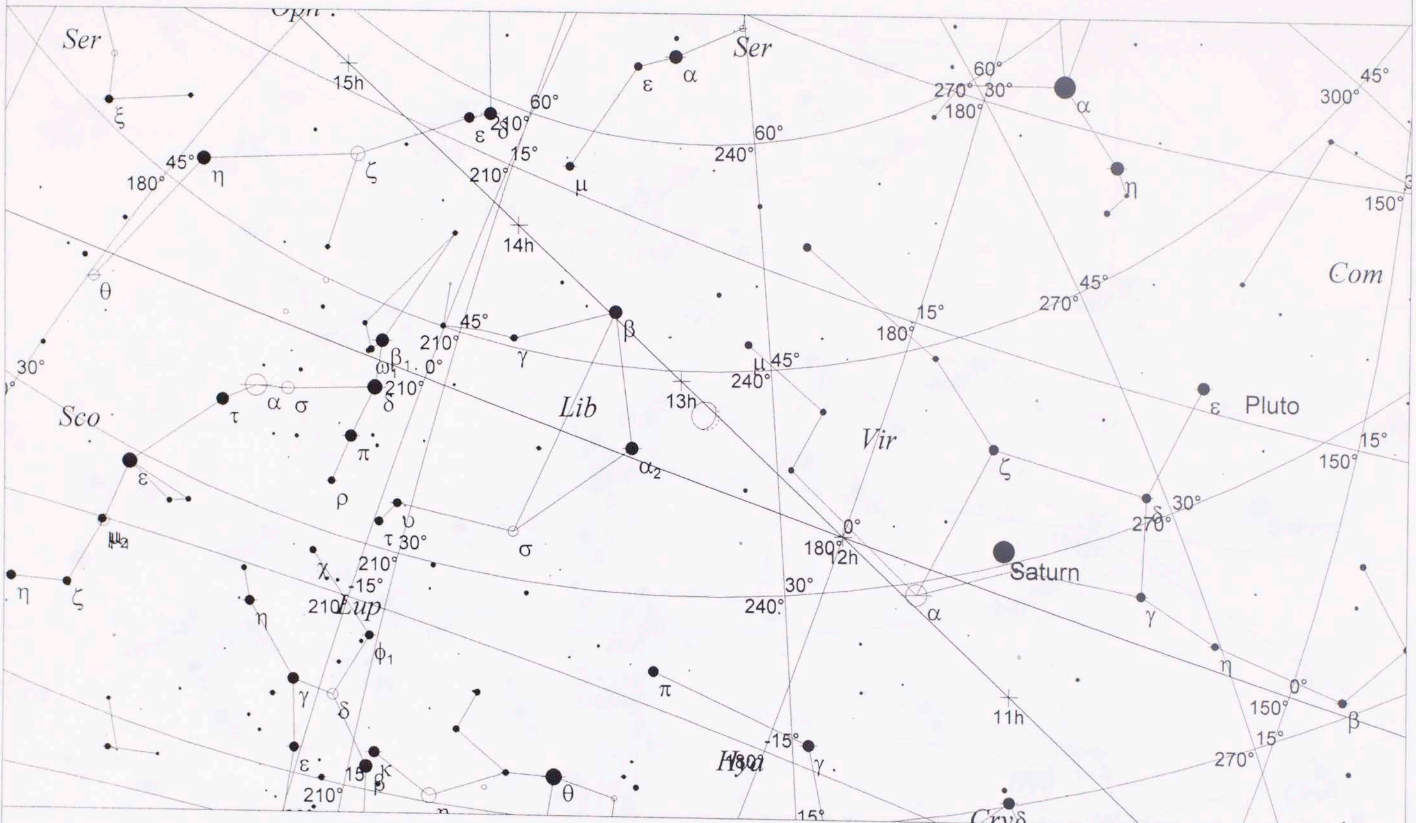


Local Time: 05:39:00 17-Feb-140BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:41:00 17-Feb-140BC
RA: 11h53m38s Dec: +5° 26' Field: 90.0°

Sidereal Time: 15:13:14
Julian Day: 1670335.6118

-140 XI 17

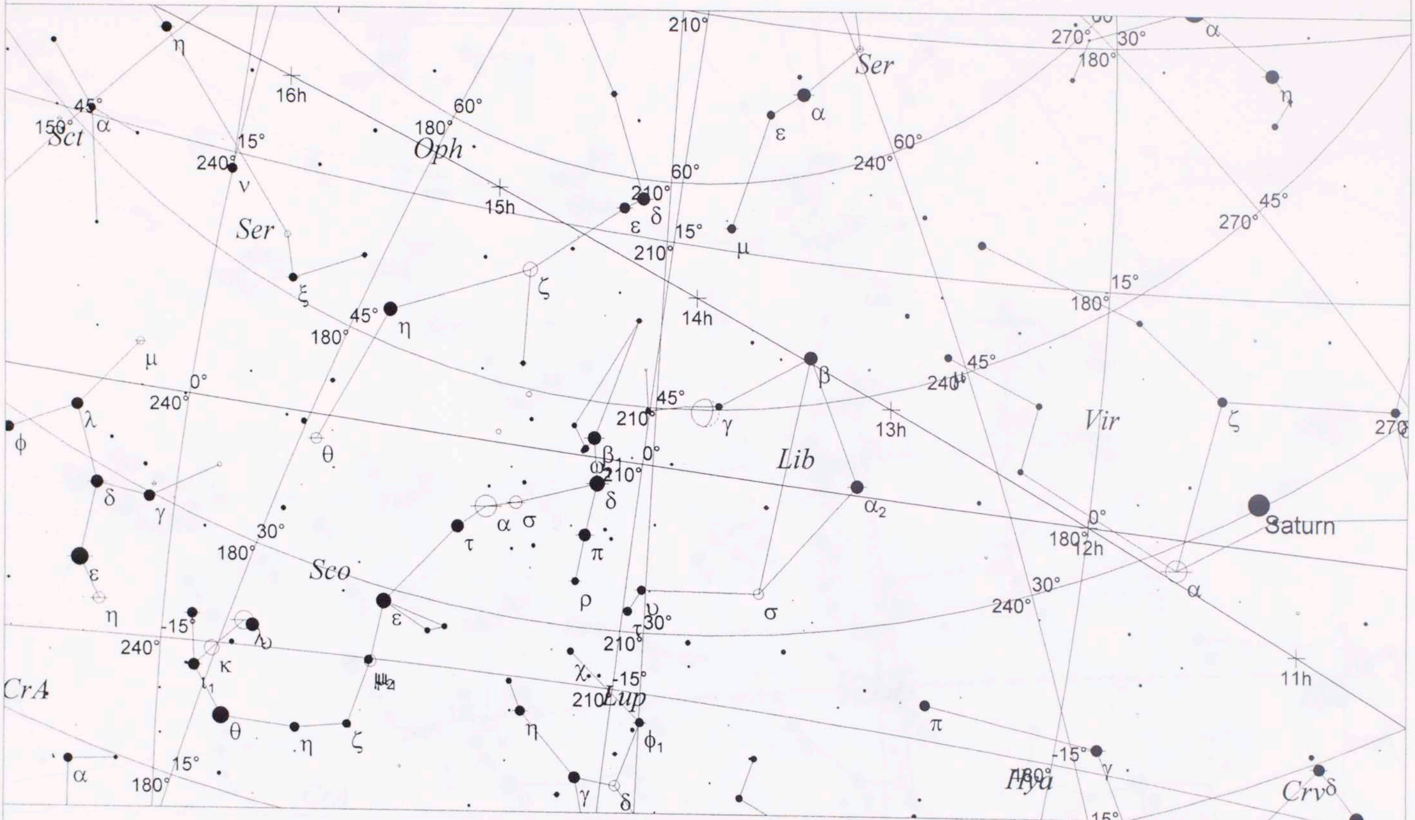


Local Time: 05:38:00 18-Feb-140BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:40:00 18-Feb-140BC
RA: 12h48m58s Dec: -0° 33' Field: 90.0°

Sidereal Time: 15:16:10
Julian Day: 1670336.6111

-140 XI 18

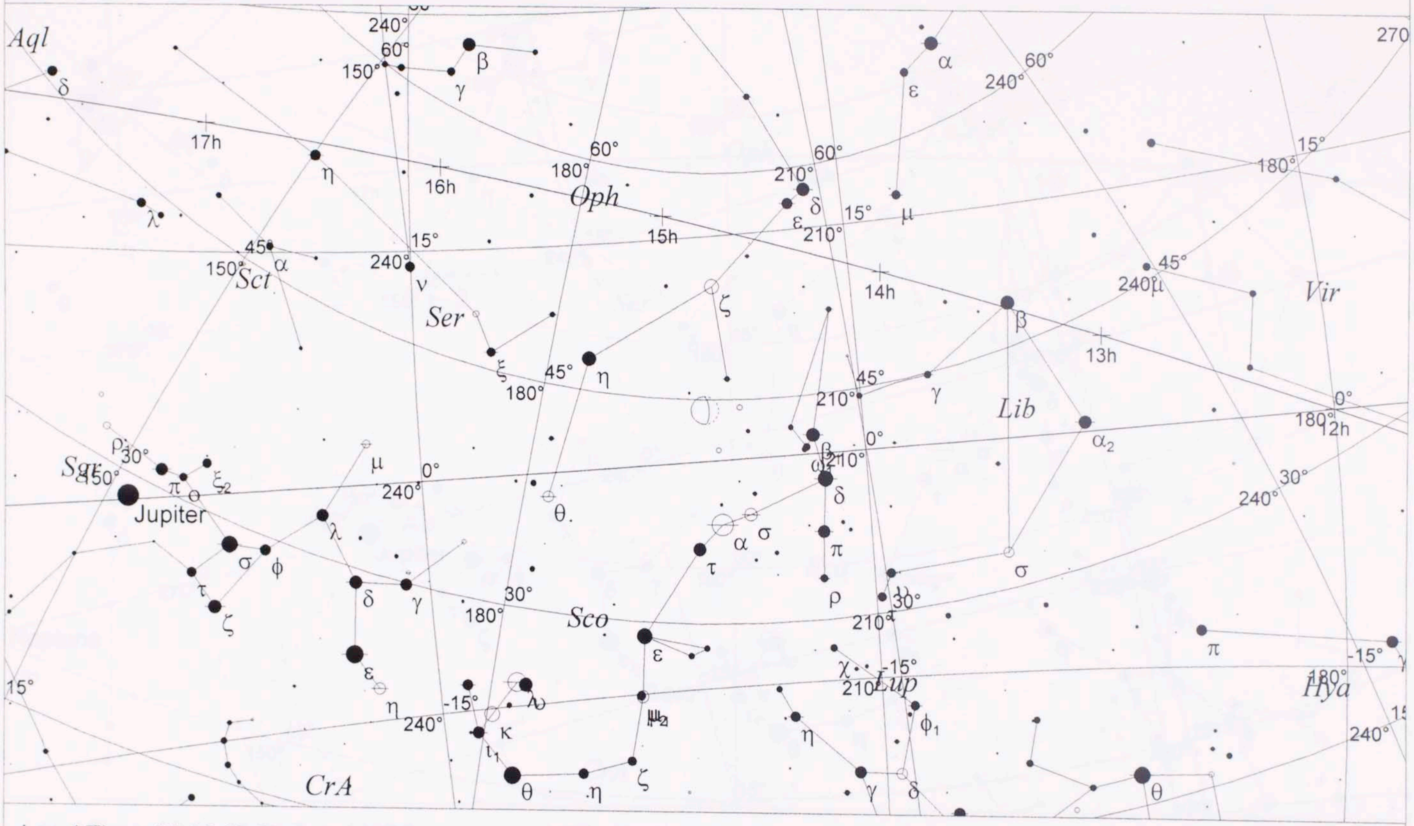


Local Time: 05:37:00 19-Feb-140BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:39:00 19-Feb-140BC
RA: 13h43m11s Dec: -6° 27' Field: 90.0°

Sidereal Time: 15:19:06
Julian Day: 1670337.6104

-140 XI 19

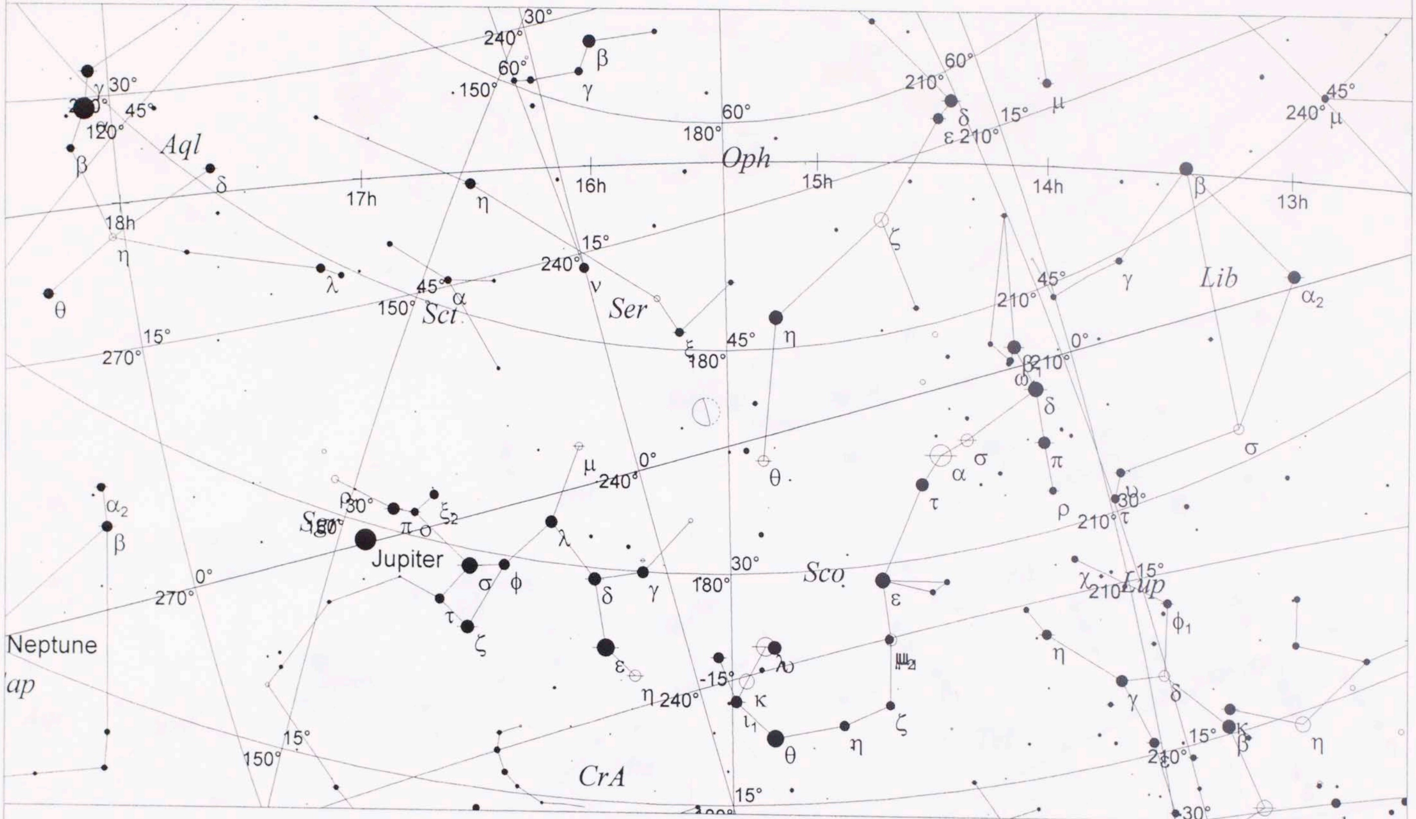


Local Time: 05:36:00 20-Feb-140BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:38:00 20-Feb-140BC
RA: 14h37m03s Dec: -11° 52' Field: 90.0°

Sidereal Time: 15:22:03
Julian Day: 1670338.6097

-140 XI 20

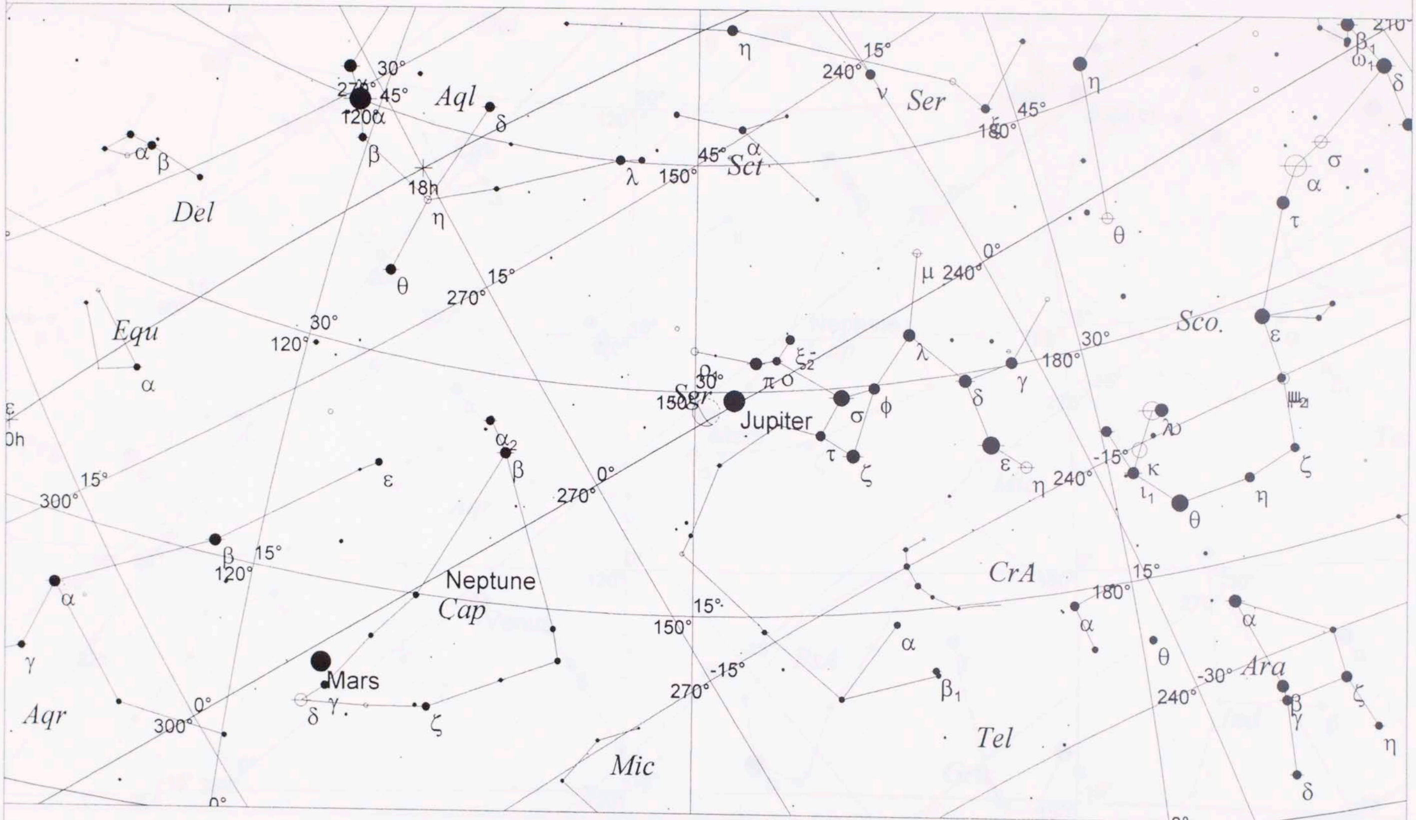


Local Time: 05:35:00 21-Feb-140BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:37:00 21-Feb-140BC
RA: 15h31m13s Dec: -16° 33' Field: 90.0°

Sidereal Time: 15:24:59
Julian Day: 1670339.6090

-140 XI 22

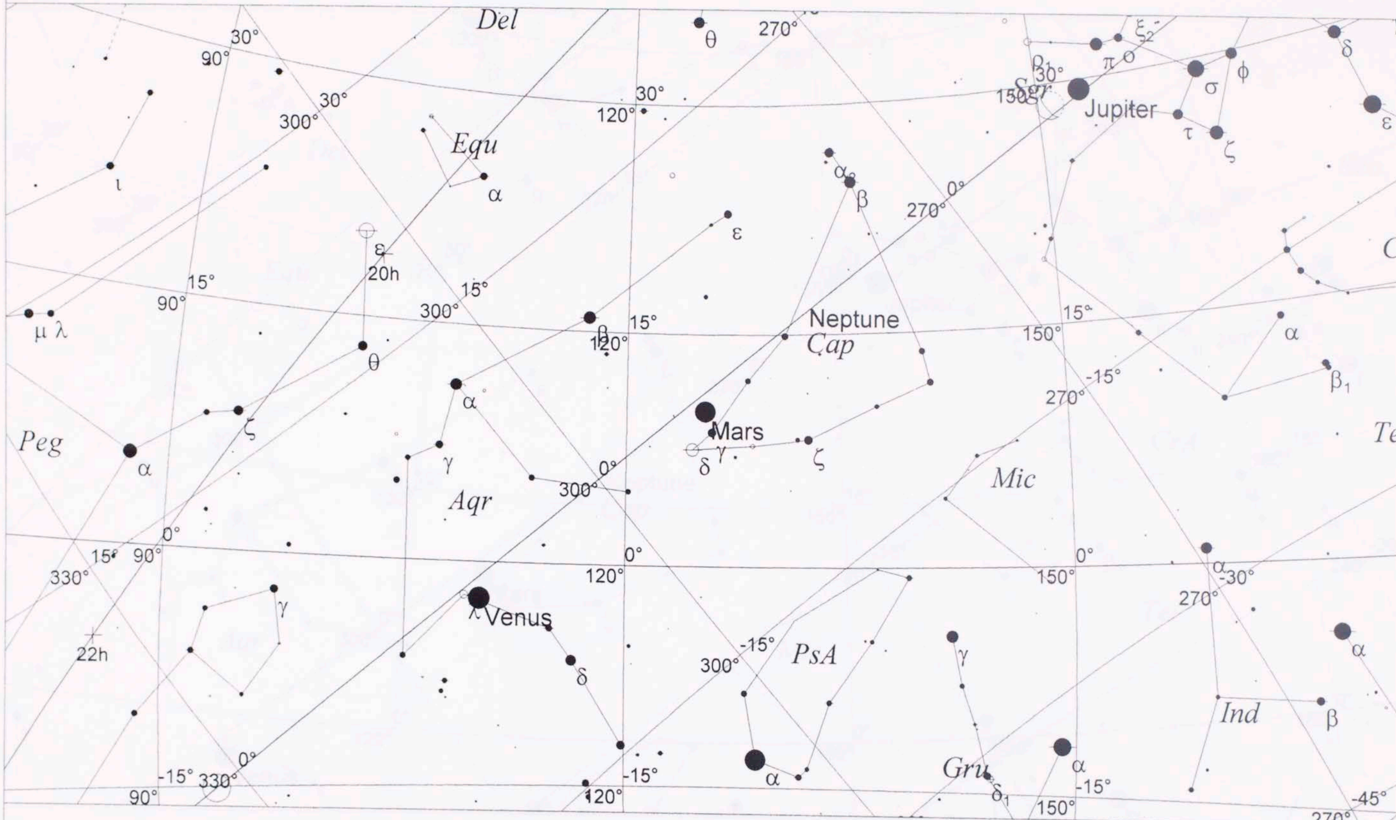


Local Time: 05:33:00 23-Feb-140BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:35:00 23-Feb-140BC
RA: 17h21m25s Dec: -22° 51' Field: 90.0°

Sidereal Time: 15:30:52
Julian Day: 1670341.6076

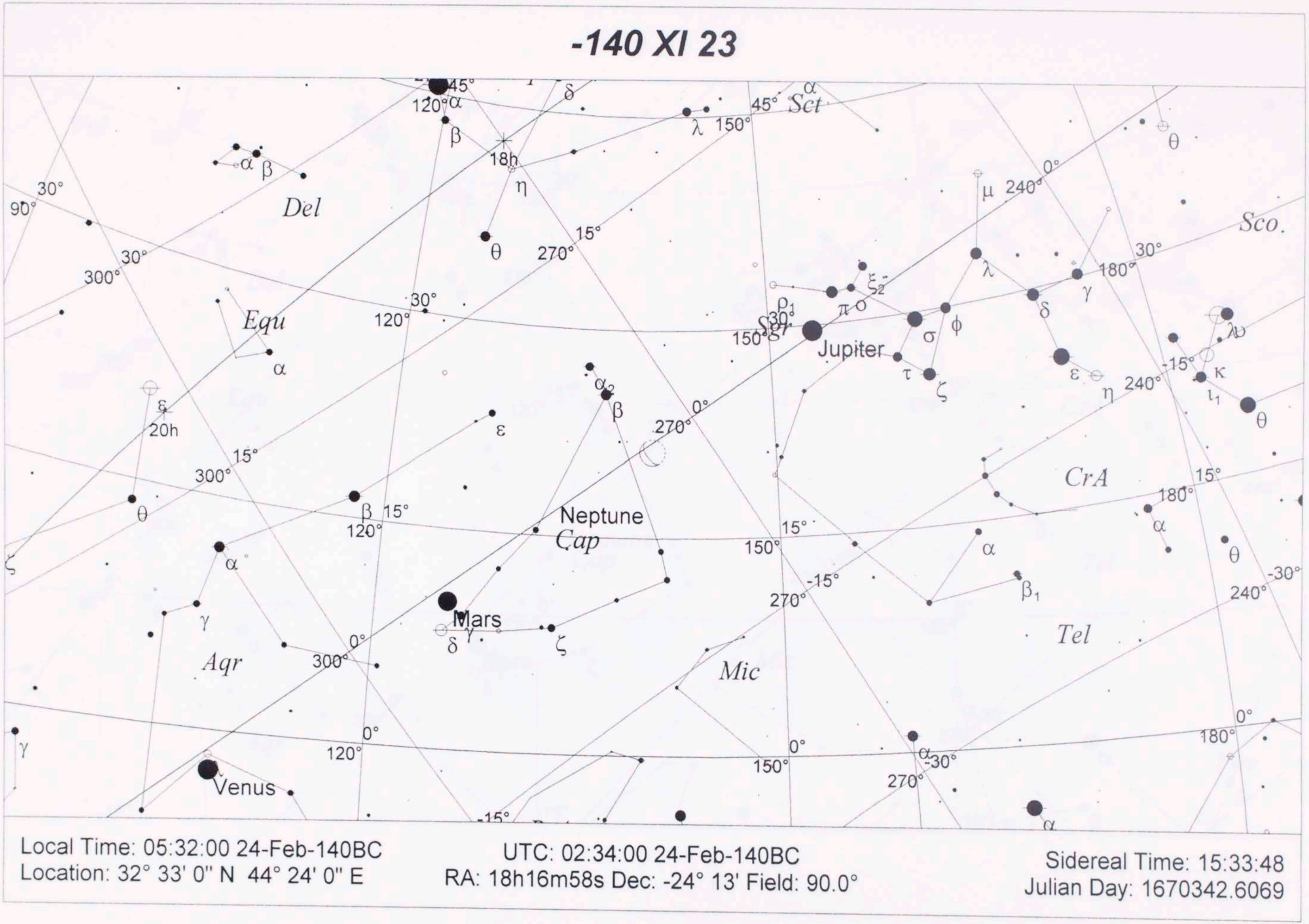
-140 XI 22



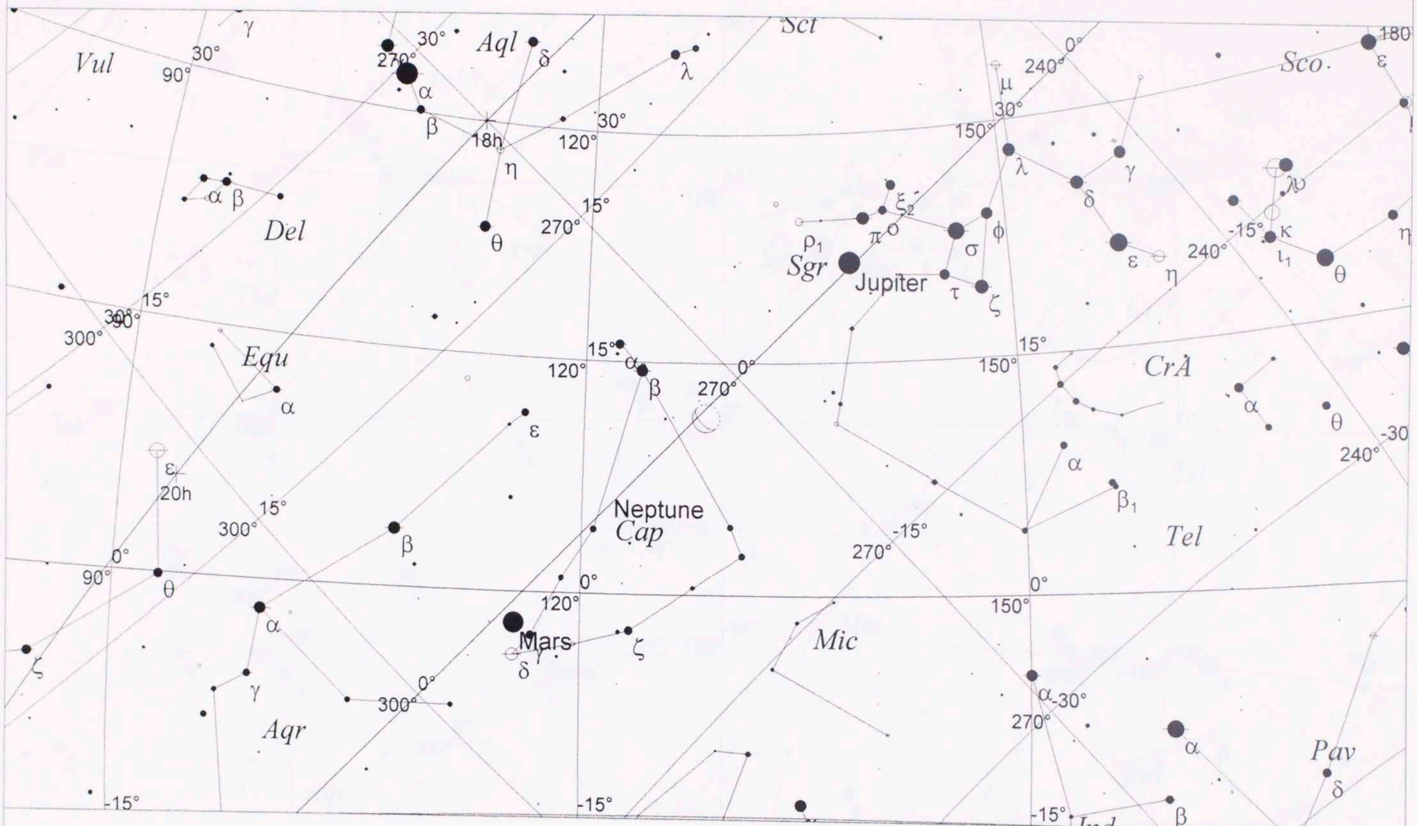
Local Time: 05:33:00 23-Feb-140BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:35:00 23-Feb-140BC
RA: 19h33m51s Dec: -22° 58' Field: 90.0°

Sidereal Time: 15:30:52
Julian Day: 1670341.6076


-140 XI 23
Del
Equ
Sct
Sco.
Sgr
Jupiter
CrA
Neptune
Cap
Mars
Aqr
Mic
Tel
Venus
Local Time: 05:32:00 24-Feb-140BC
Location: 32° 33' 0" N 44° 24' 0" E
UTC: 02:34:00 24-Feb-140BC
RA: 18h16m58s Dec: -24° 13' Field: 90.0°
Sidereal Time: 15:33:48
Julian Day: 1670342.6069

-140 XI 23

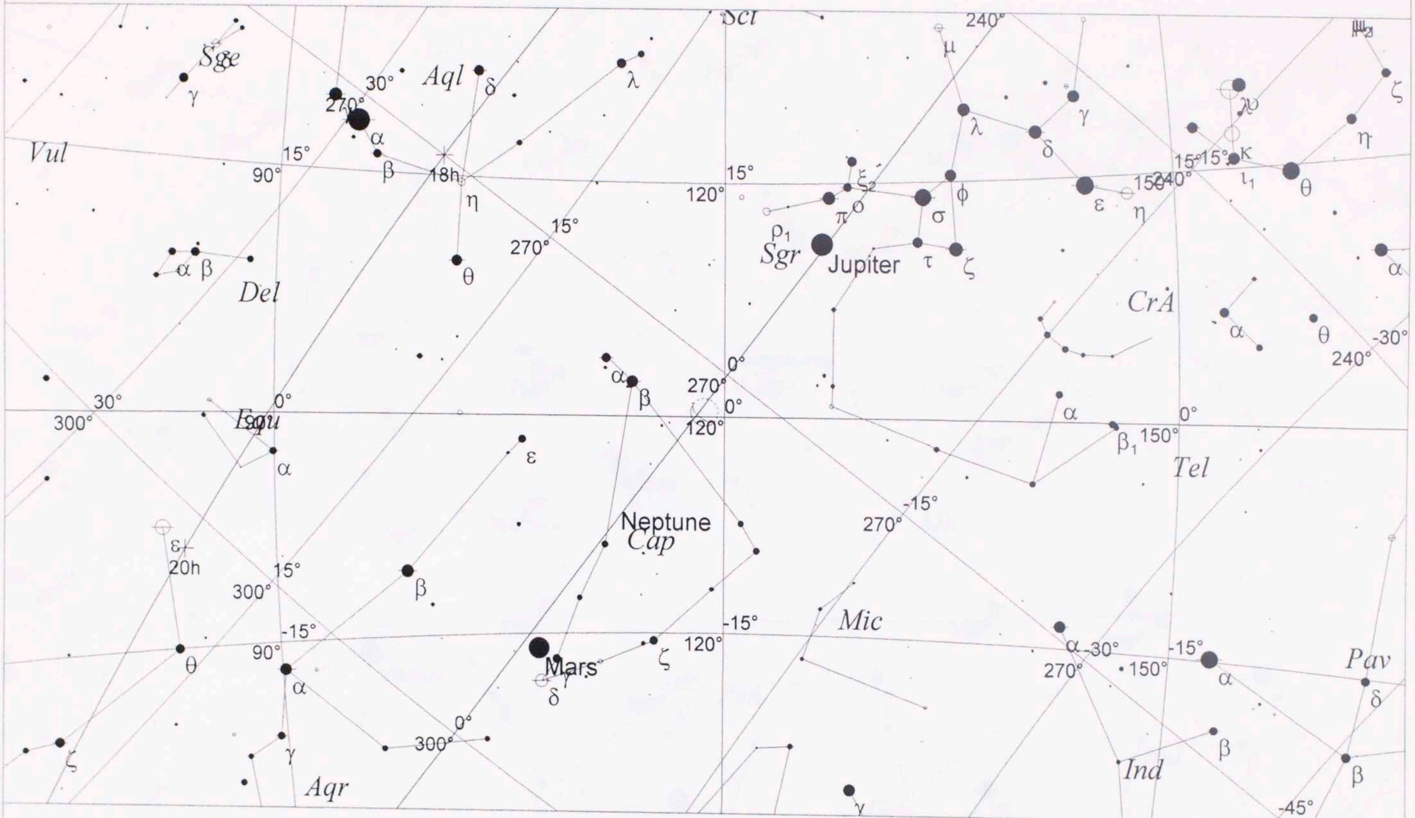


Local Time: 04:24:00 24-Feb-140BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:26:00 24-Feb-140BC
RA: 18h15m02s Dec: -24° 06' Field: 90.0°

Sidereal Time: 14:25:37
Julian Day: 1670342.5597

-140 XI 23

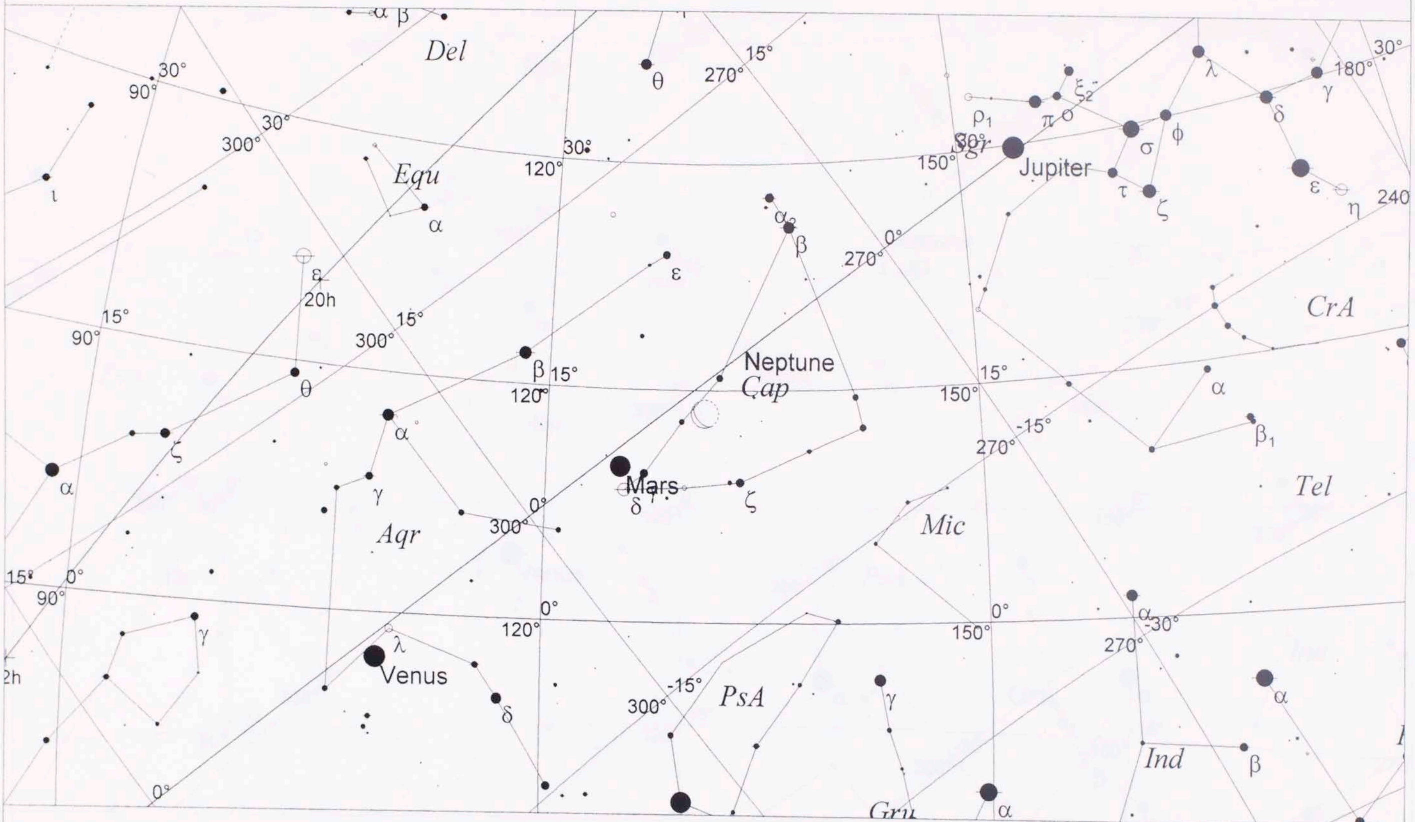


Local Time: 03:16:00 24-Feb-140BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 00:18:00 24-Feb-140BC
RA: 18h12m51s Dec: -23° 59' Field: 90.0°

Sidereal Time: 13:17:26
Julian Day: 1670342.5125

-140 XI 24

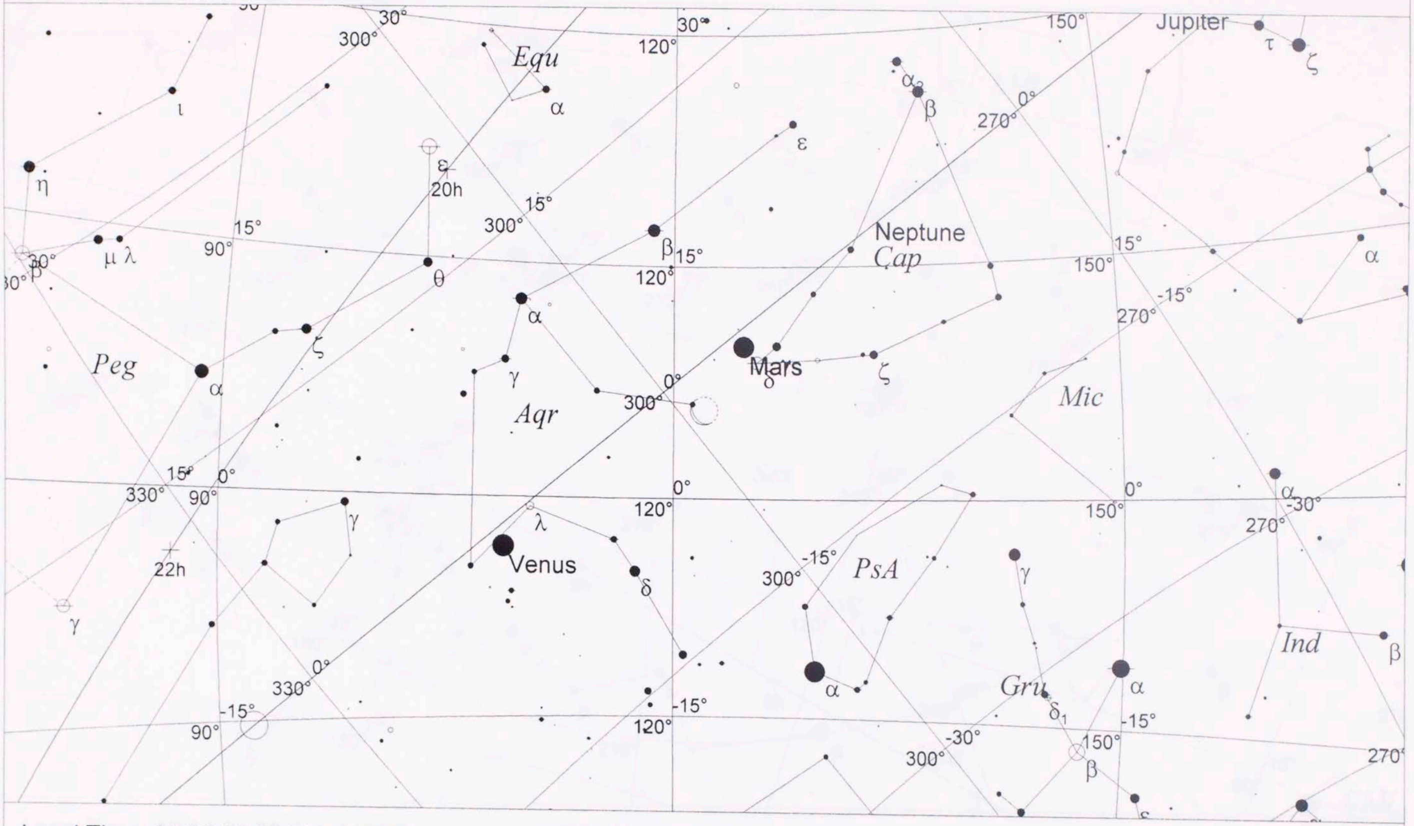


Local Time: 05:31:00 25-Feb-140BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:33:00 25-Feb-140BC
RA: 19h11m57s Dec: -24° 21' Field: 90.0°

Sidereal Time: 15:36:45
Julian Day: 1670343.6063

-140 XI 25

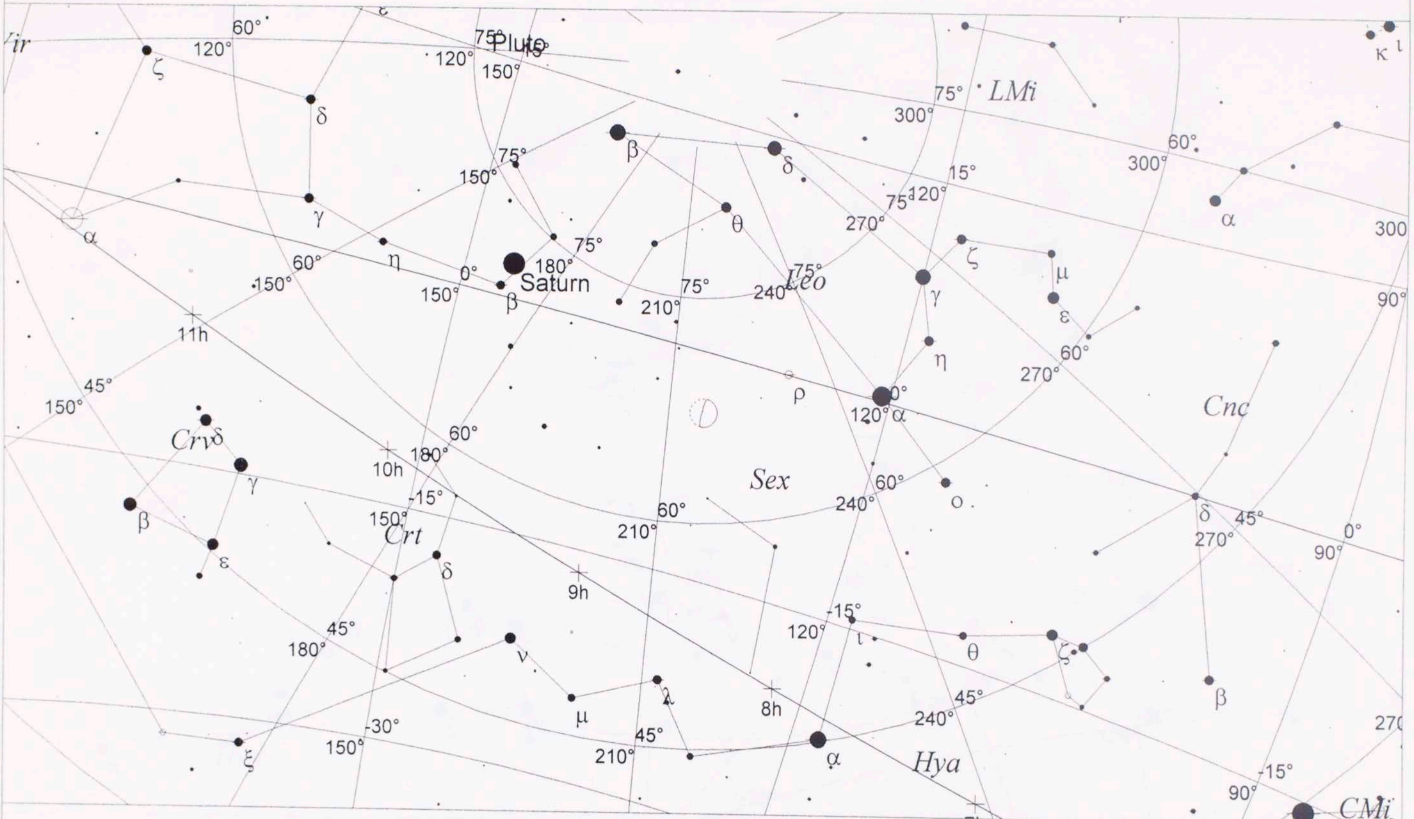


Local Time: 05:29:00 26-Feb-140BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 02:31:00 26-Feb-140BC
RA: 20h05m32s Dec: -23° 19' Field: 90.0°

Sidereal Time: 15:38:41
Julian Day: 1670344.6049

-111 / 8

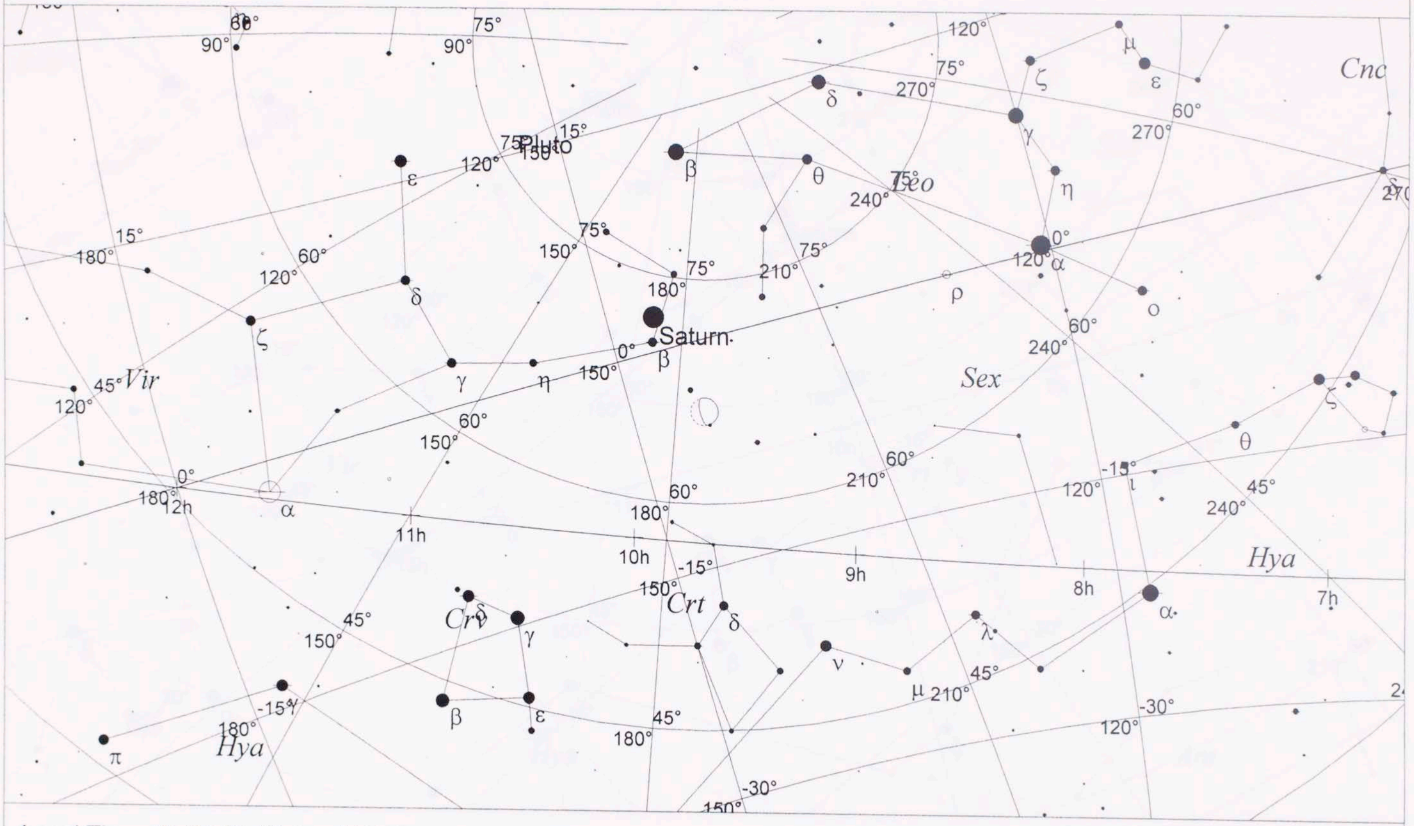


Local Time: 19:34:00 28-Apr-112BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:36:00 28-Apr-112BC
RA: 8h53m21s Dec: +13° 34' Field: 90.0°

Sidereal Time: 09:47:22
Julian Day: 1680633.1917

-111 / 9

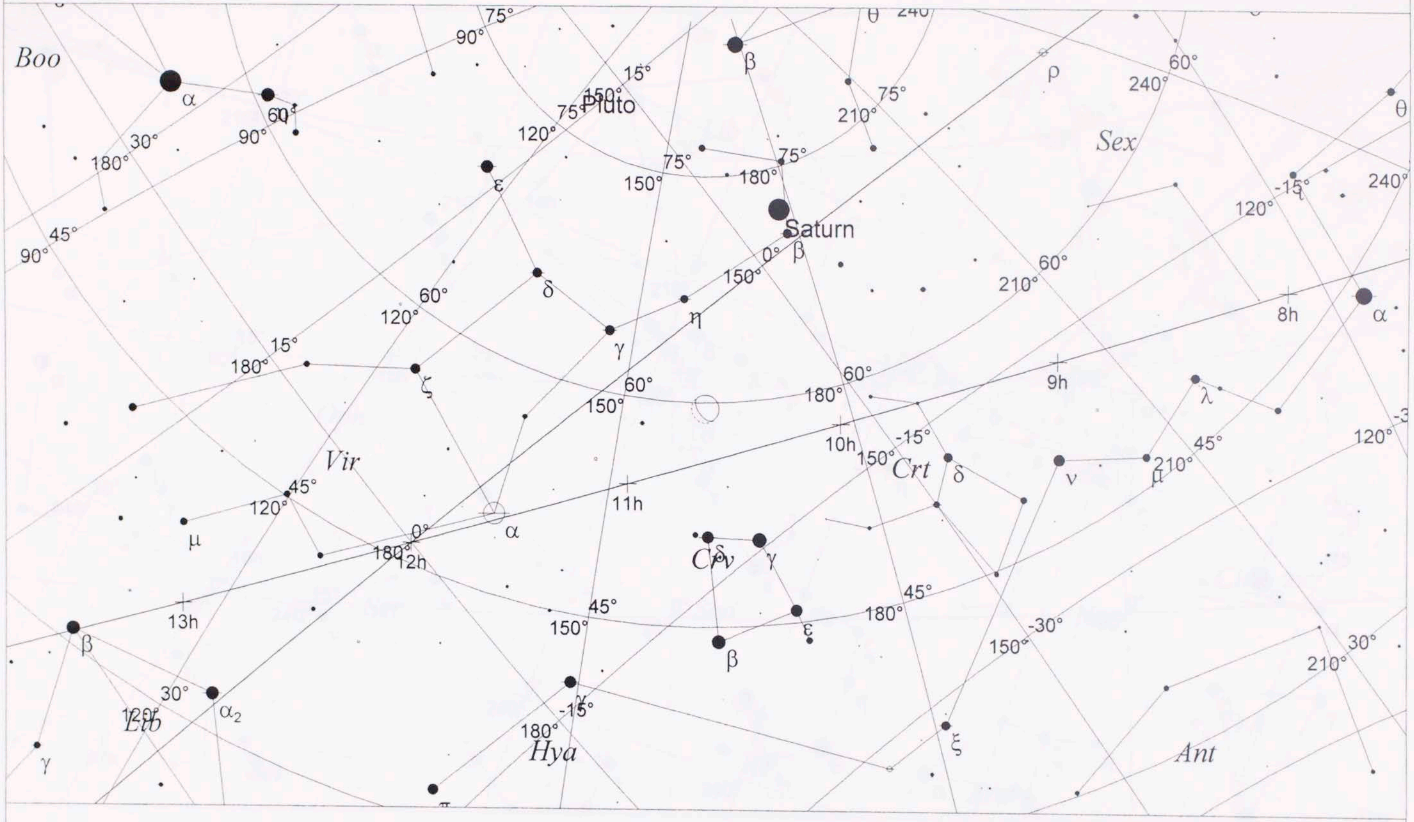


Local Time: 19:34:00 29-Apr-112BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:36:00 29-Apr-112BC
RA: 9h43m36s Dec: +8° 49' Field: 90.0°

Sidereal Time: 09:51:19
Julian Day: 1680634.1917

-111 / 10

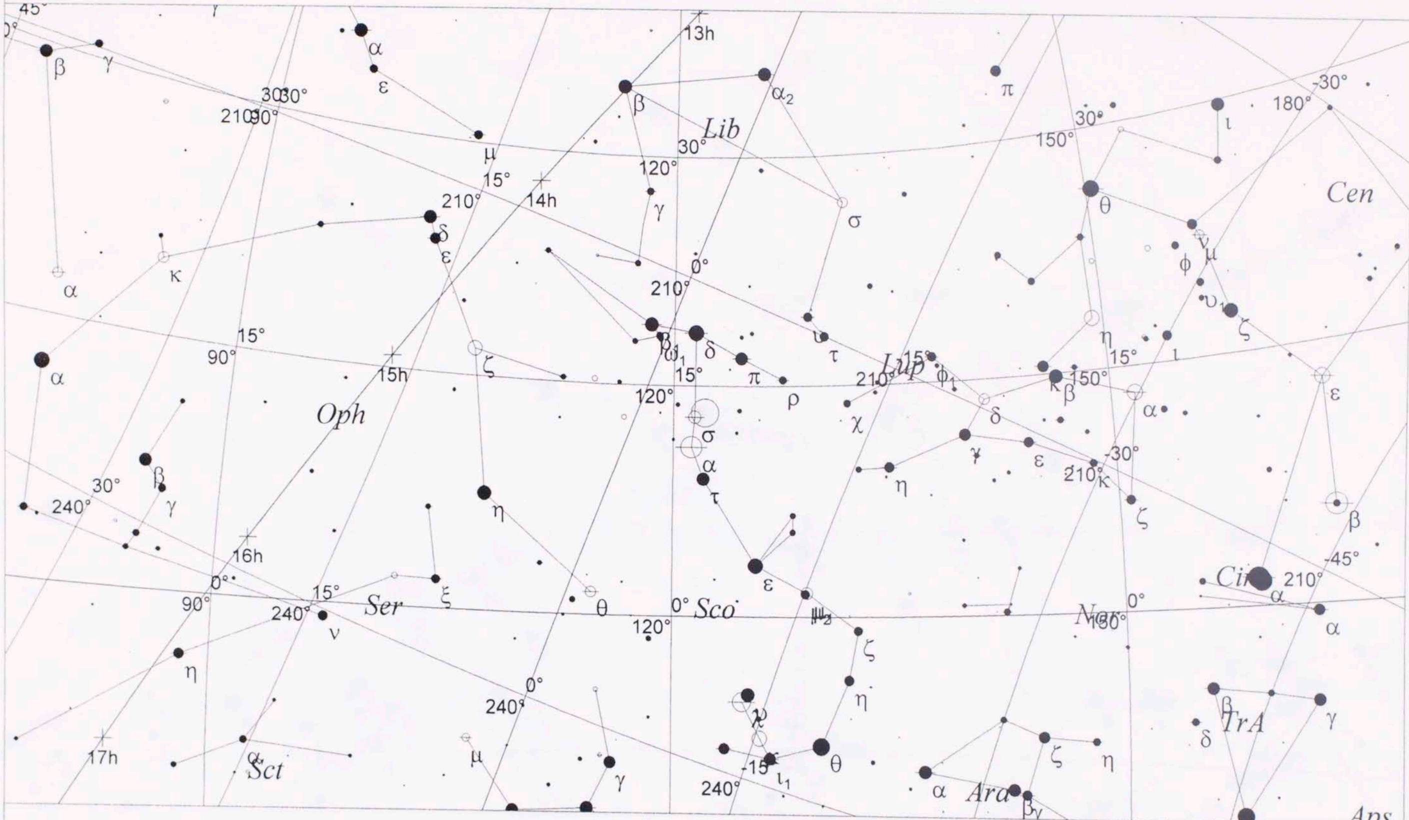


Local Time: 19:35:00 30-Apr-112BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:37:00 30-Apr-112BC
RA: 10h34m10s Dec: +3° 27' Field: 90.0°

Sidereal Time: 09:56:15
Julian Day: 1680635.1924

-111 / 14

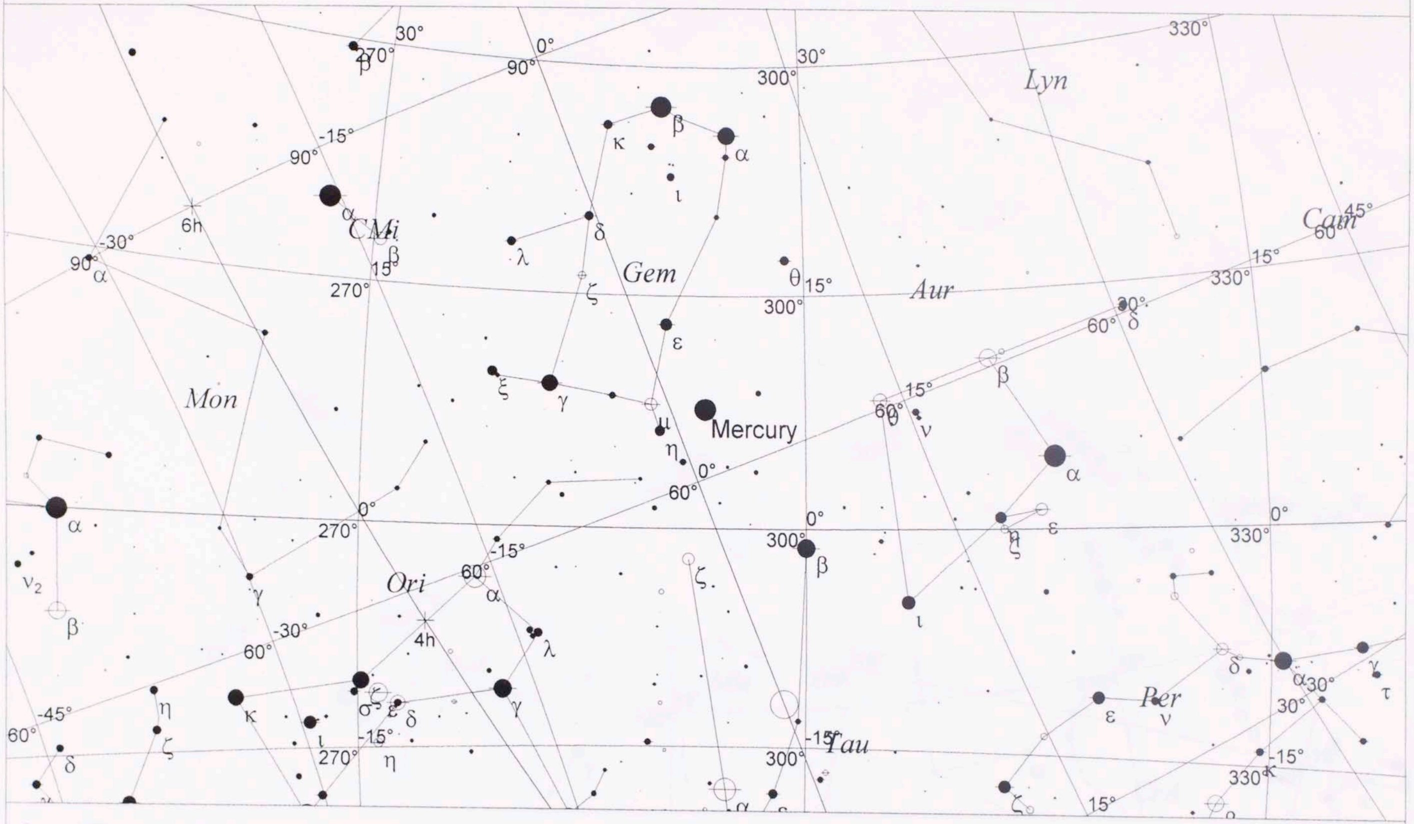


Local Time: 19:38:00 4-May-112BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:40:00 4-May-112BC
RA: 14h16m00s Dec: -18° 20' Field: 90.0°

Sidereal Time: 10:15:02
Julian Day: 1680639.1944

-111 / 18

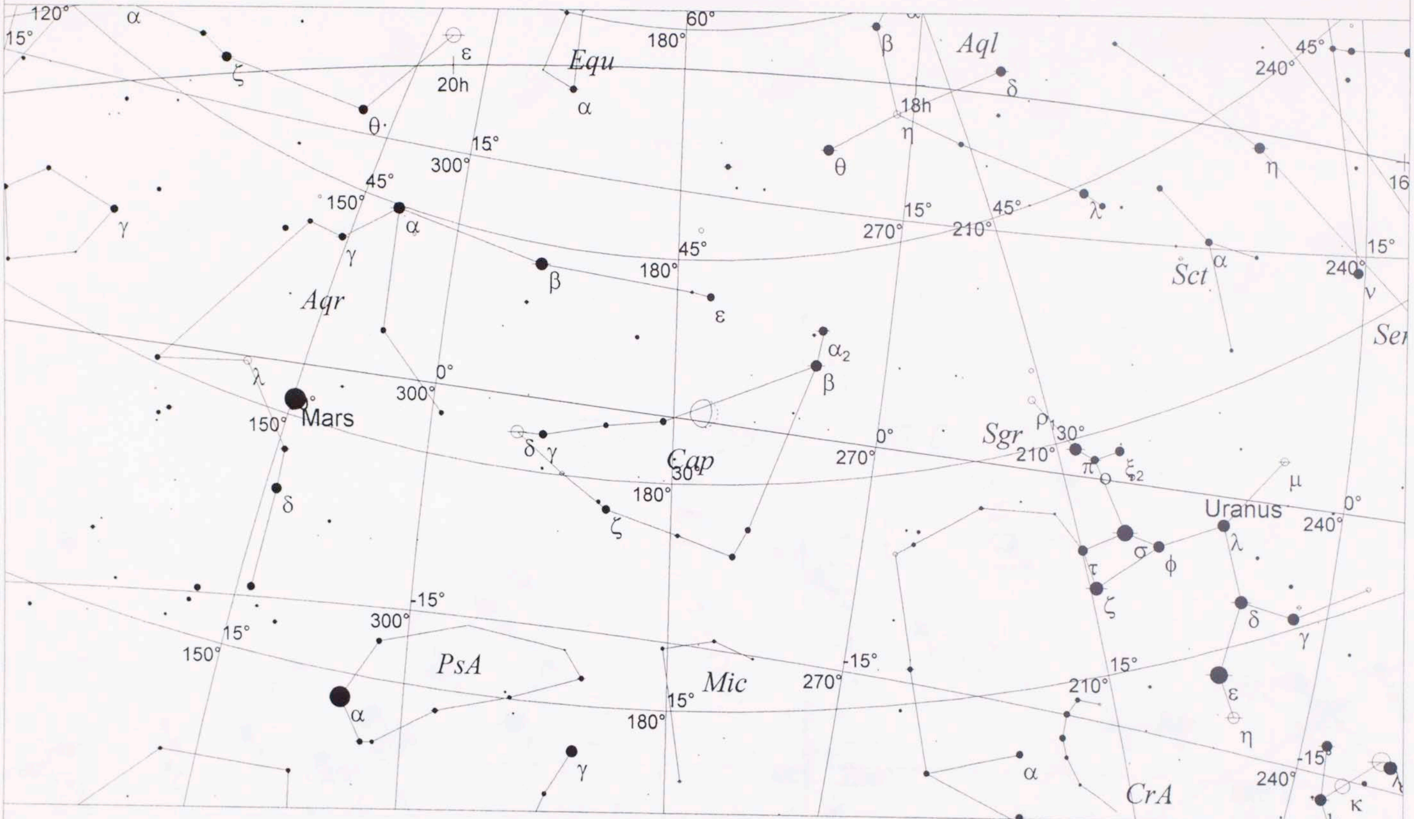


Local Time: 19:40:00 8-May-112BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:42:00 8-May-112BC
RA: 4h07m16s Dec: +23° 25' Field: 90.0°

Sidereal Time: 10:32:49
Julian Day: 1680643.1958

-111 / 18

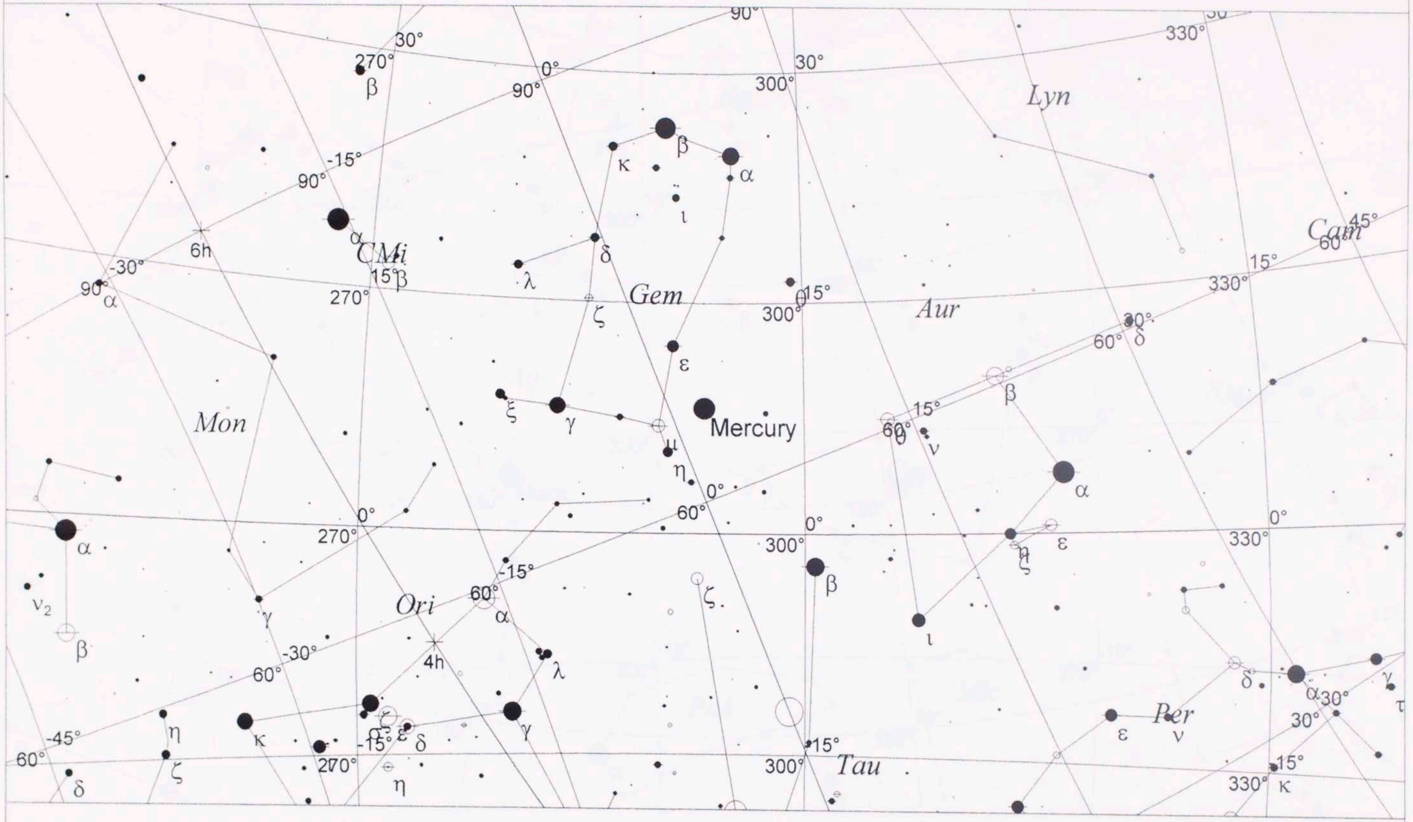


Local Time: 04:06:00 9-May-112BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 01:08:00 9-May-112BC
RA: 18h51m14s Dec: -22° 36' Field: 90.0°

Sidereal Time: 19:00:12
Julian Day: 1680643.5472

-111 / 19

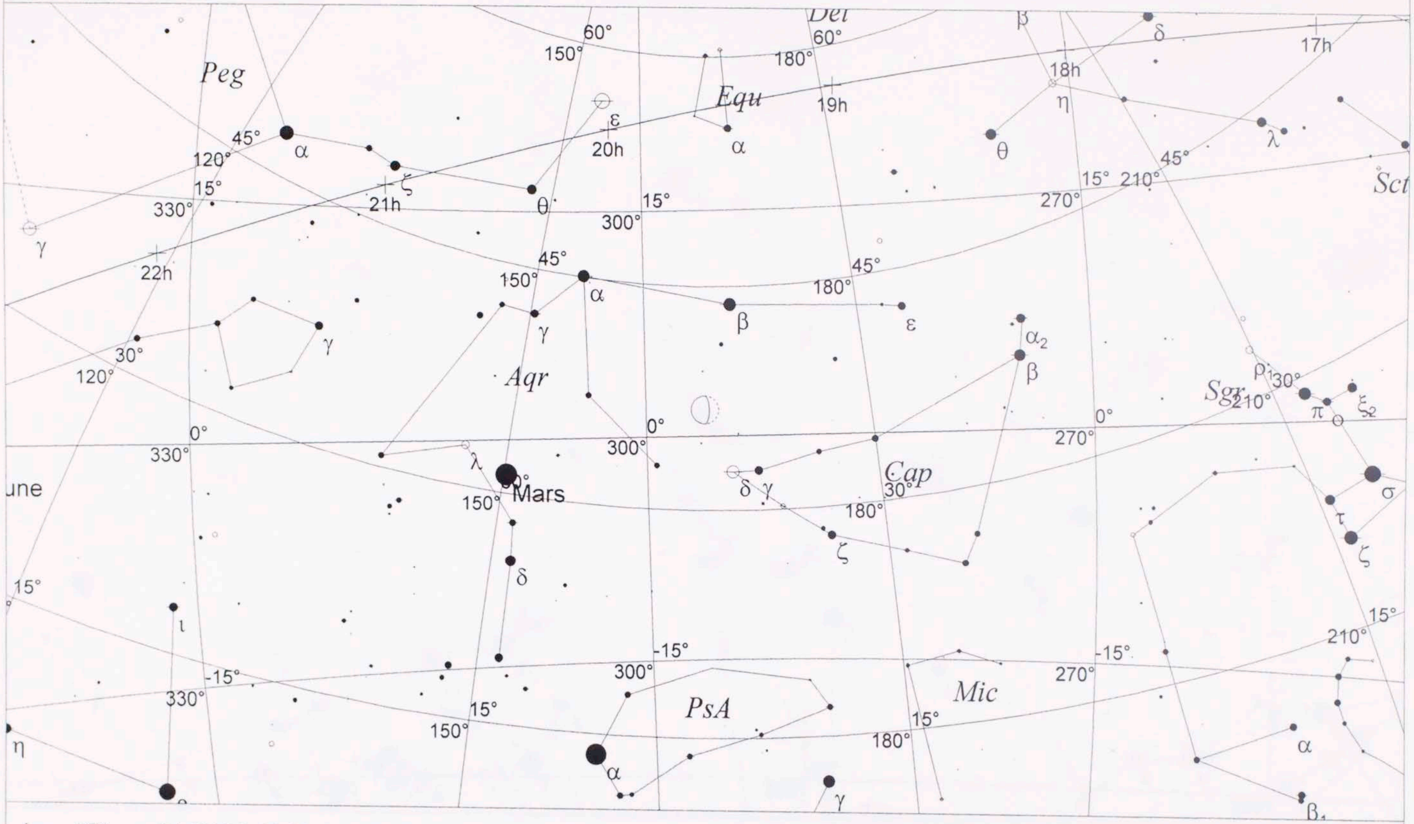


Local Time: 19:41:00 9-May-112BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:43:00 9-May-112BC
RA: 4h14m09s Dec: +23° 43' Field: 90.0°

Sidereal Time: 10:37:45
Julian Day: 1680644.1965

-111 / 19

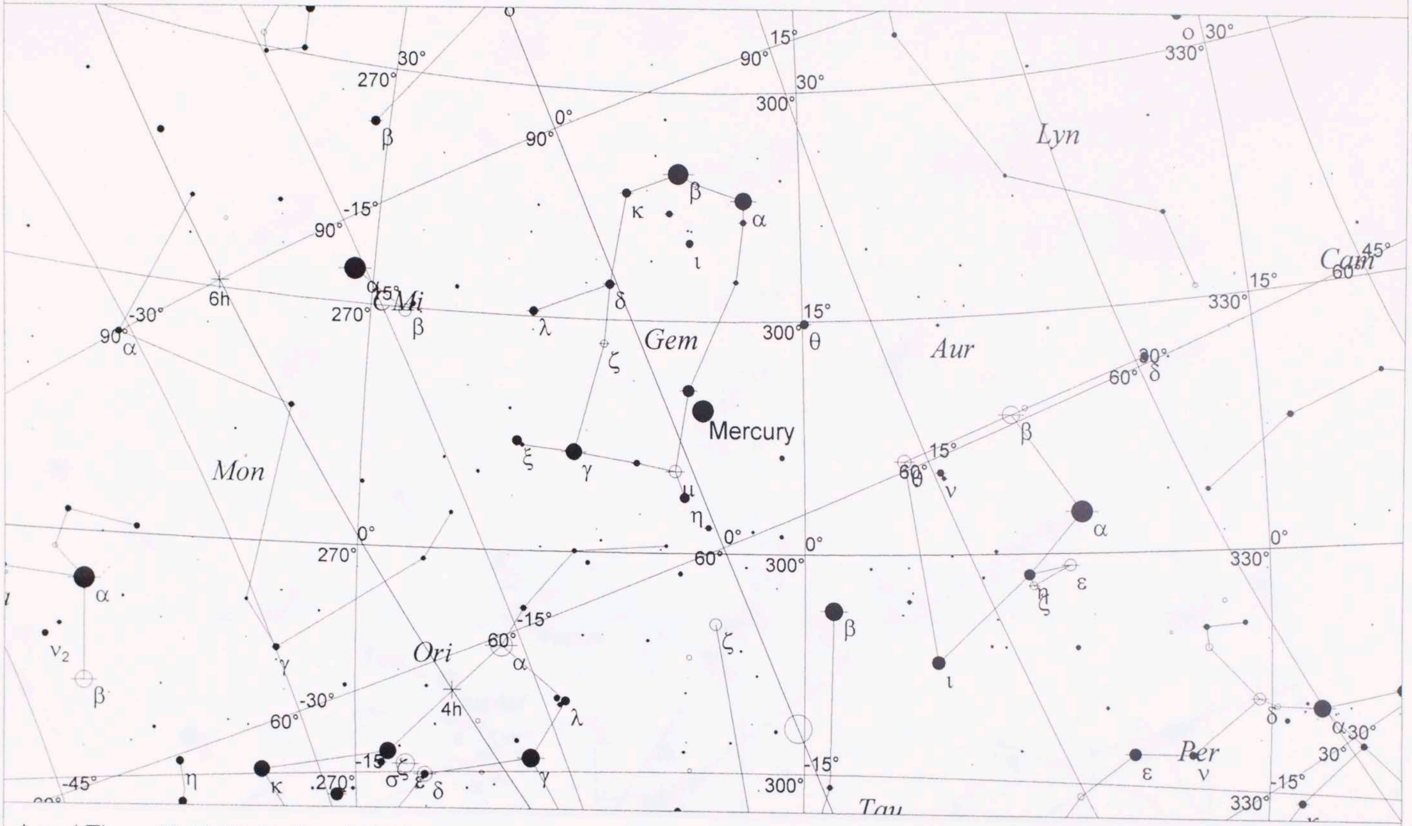


Local Time: 04:05:00 10-May-112BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:07:00 10-May-112BC
RA: 19h50m46s Dec: -19° 26' Field: 90.0°

Sidereal Time: 19:03:08
Julian Day: 1680644.5465

-111 / 21

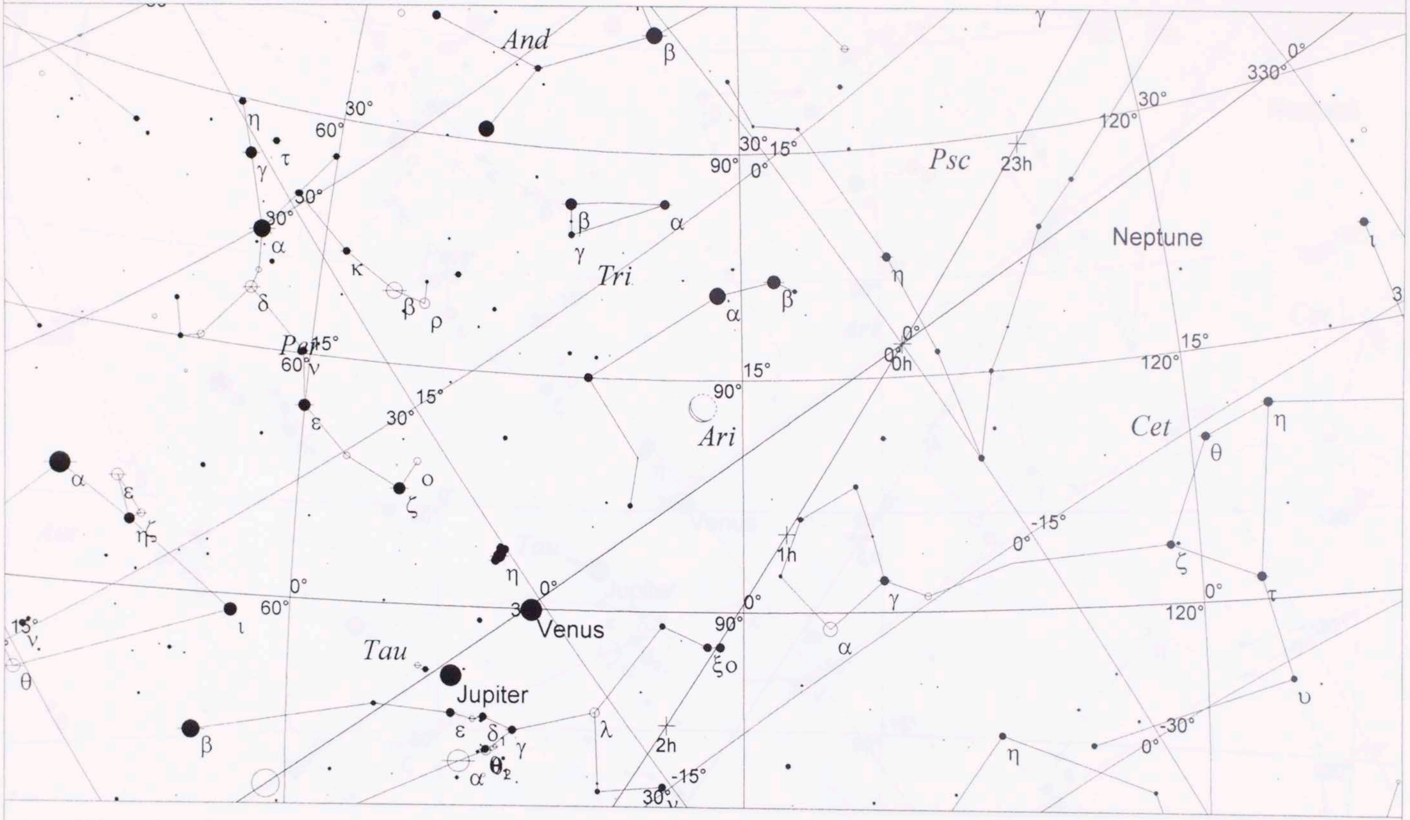


Local Time: 19:42:00 11-May-112BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:44:00 11-May-112BC
RA: 4h27m27s Dec: +24° 12' Field: 90.0°

Sidereal Time: 10:46:39
Julian Day: 1680646.1972

-111 / 25

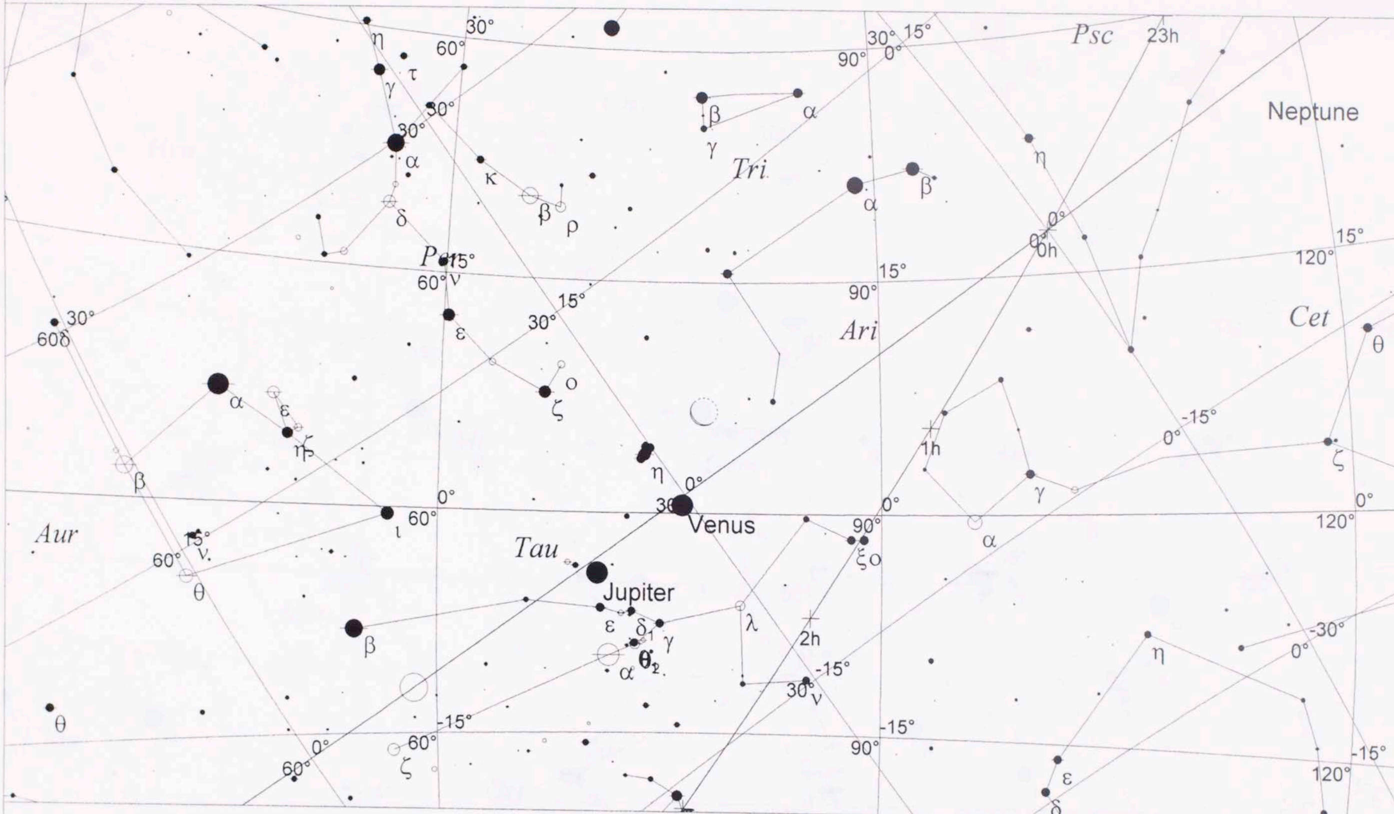


Local Time: 04:00:00 16-May-112BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:02:00 16-May-112BC
RA: 0h43m13s Dec: +9° 19' Field: 90.0°

Sidereal Time: 19:21:47
Julian Day: 1680650.5431

-111 / 26

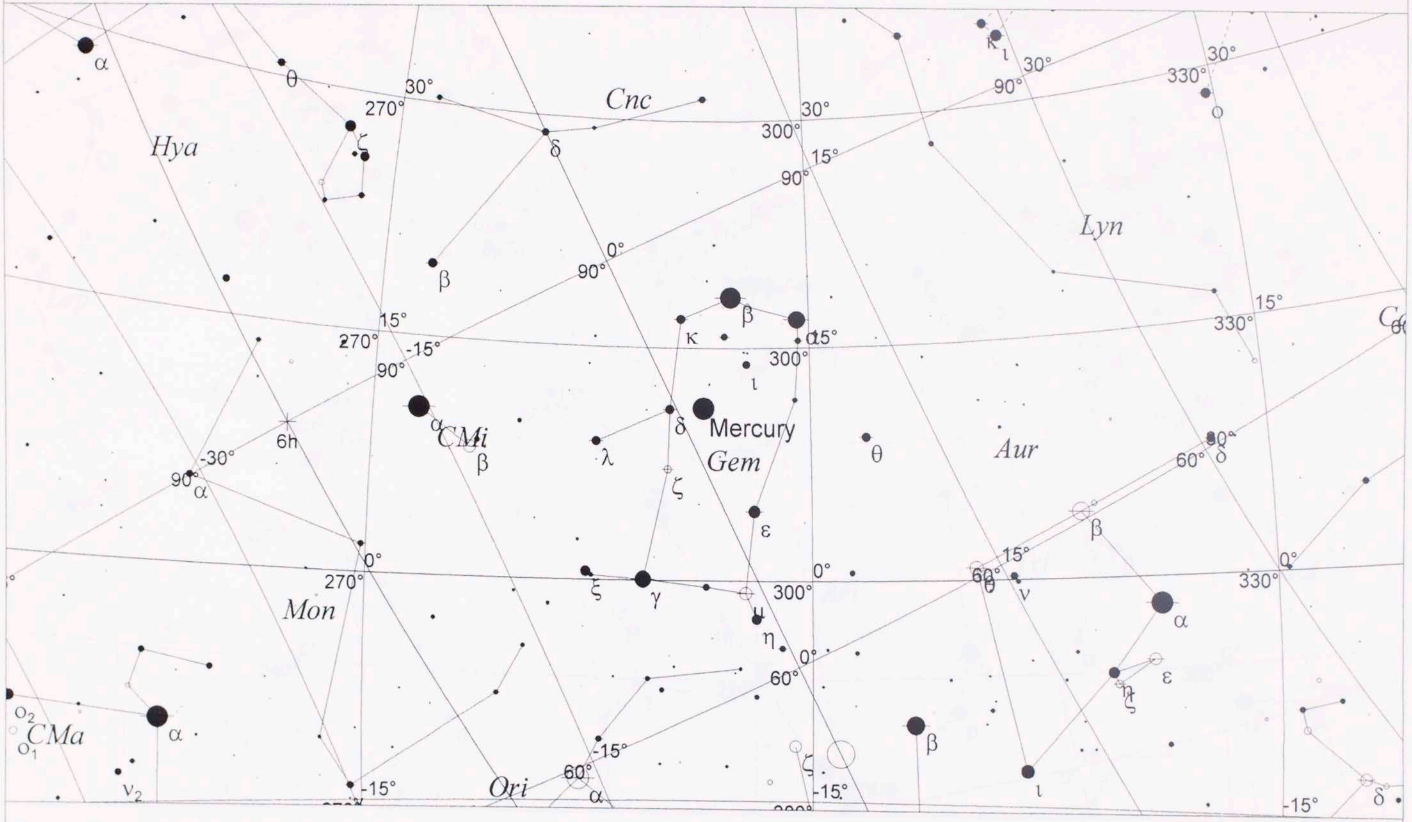


Local Time: 03:59:00 17-May-112BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 01:01:00 17-May-112BC
RA: 1h29m14s Dec: +13° 34' Field: 90.0°

Sidereal Time: 19:24:43
Julian Day: 1680651.5424

-111 / 28

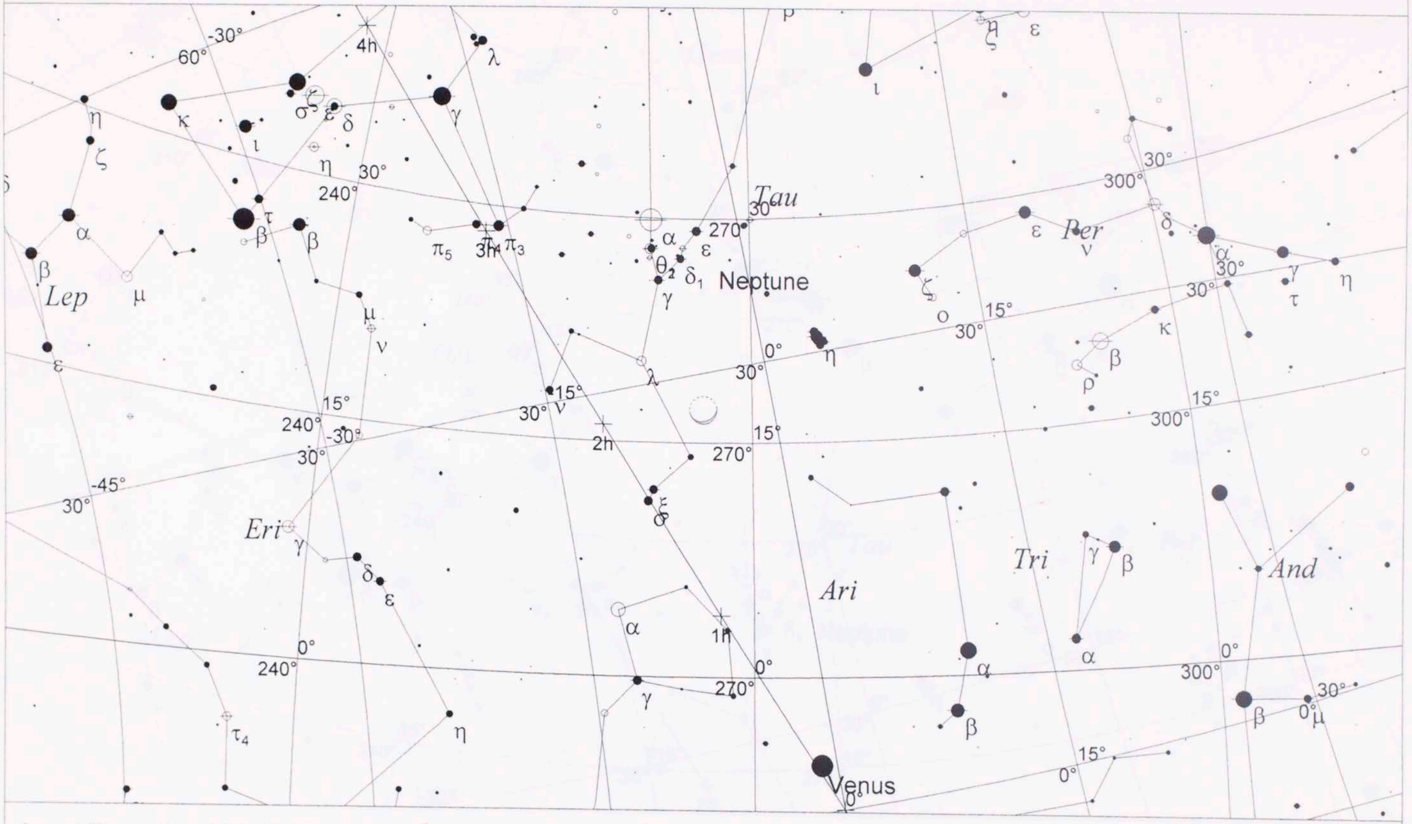


Local Time: 19:47:00 18-May-112BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:49:00 18-May-112BC
RA: 5h08m12s Dec: +24° 50' Field: 90.0°

Sidereal Time: 11:19:15
Julian Day: 1680653.2007

-87 XII2 2

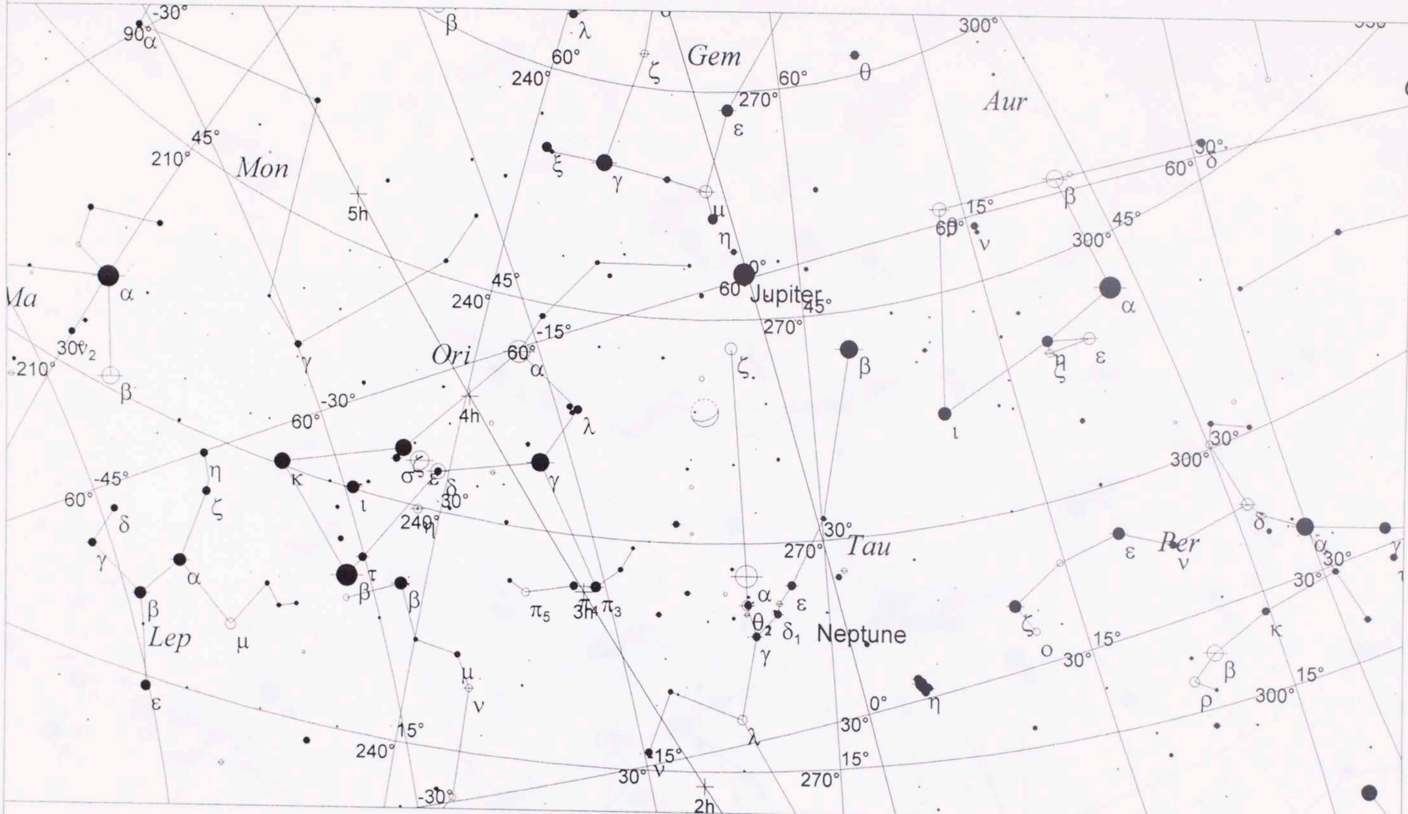


Local Time: 19:12:00 18-Mar-87BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:14:00 18-Mar-87BC
RA: 1h48m57s Dec: +6° 19' Field: 90.0°

Sidereal Time: 06:43:24
Julian Day: 1689723.1764

-87 XII2 4

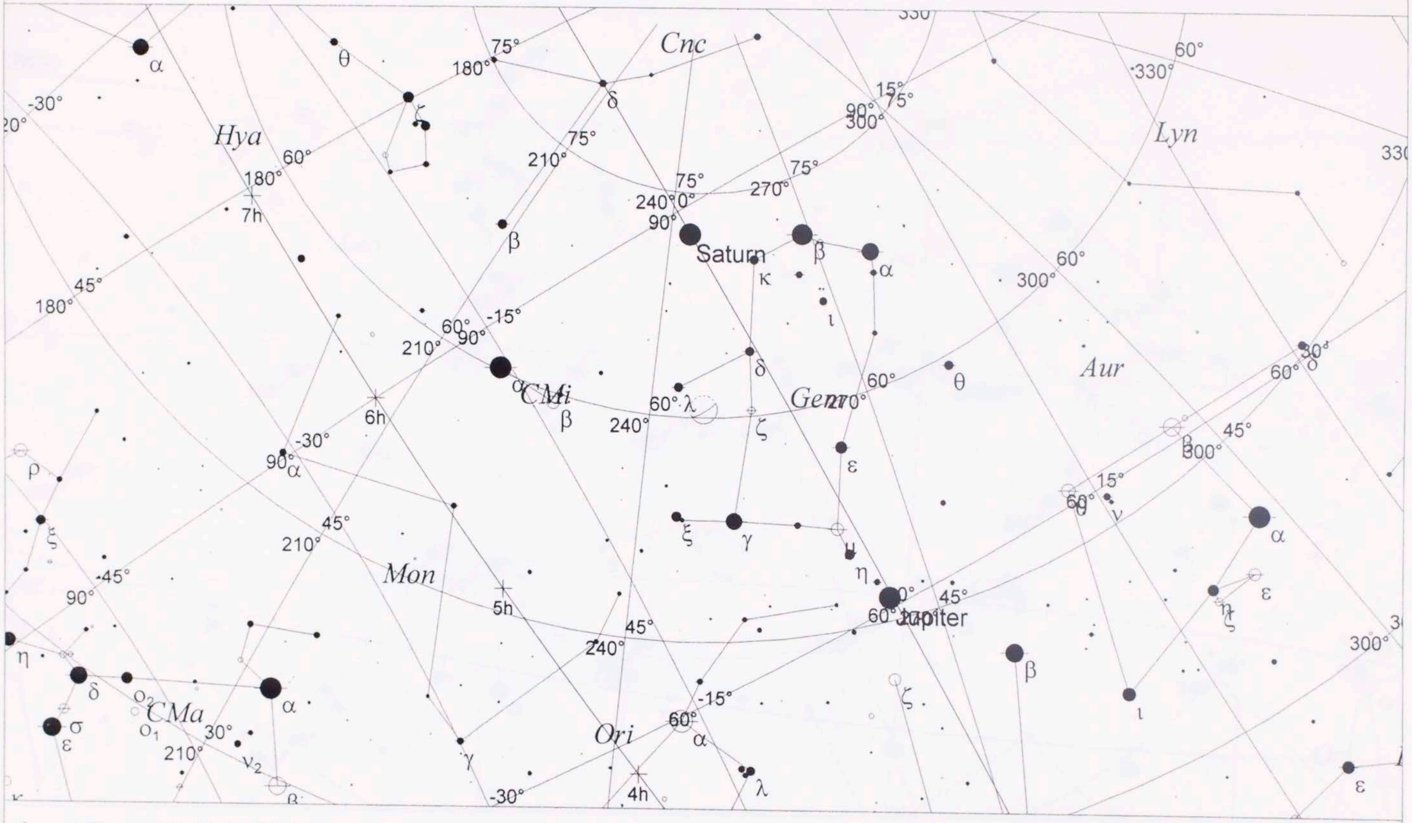


Local Time: 19:14:00 20-Mar-87BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:16:00 20-Mar-87BC
RA: 3h24m18s Dec: +13° 16' Field: 90.0°

Sidereal Time: 06:53:18
Julian Day: 1689725.1778

-87 XII2 6

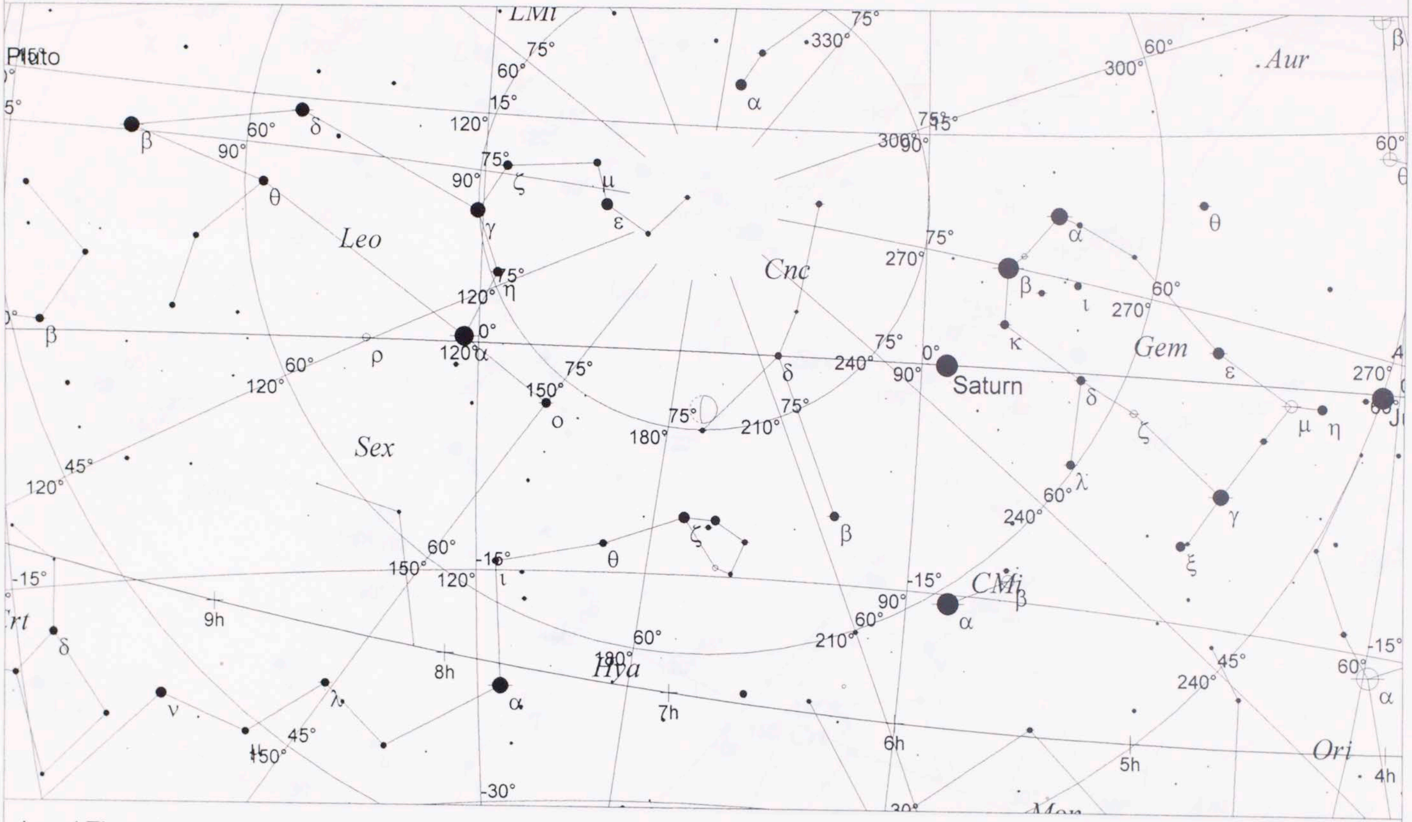


Local Time: 19:15:00 22-Mar-87BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:17:00 22-Mar-87BC
RA: 5h08m19s Dec: +18° 00' Field: 90.0°

Sidereal Time: 07:02:11
Julian Day: 1689727.1785

-87 XII2 8

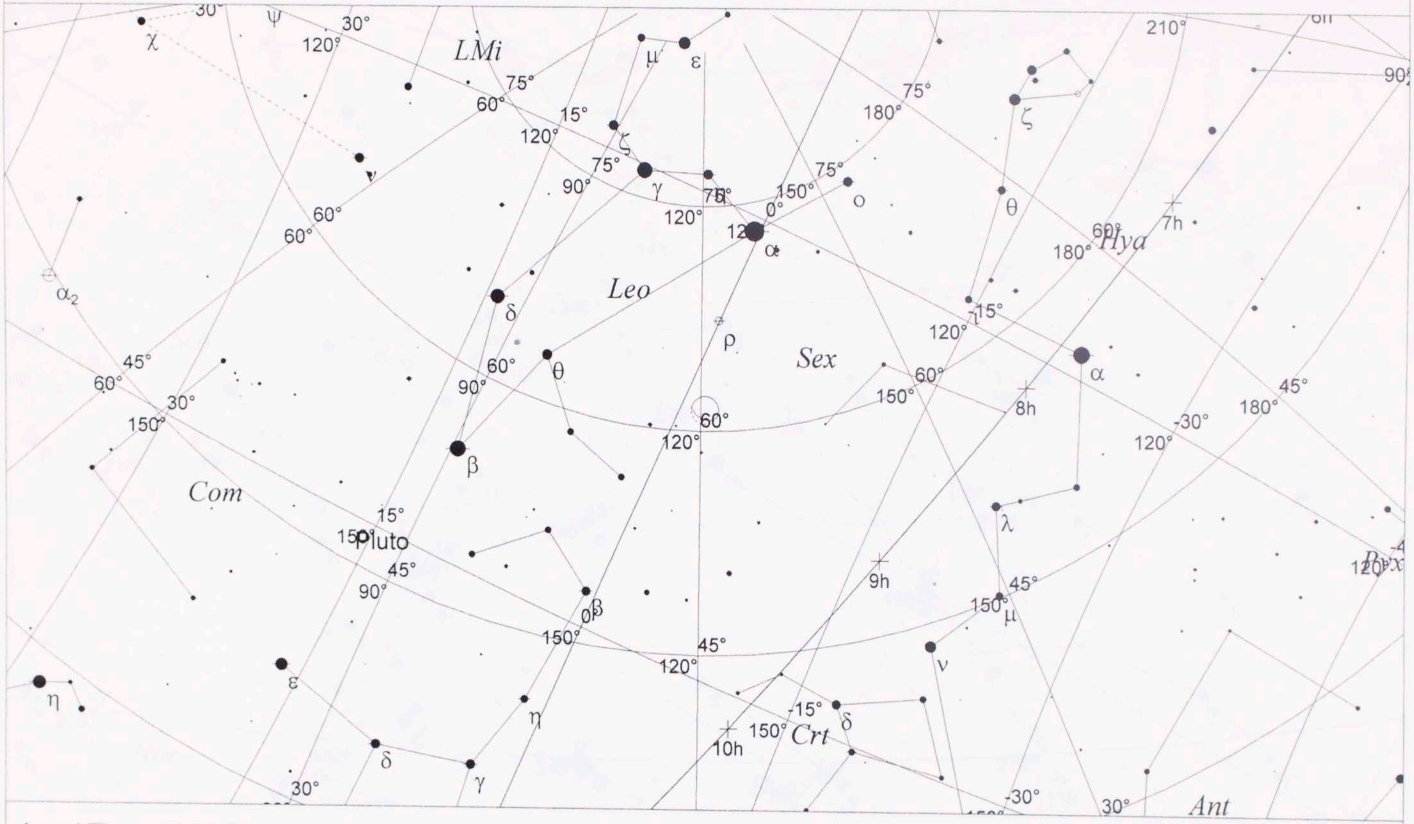


Local Time: 19:16:00 24-Mar-87BC
Location: 32° 33' 0'' N 44° 24' 0'' E

UTC: 16:18:00 24-Mar-87BC
RA: 7h01m53s Dec: +19° 05' Field: 90.0°

Sidereal Time: 07:11:04
Julian Day: 1689729.1792

-87 XII2 10

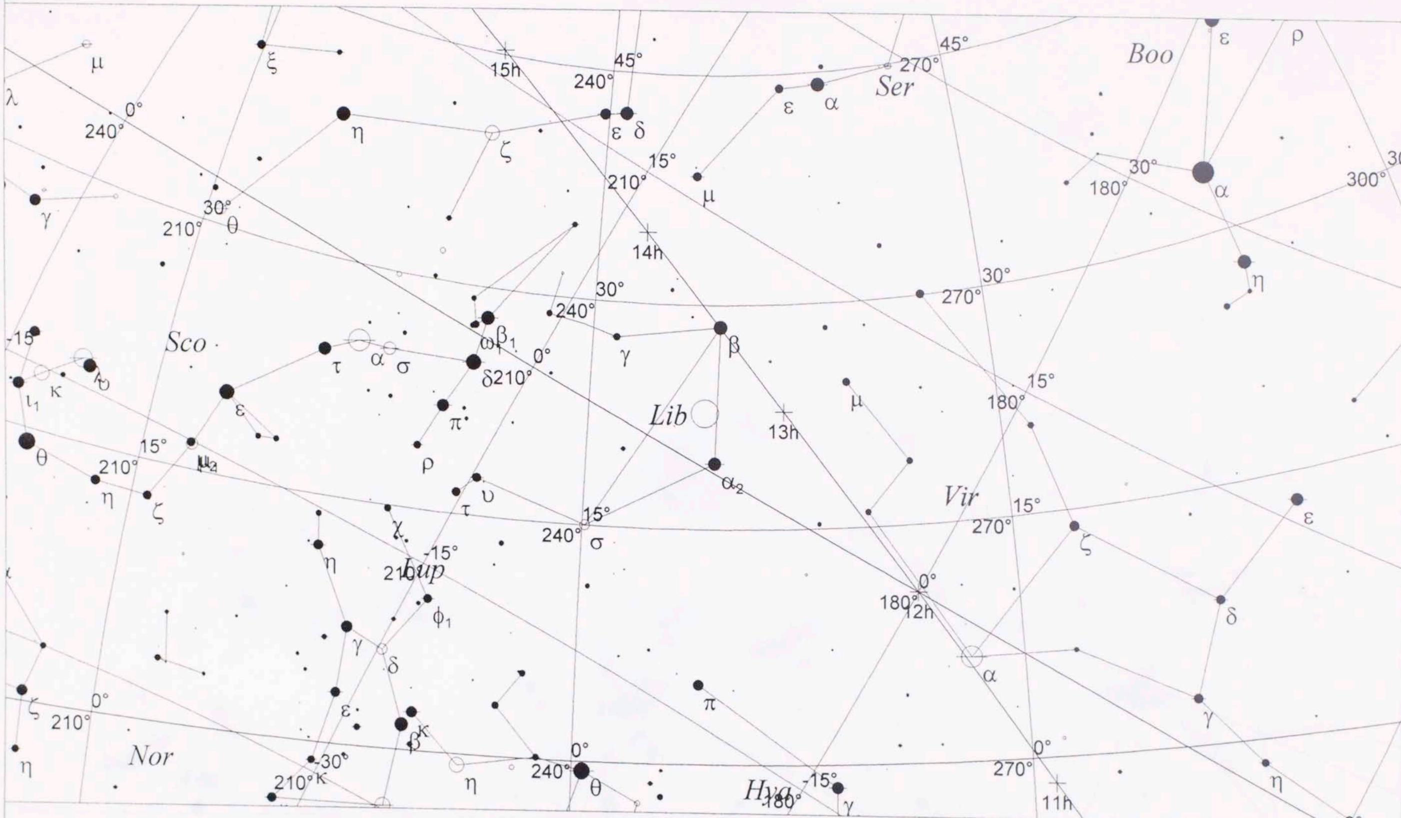


Local Time: 19:17:00 26-Mar-87BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:19:00 26-Mar-87BC
RA: 9h01m09s Dec: +15° 30' Field: 90.0°

Sidereal Time: 07:19:58
Julian Day: 1689731.1799

-87 XII2 14

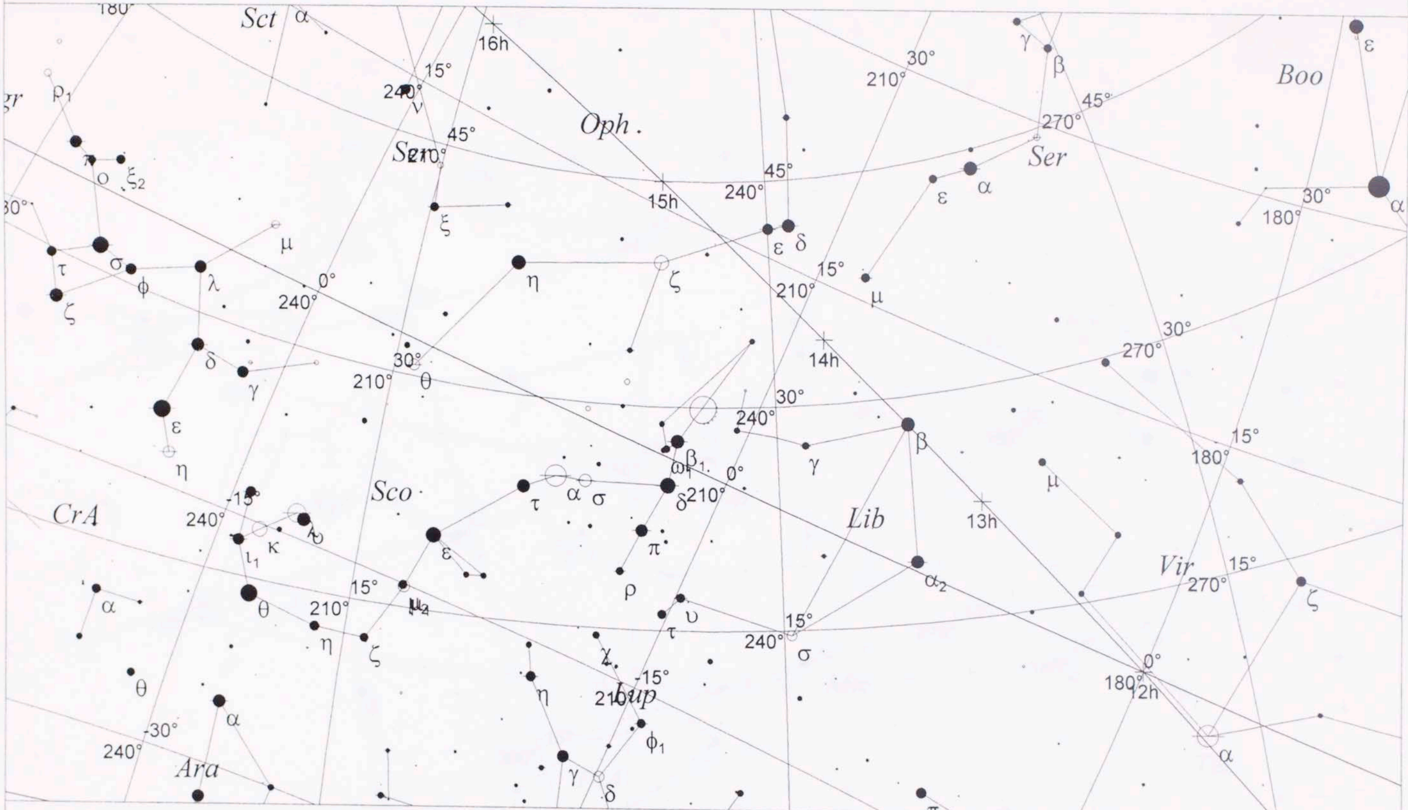


Local Time: 04:50:00 31-Mar-87BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:52:00 31-Mar-87BC
RA: 13h12m39s Dec: -4° 19' Field: 90.0°

Sidereal Time: 17:10:18
Julian Day: 1689735.5778

-87 XII2 15

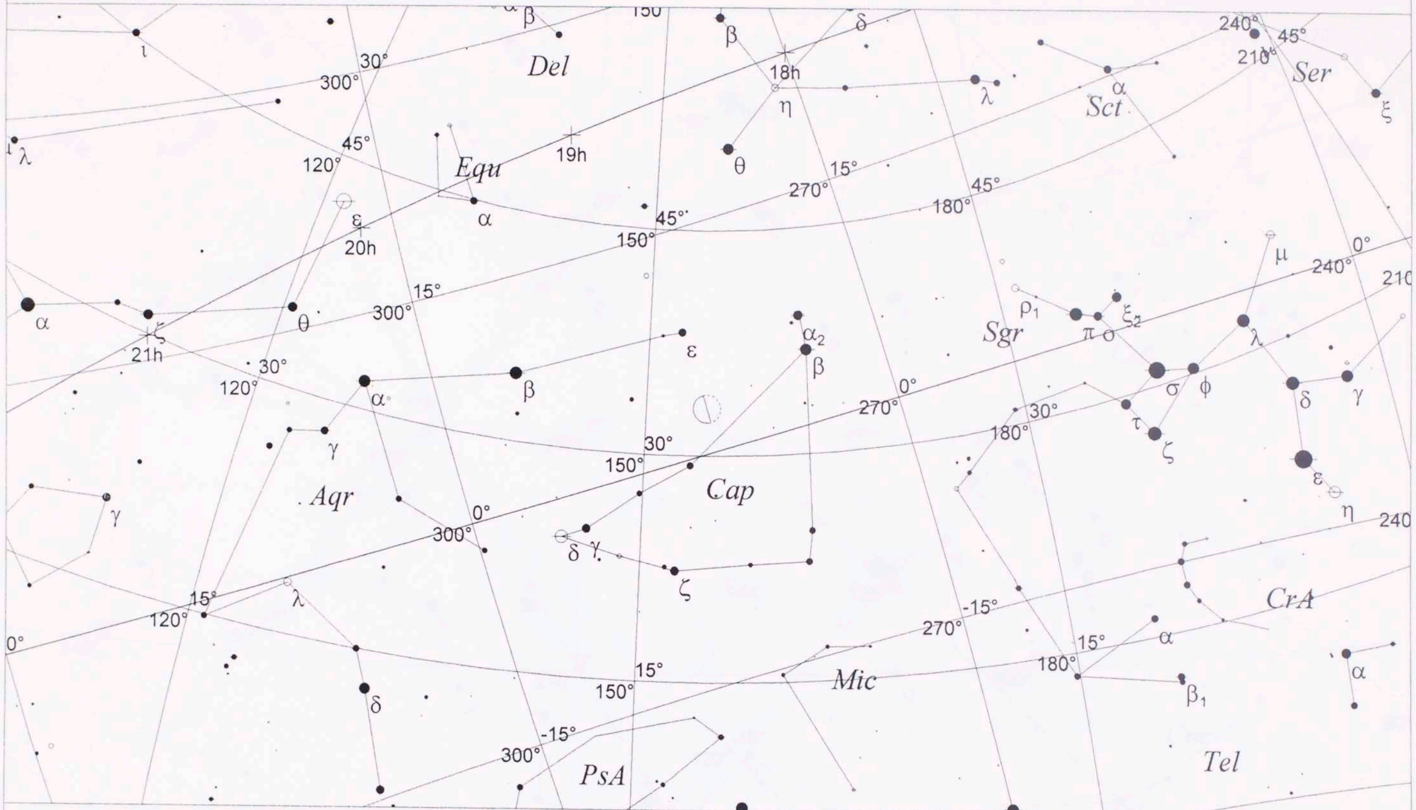


Local Time: 04:48:00 1-Apr-87BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:50:00 1-Apr-87BC
RA: 14h10m09s Dec: -9° 06' Field: 90.0°

Sidereal Time: 17:12:14
Julian Day: 1689736.5764

-87 XII2 20

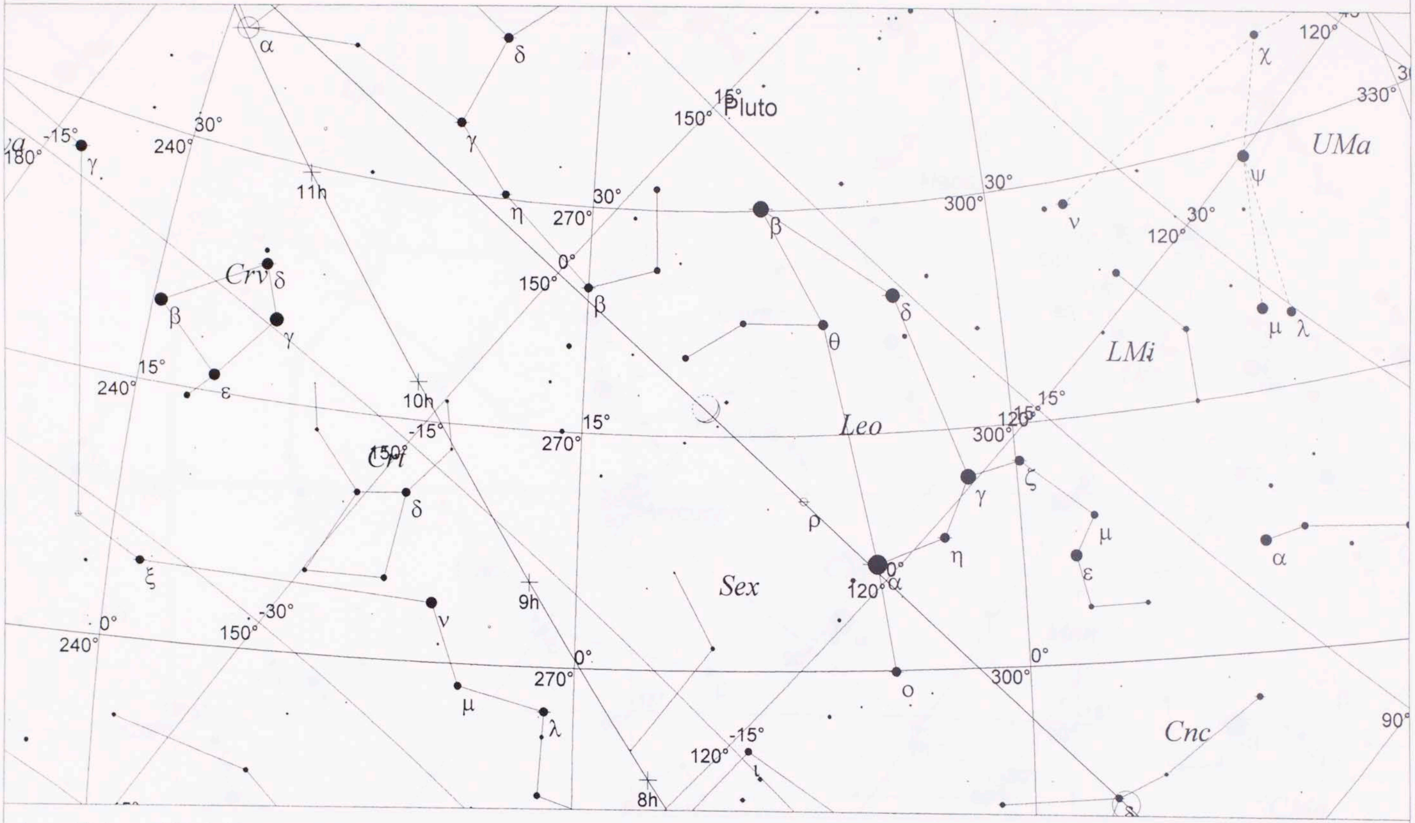


Local Time: 04:41:00 6-Apr-87BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:43:00 6-Apr-87BC
RA: 18h53m50s Dec: -20° 10' Field: 90.0°

Sidereal Time: 17:24:56
Julian Day: 1689741.5715

-77 IV 3

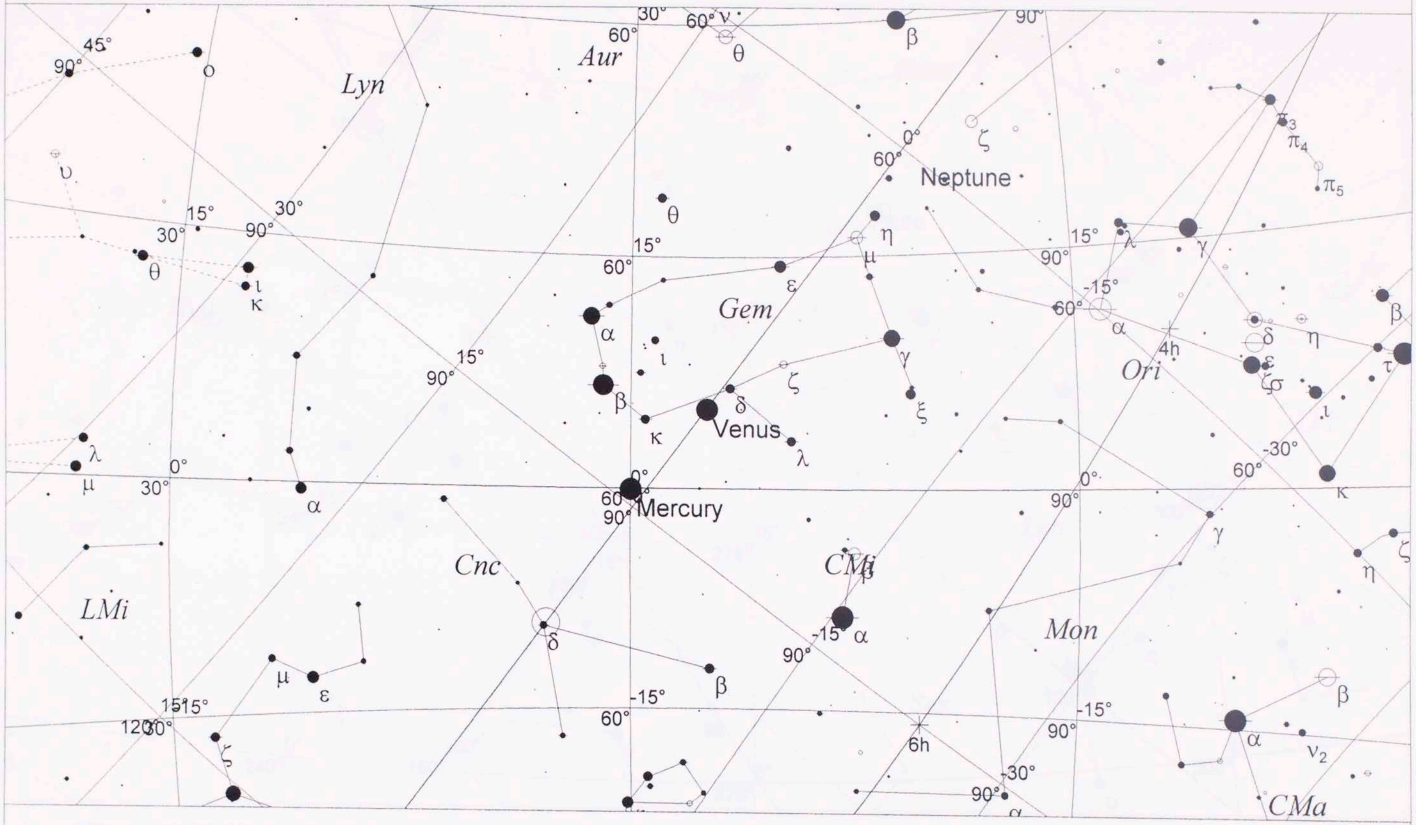


Local Time: 19:56:00 5-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:58:00 5-Jul-78BC
RA: 9h16m24s Dec: +16° 08' Field: 90.0°

Sidereal Time: 14:36:34
Julian Day: 1693119.2069

-77 IV 3

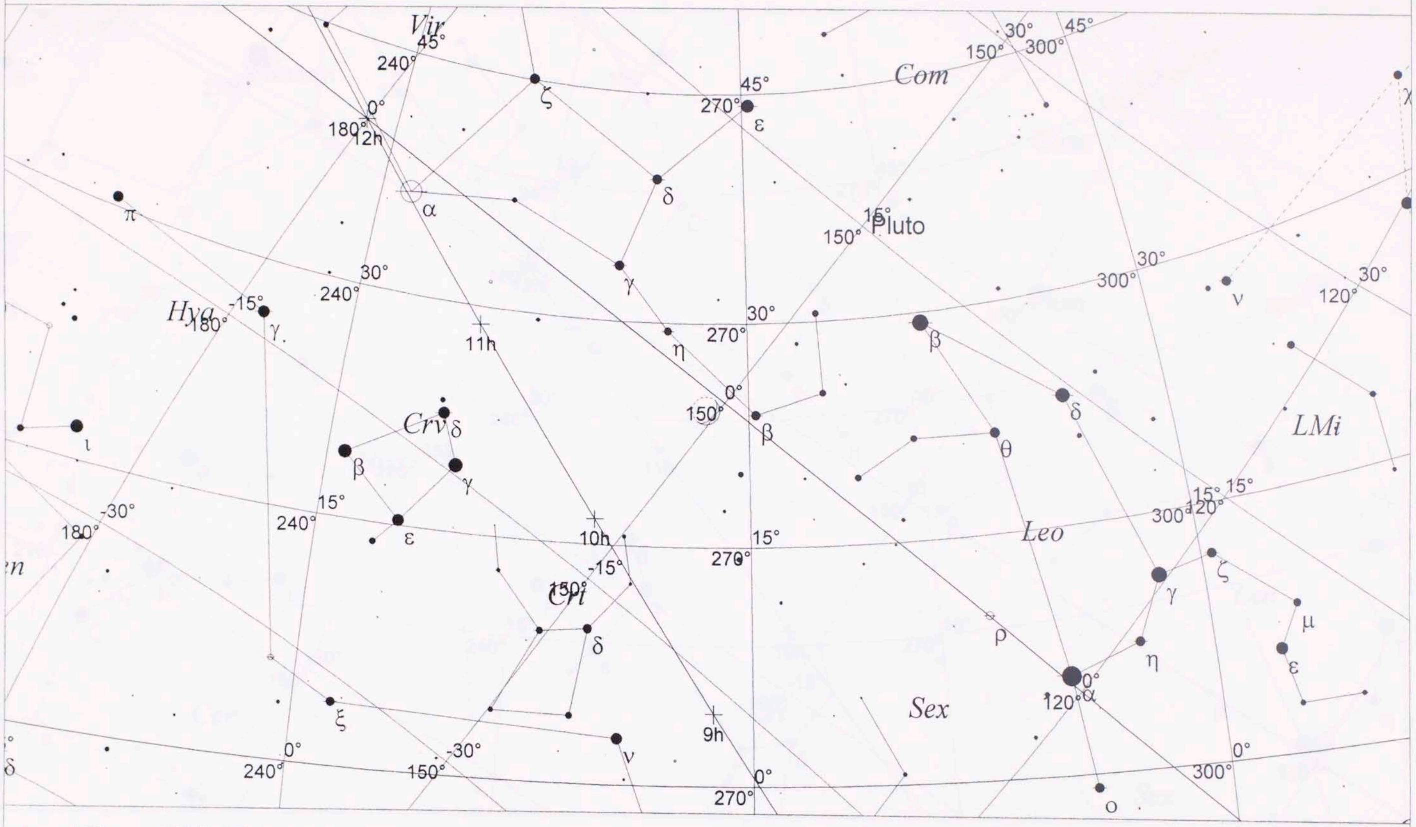


Local Time: 04:03:00 6-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:05:00 6-Jul-78BC
RA: 5h23m55s Dec: +23° 23' Field: 90.0°

Sidereal Time: 22:44:54
Julian Day: 1693119.5451

-77 IV 4

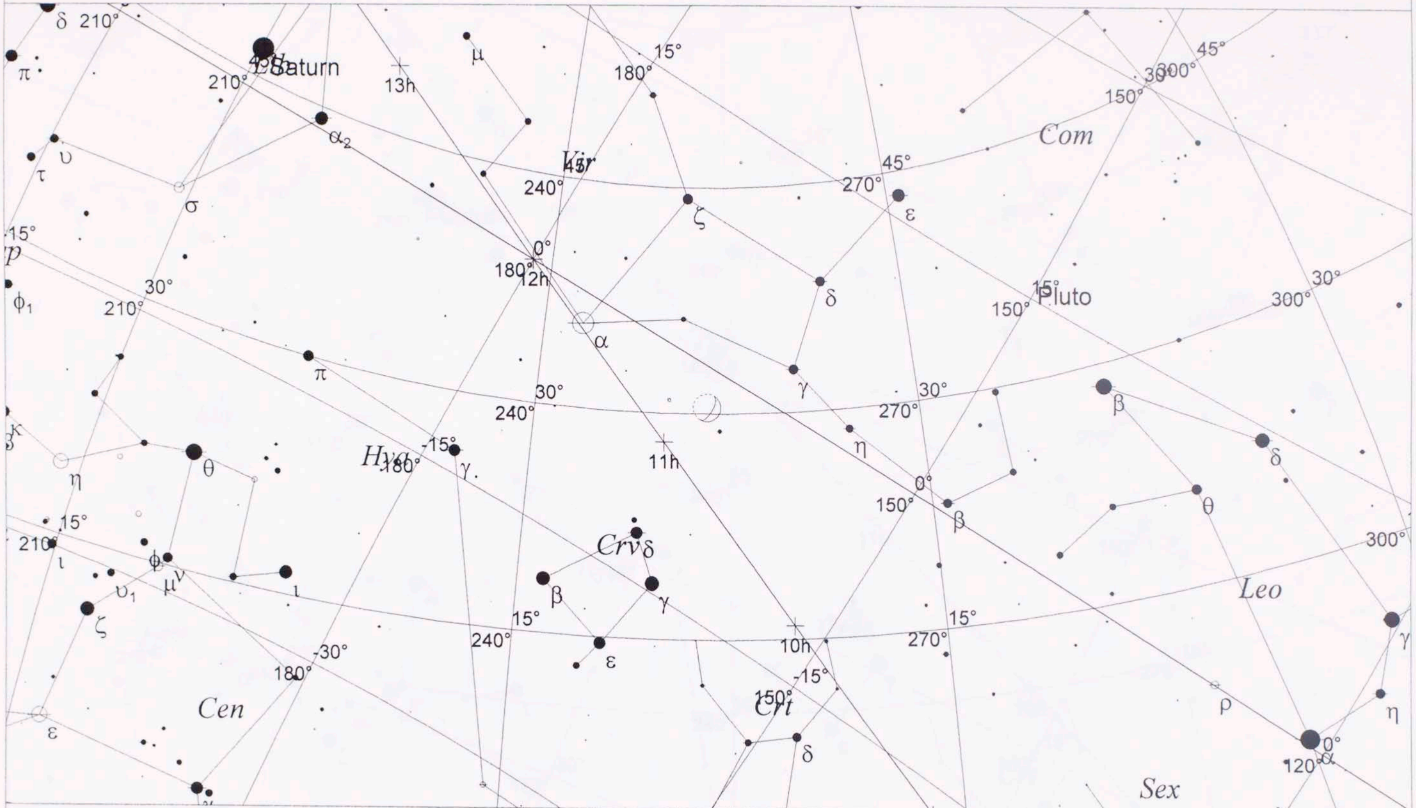


Local Time: 19:56:00 6-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:58:00 6-Jul-78BC
RA: 10h09m25s Dec: +10° 14' Field: 90.0°

Sidereal Time: 14:40:31
Julian Day: 1693120.2069

-77 IV 5

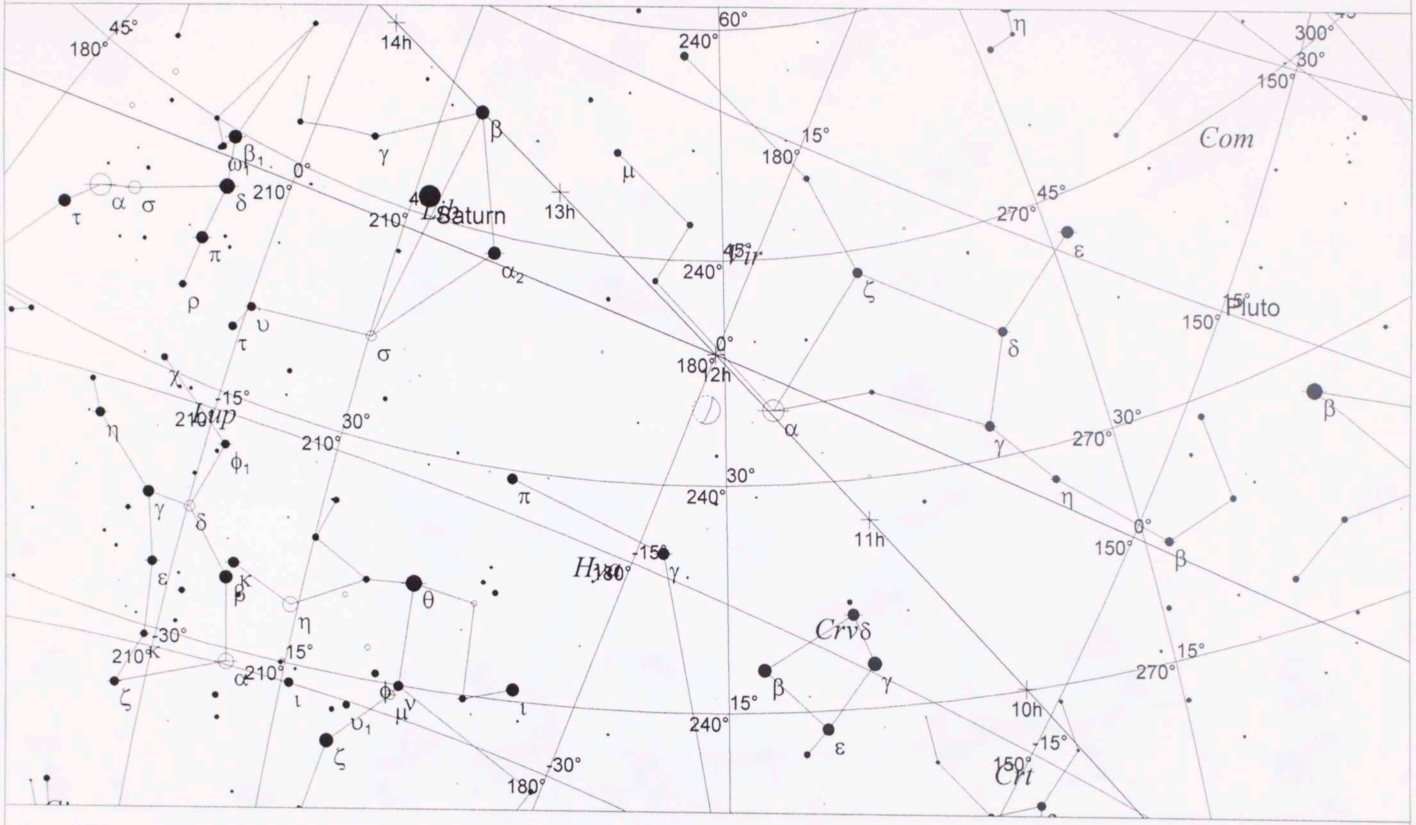


Local Time: 19:56:00 7-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:58:00 7-Jul-78BC
RA: 11h00m41s Dec: +3° 45' Field: 90.0°

Sidereal Time: 14:44:27
Julian Day: 1693121.2069

-77 IV 6

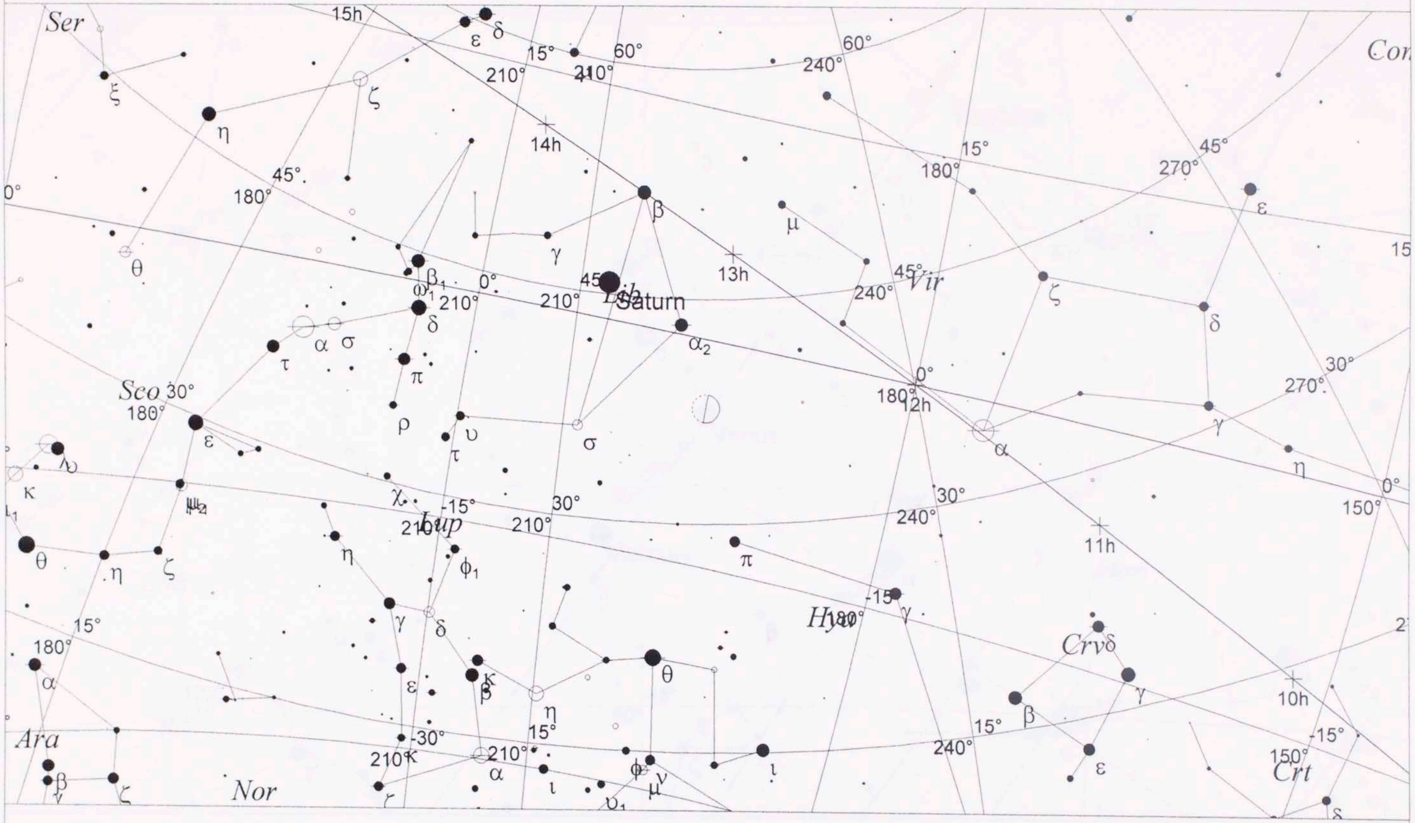


Local Time: 19:56:00 8-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:58:00 8-Jul-78BC
RA: 11h51m16s Dec: -2° 58' Field: 90.0°

Sidereal Time: 14:48:24
Julian Day: 1693122.2069

-77 IV 7

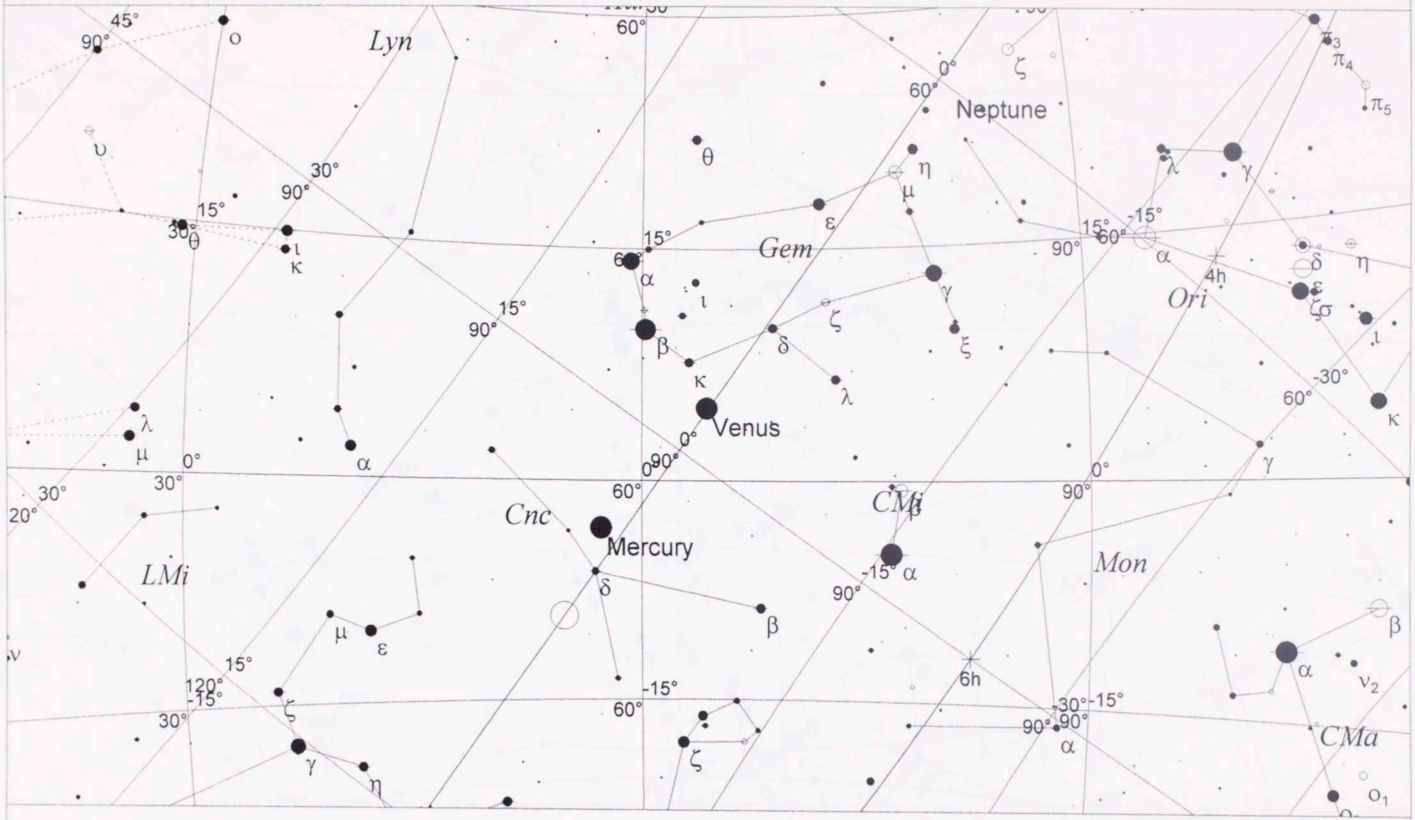


Local Time: 19:56:00 9-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:58:00 9-Jul-78BC
RA: 12h42m24s Dec: -9° 36' Field: 90.0°

Sidereal Time: 14:52:21
Julian Day: 1693123.2069

-77 IV 7

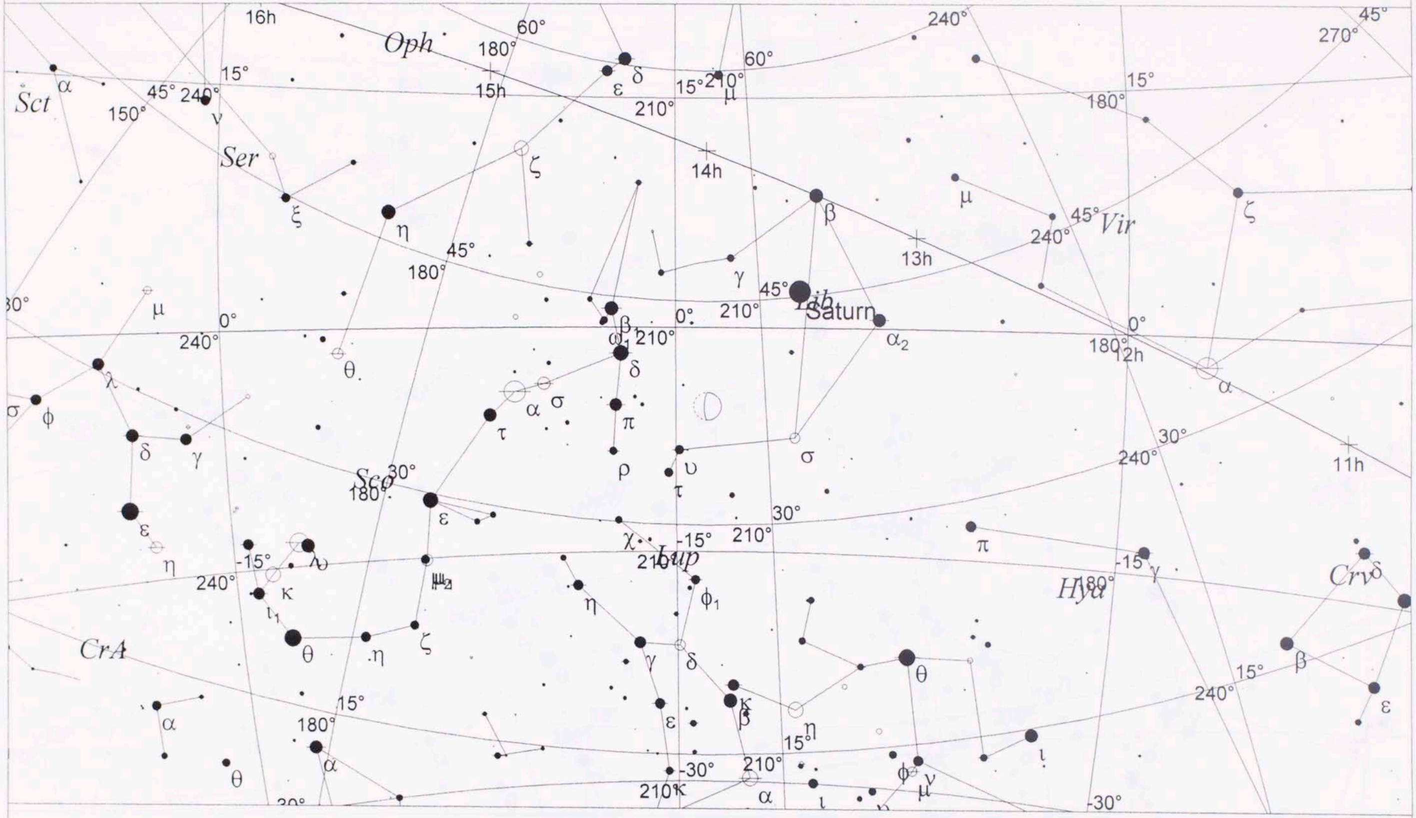


Local Time: 04:05:00 10-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:07:00 10-Jul-78BC
RA: 5h45m14s Dec: +23° 46' Field: 90.0°

Sidereal Time: 23:02:41
Julian Day: 1693123.5465

-77 IV 8

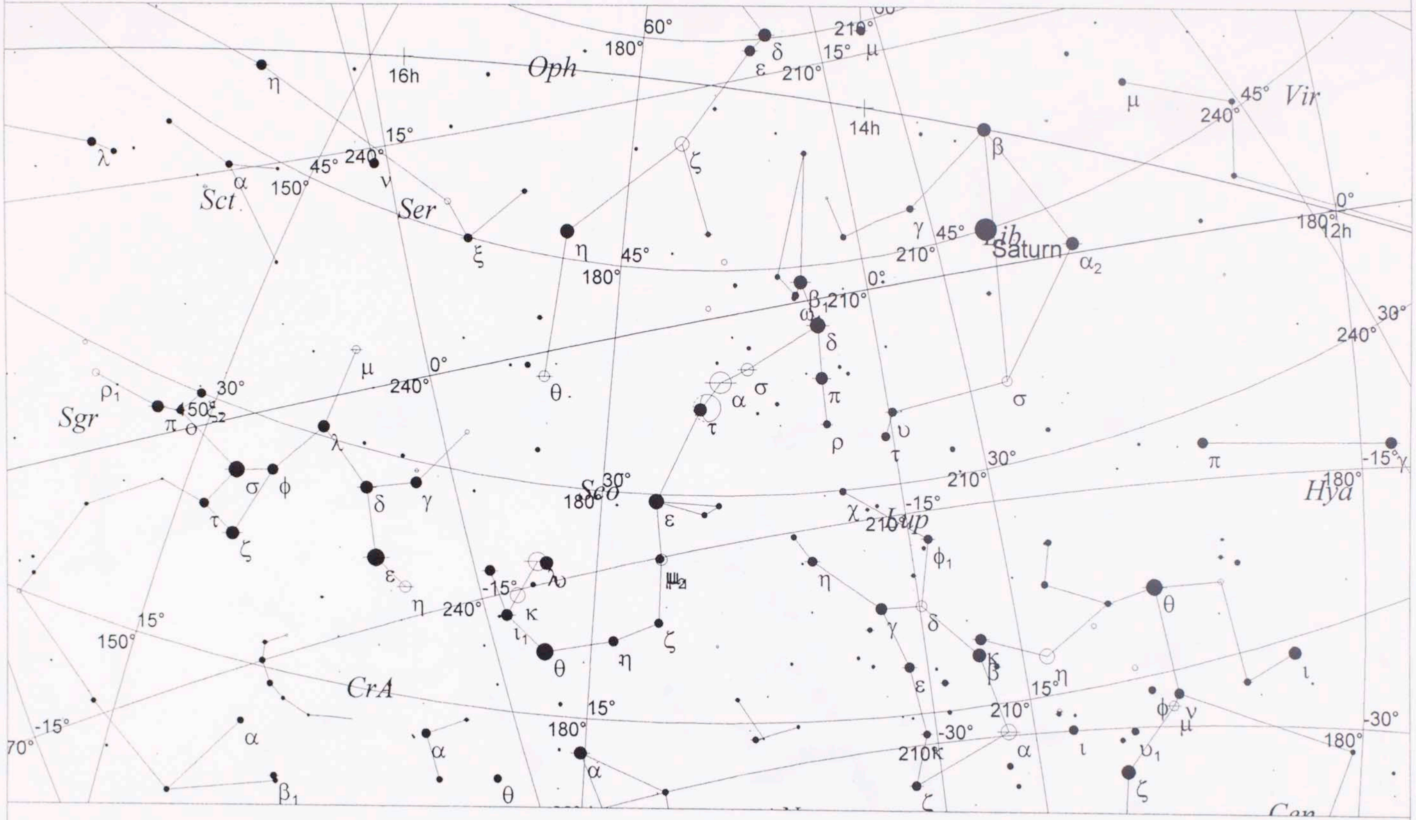


Local Time: 19:56:00 10-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:58:00 10-Jul-78BC
RA: 13h35m17s Dec: -15° 47' Field: 90.0°

Sidereal Time: 14:56:17
Julian Day: 1693124.2069

-77 IV 9

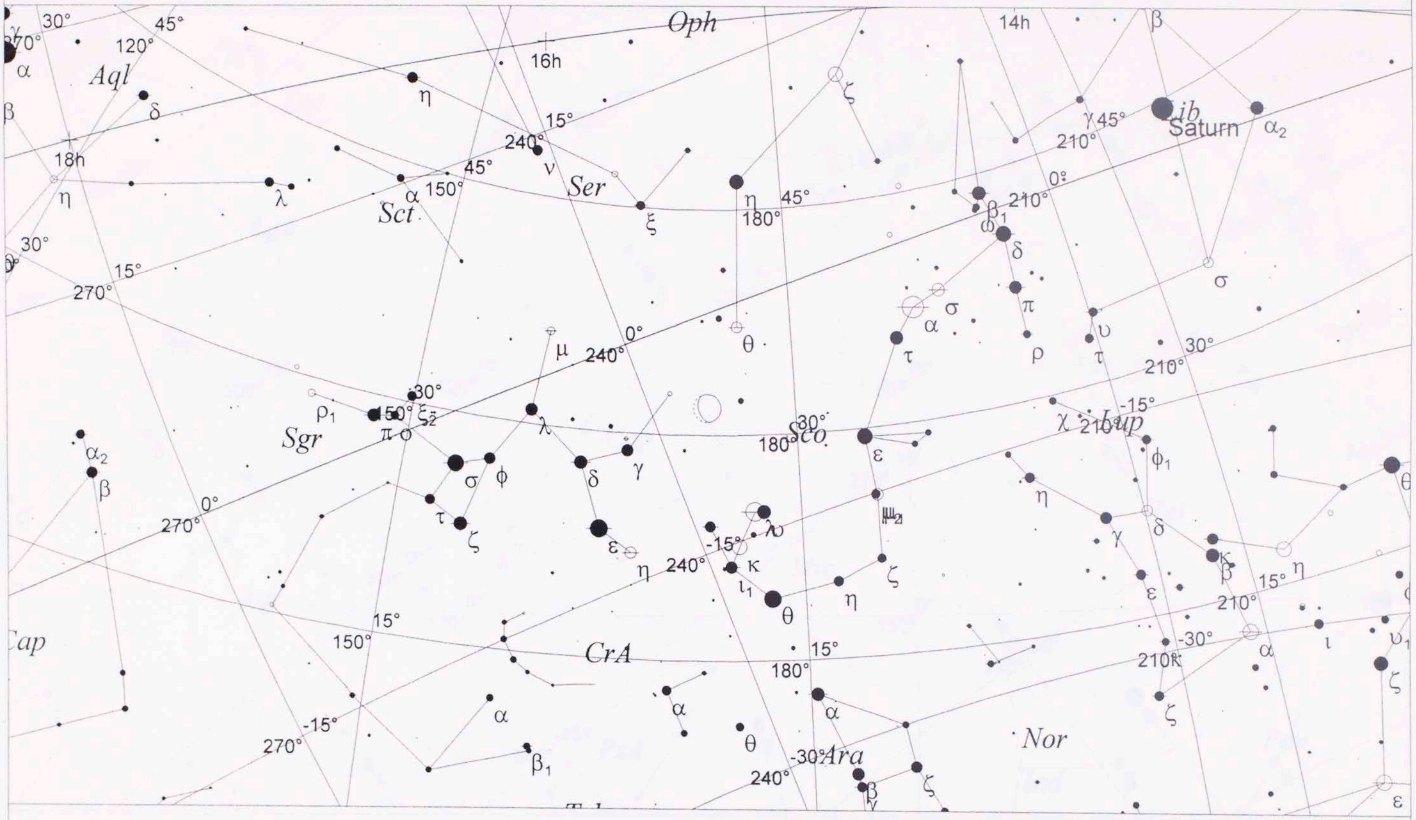


Local Time: 19:55:00 11-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:57:00 11-Jul-78BC
RA: 14h30m52s Dec: -21° 08' Field: 90.0°

Sidereal Time: 14:59:13
Julian Day: 1693125.2062

-77 IV 10

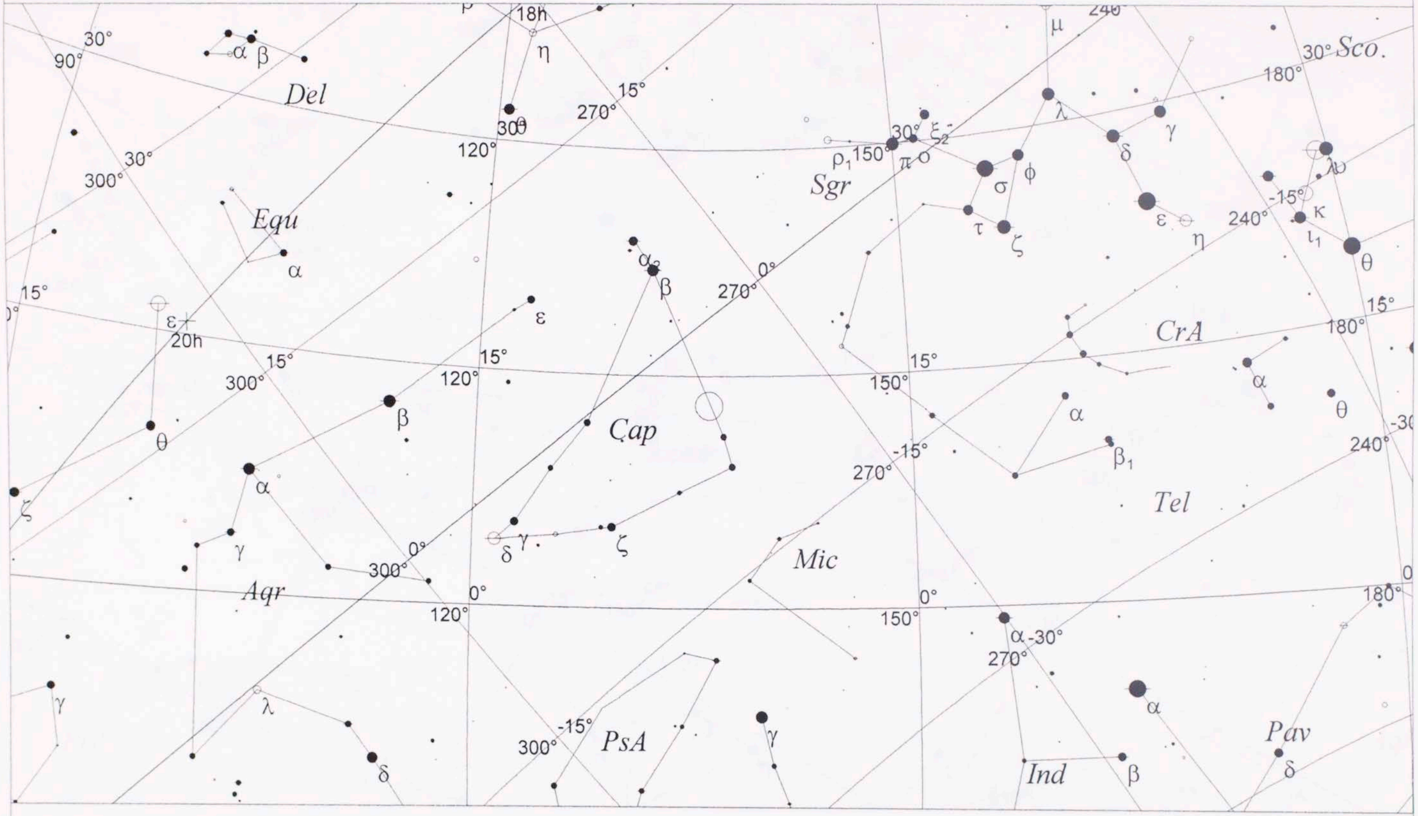


Local Time: 19:55:00 12-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:57:00 12-Jul-78BC
RA: 15h29m37s Dec: -25° 18' Field: 90.0°

Sidereal Time: 15:03:10
Julian Day: 1693126.2062

-77 IV 13

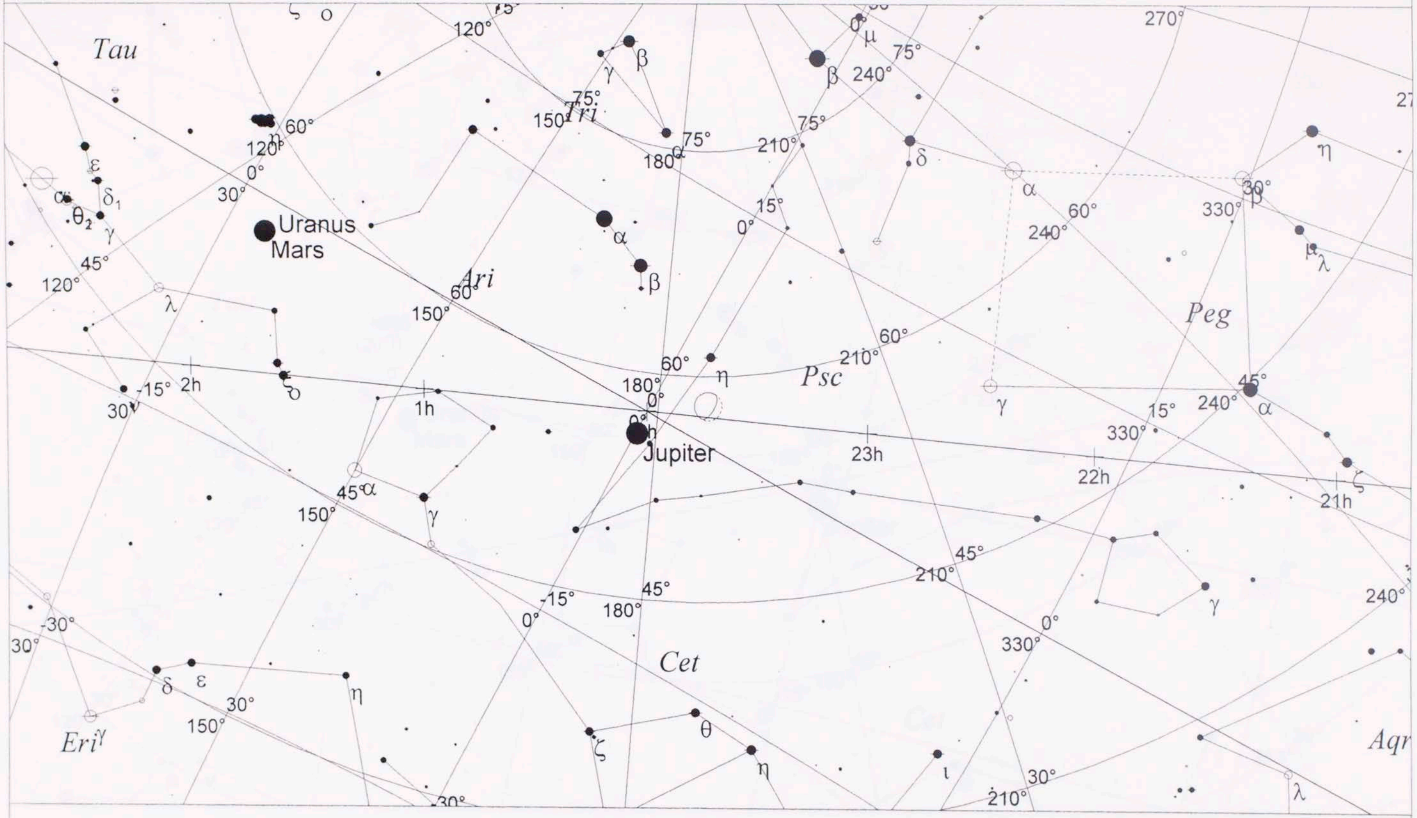


Local Time: 19:55:00 15-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 16:57:00 15-Jul-78BC
RA: 18h35m10s Dec: -28° 04' Field: 90.0°

Sidereal Time: 15:15:00
Julian Day: 1693129.2062

-77 IV 19

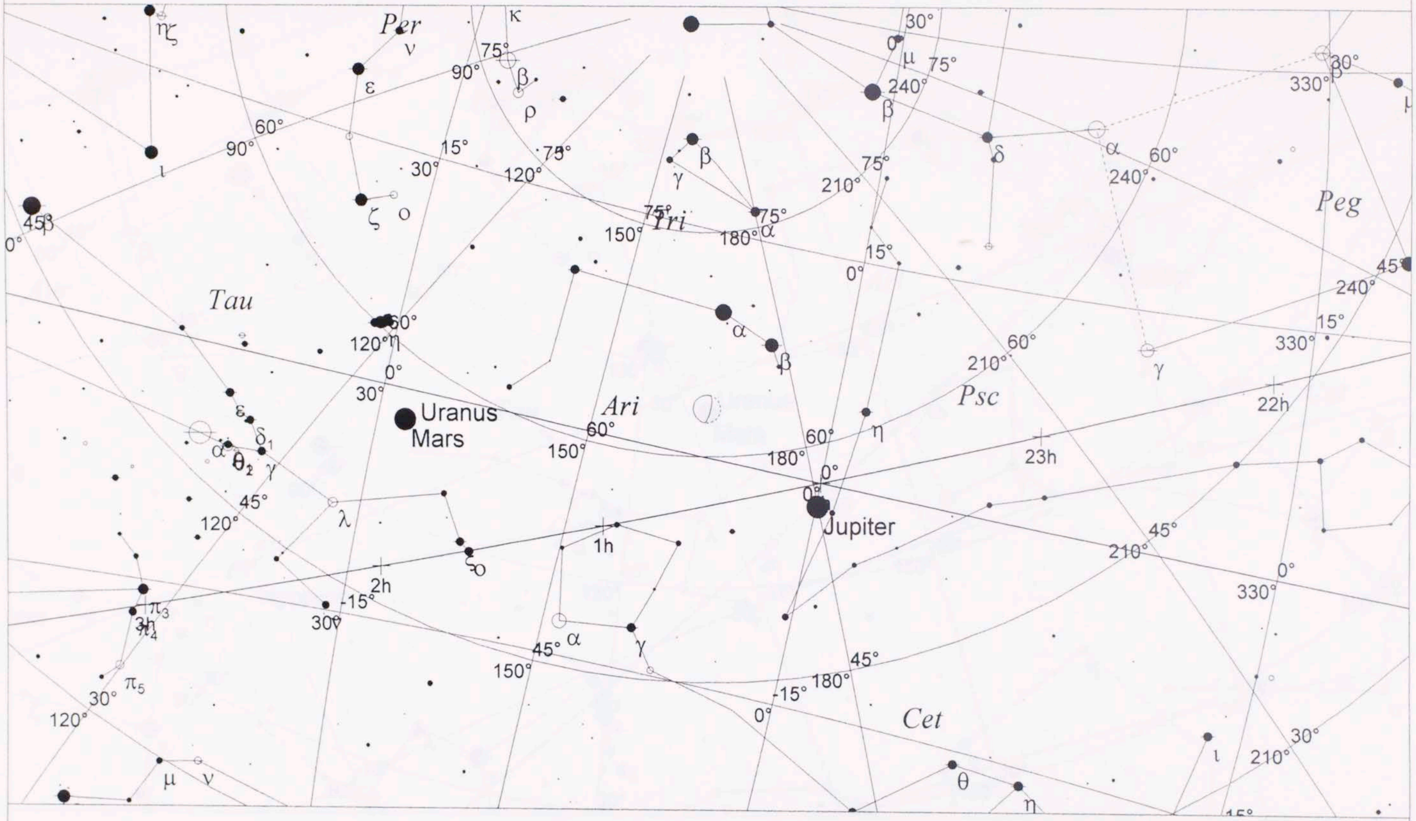


Local Time: 04:12:00 22-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:14:00 22-Jul-78BC
RA: 23h43m37s Dec: +0° 43' Field: 90.0°

Sidereal Time: 23:57:01
Julian Day: 1693135.5514

-77 IV 20

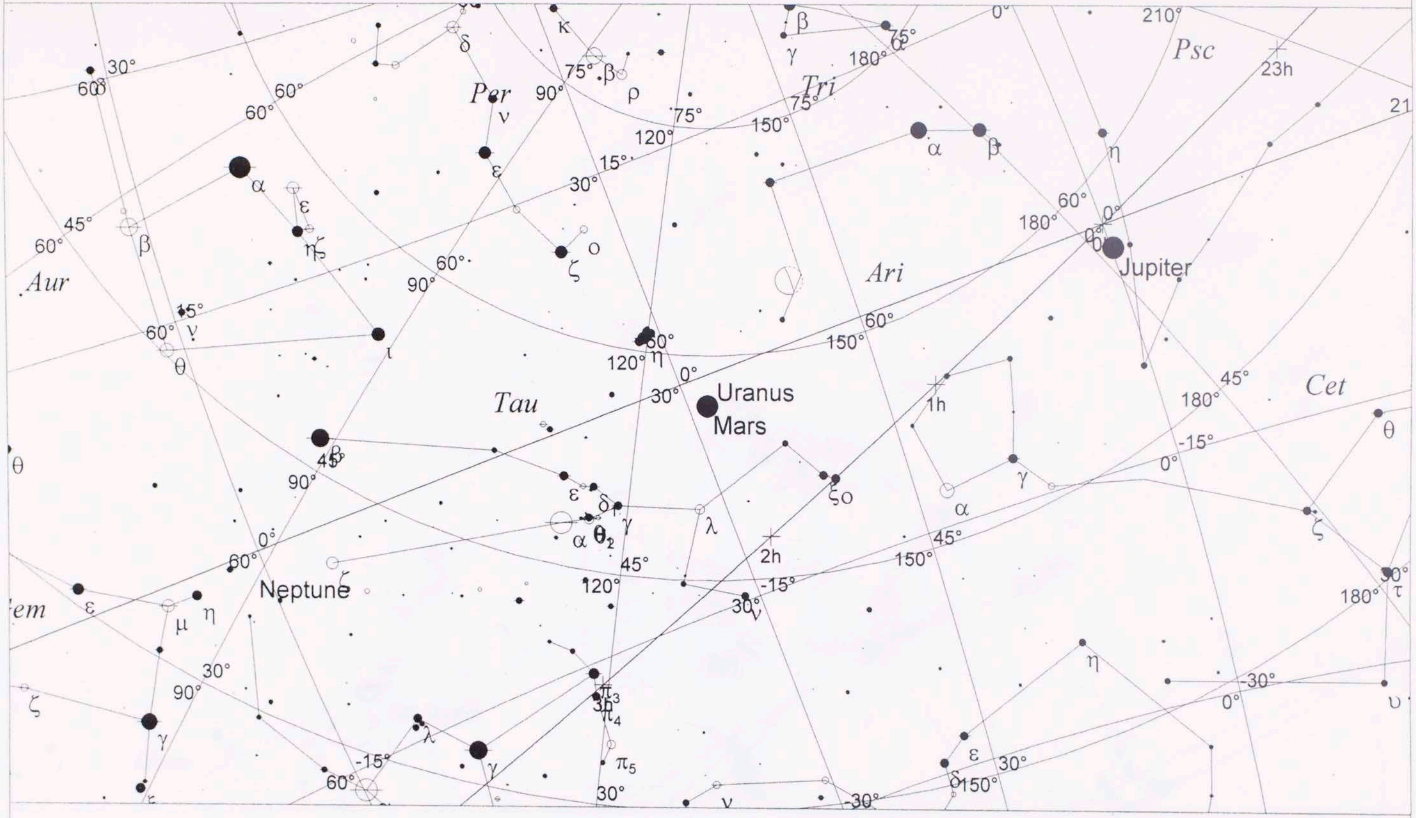


Local Time: 04:13:00 23-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:15:00 23-Jul-78BC
RA: 0h26m15s Dec: +6° 21' Field: 90.0°

Sidereal Time: 00:01:57
Julian Day: 1693136.5521

-77 IV 21

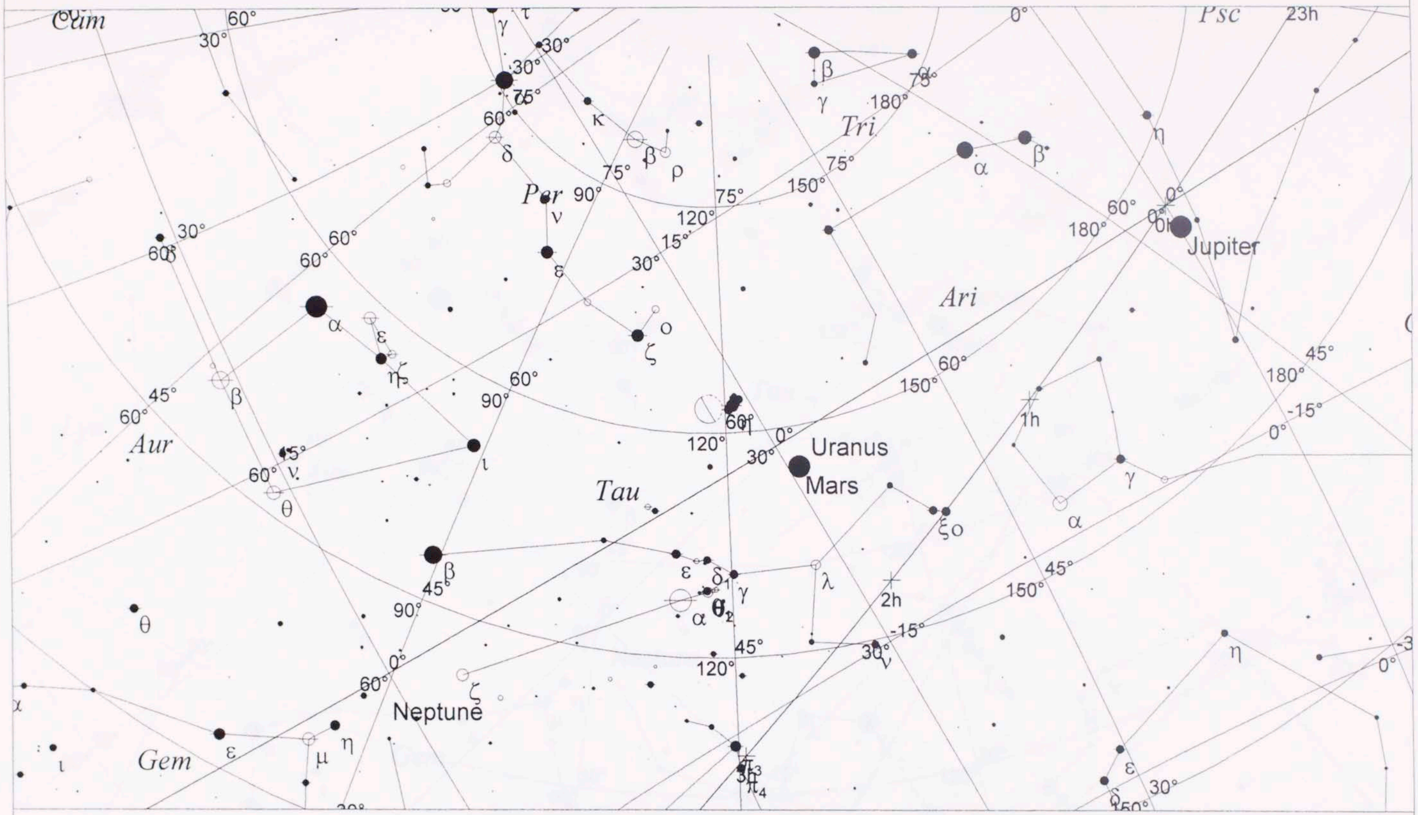


Local Time: 04:13:00 24-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:15:00 24-Jul-78BC
RA: 1h49m33s Dec: +9° 18' Field: 90.0°

Sidereal Time: 00:05:54
Julian Day: 1693137.5521

-77 IV 22

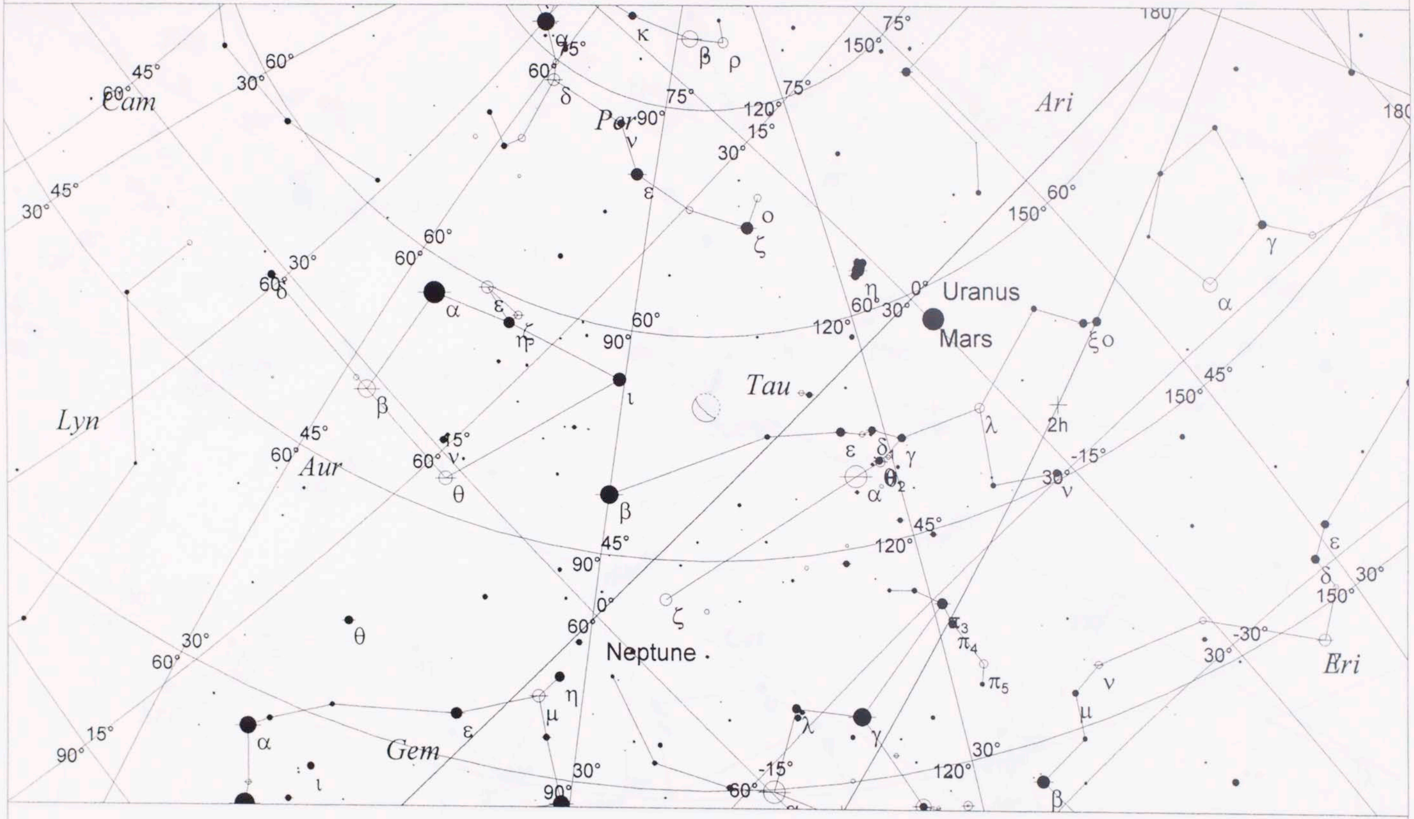


Local Time: 04:14:00 25-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:16:00 25-Jul-78BC
RA: 1h55m05s Dec: +16° 41' Field: 90.0°

Sidereal Time: 00:10:51
Julian Day: 1693138.5528

-77 IV 23

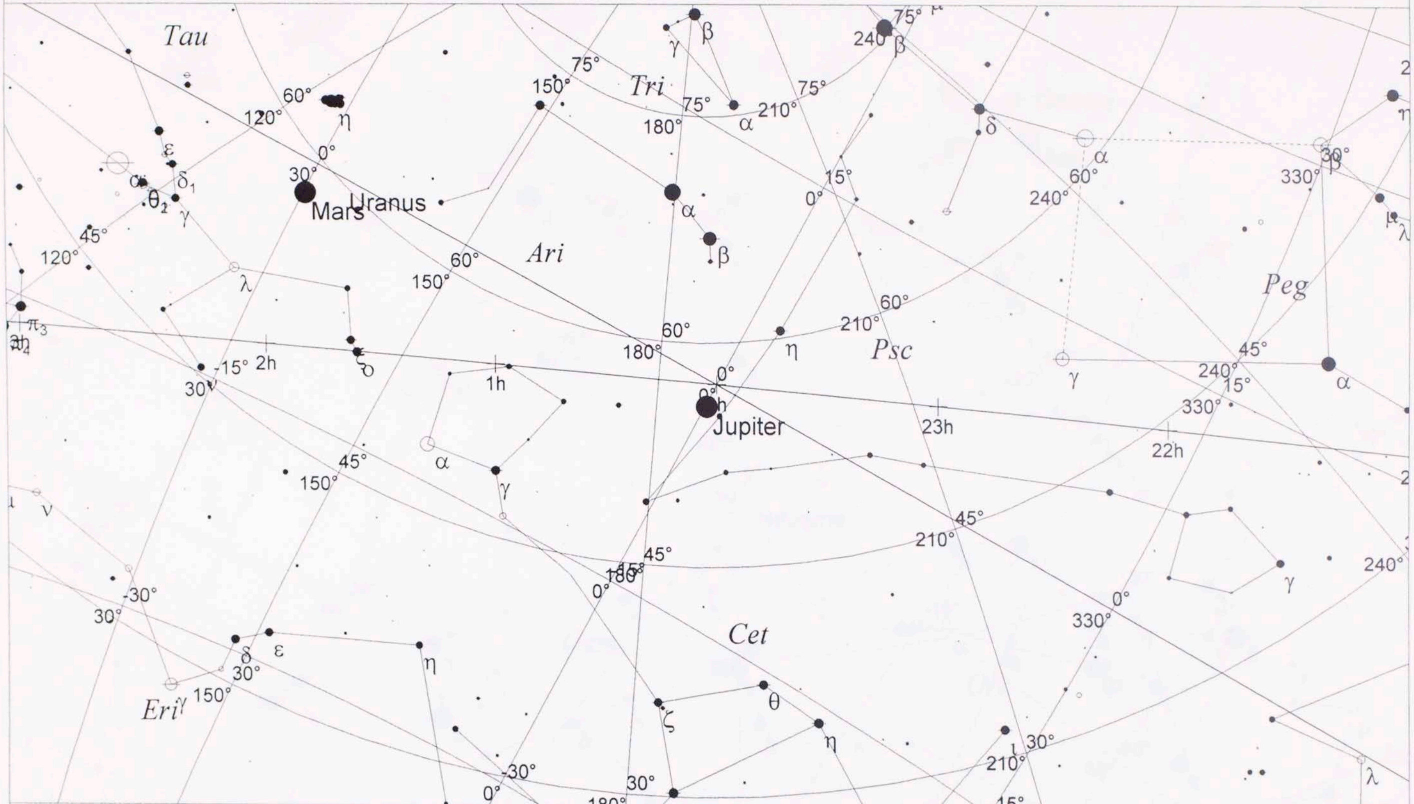


Local Time: 04:15:00 26-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:17:00 26-Jul-78BC
RA: 2h43m16s Dec: +21° 01' Field: 90.0°

Sidereal Time: 00:15:47
Julian Day: 1693139.5535

-77 IV 23

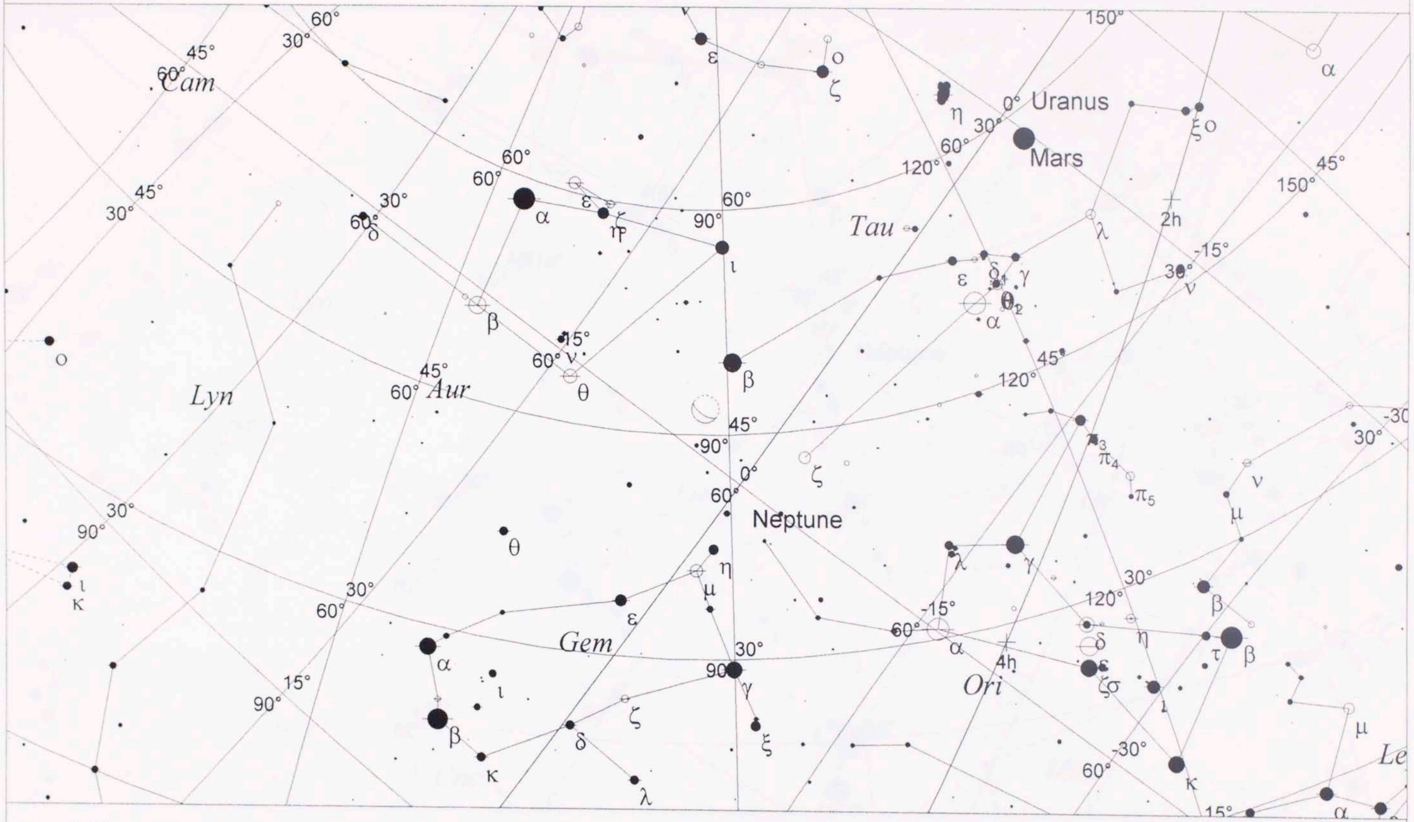


Local Time: 04:15:00 26-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:17:00 26-Jul-78BC
RA: 0h02m06s Dec: -1° 31' Field: 90.0°

Sidereal Time: 00:15:47
Julian Day: 1693139.5535

-77 IV 24

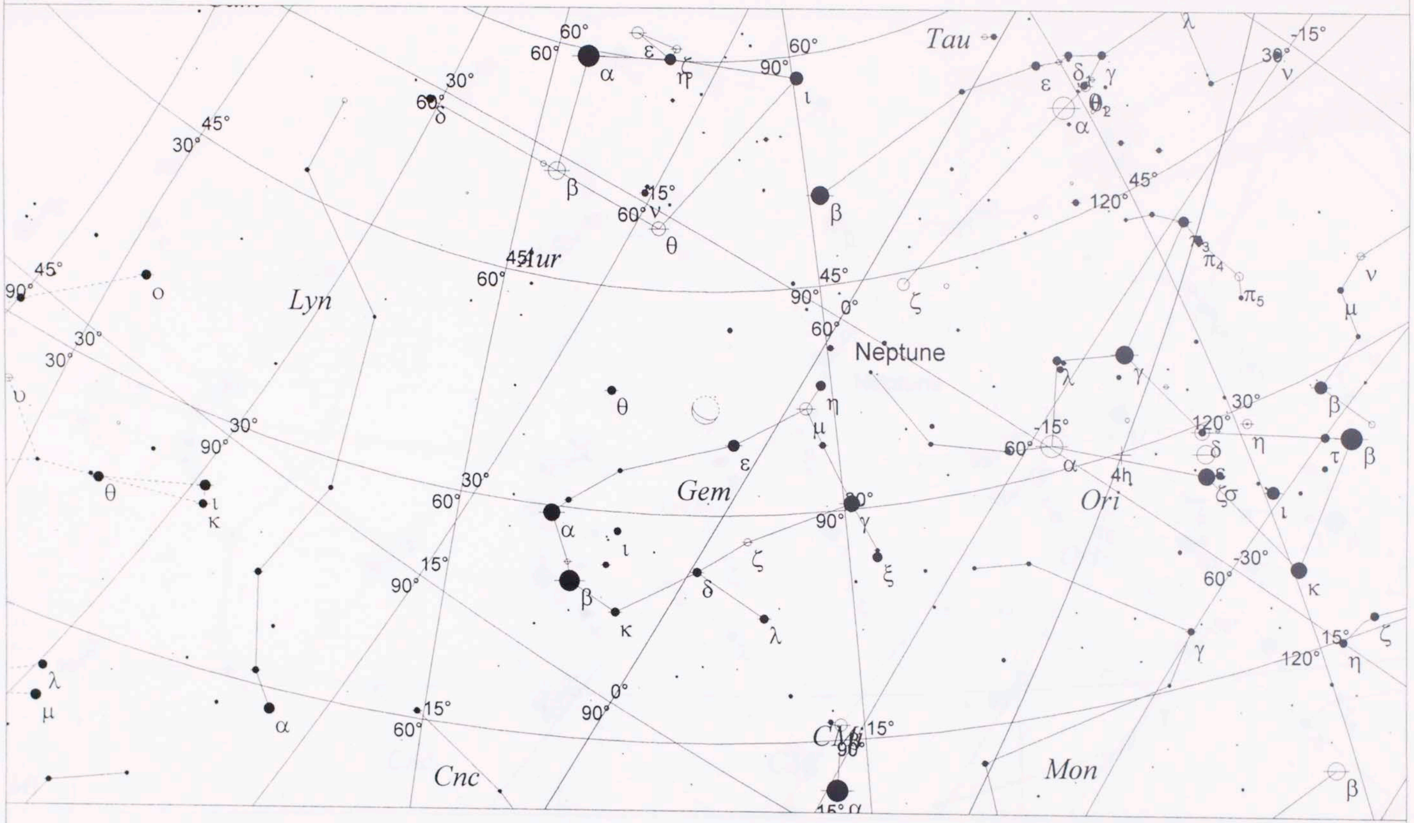


Local Time: 04:15:00 27-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:17:00 27-Jul-78BC
RA: 3h34m55s Dec: +24° 30' Field: 90.0°

Sidereal Time: 00:19:44
Julian Day: 1693140.5535

-77 IV 25

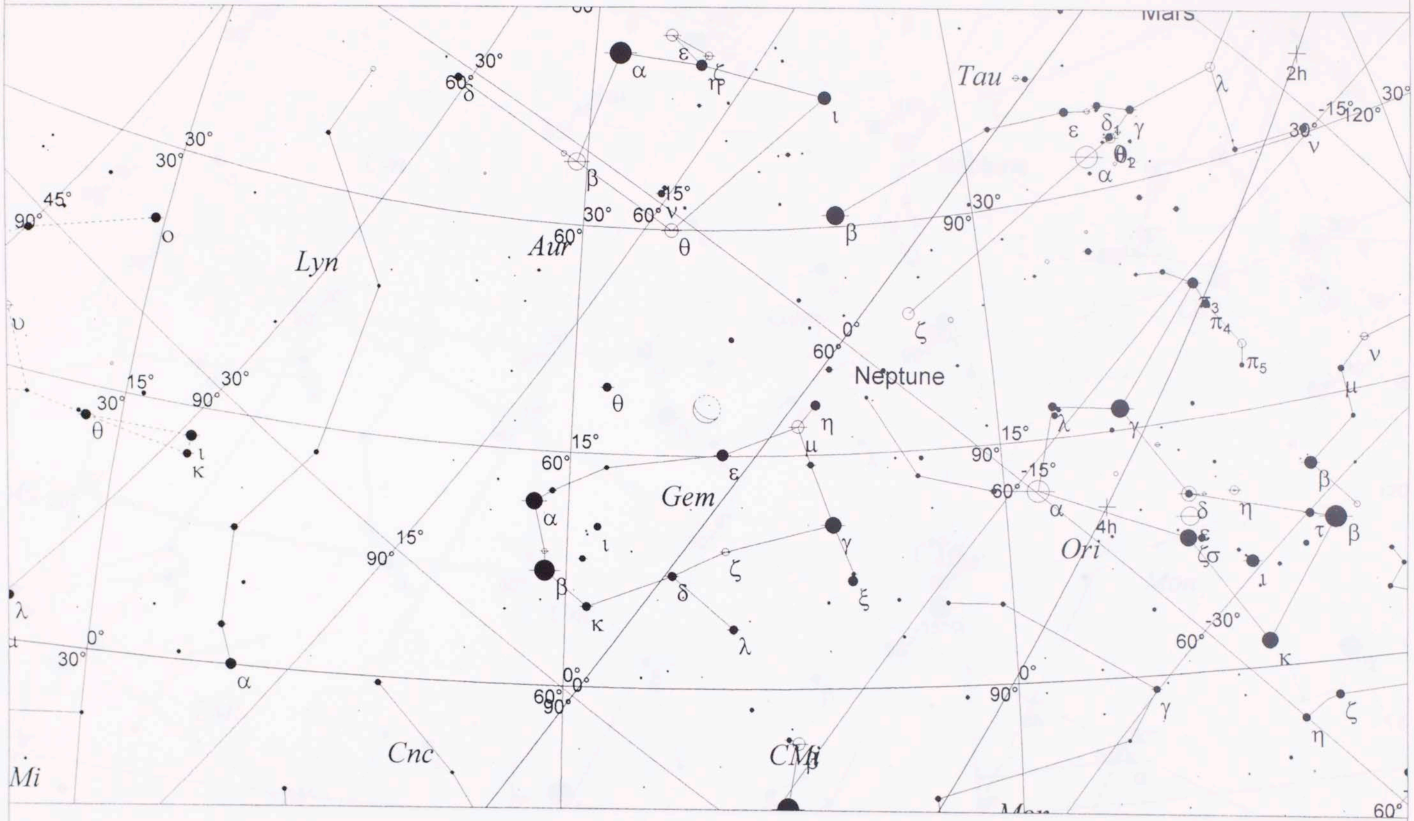


Local Time: 04:16:00 28-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:18:00 28-Jul-78BC
RA: 4h30m16s Dec: +26° 50' Field: 90.0°

Sidereal Time: 00:24:41
Julian Day: 1693141.5542

-77 IV 25

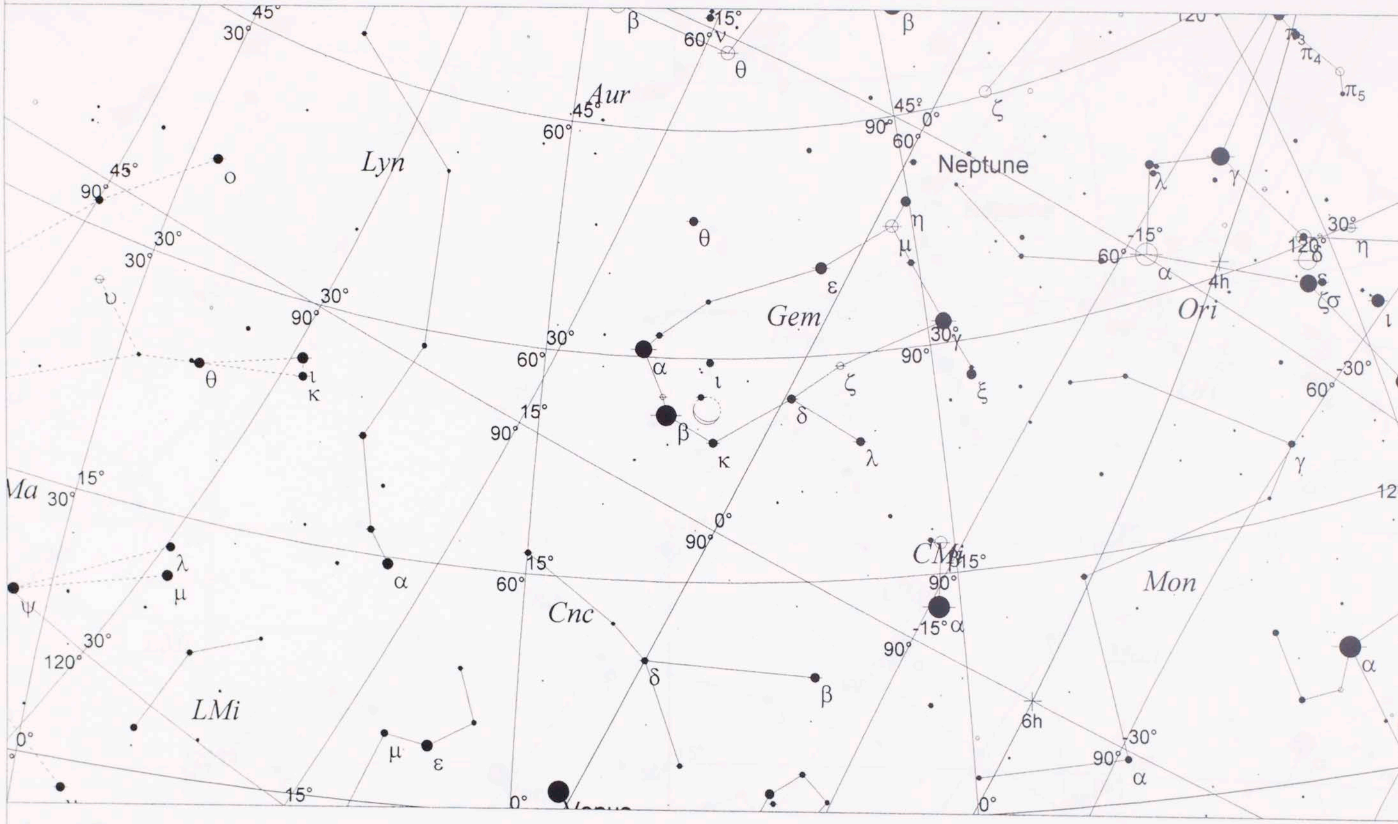


Local Time: 02:40:00 28-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 23:42:00 27-Jul-78BC
RA: 4h26m55s Dec: +26° 35' Field: 90.0°

Sidereal Time: 22:48:25
Julian Day: 1693141.4875

-77 IV 26

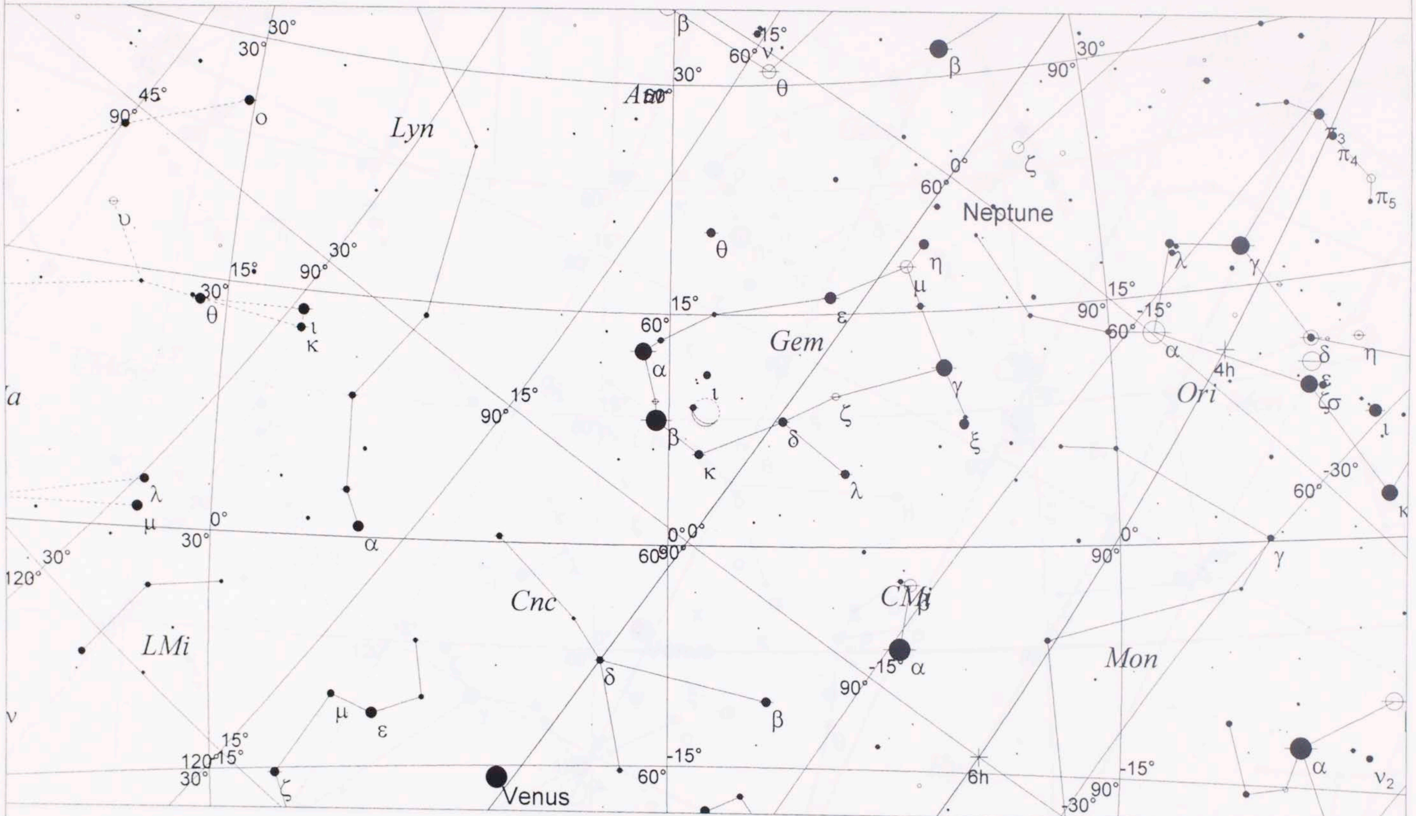


Local Time: 04:17:00 29-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:19:00 29-Jul-78BC
RA: 5h28m43s Dec: +27° 47' Field: 90.0°

Sidereal Time: 00:29:37
Julian Day: 1693142.5549

-77 IV 26

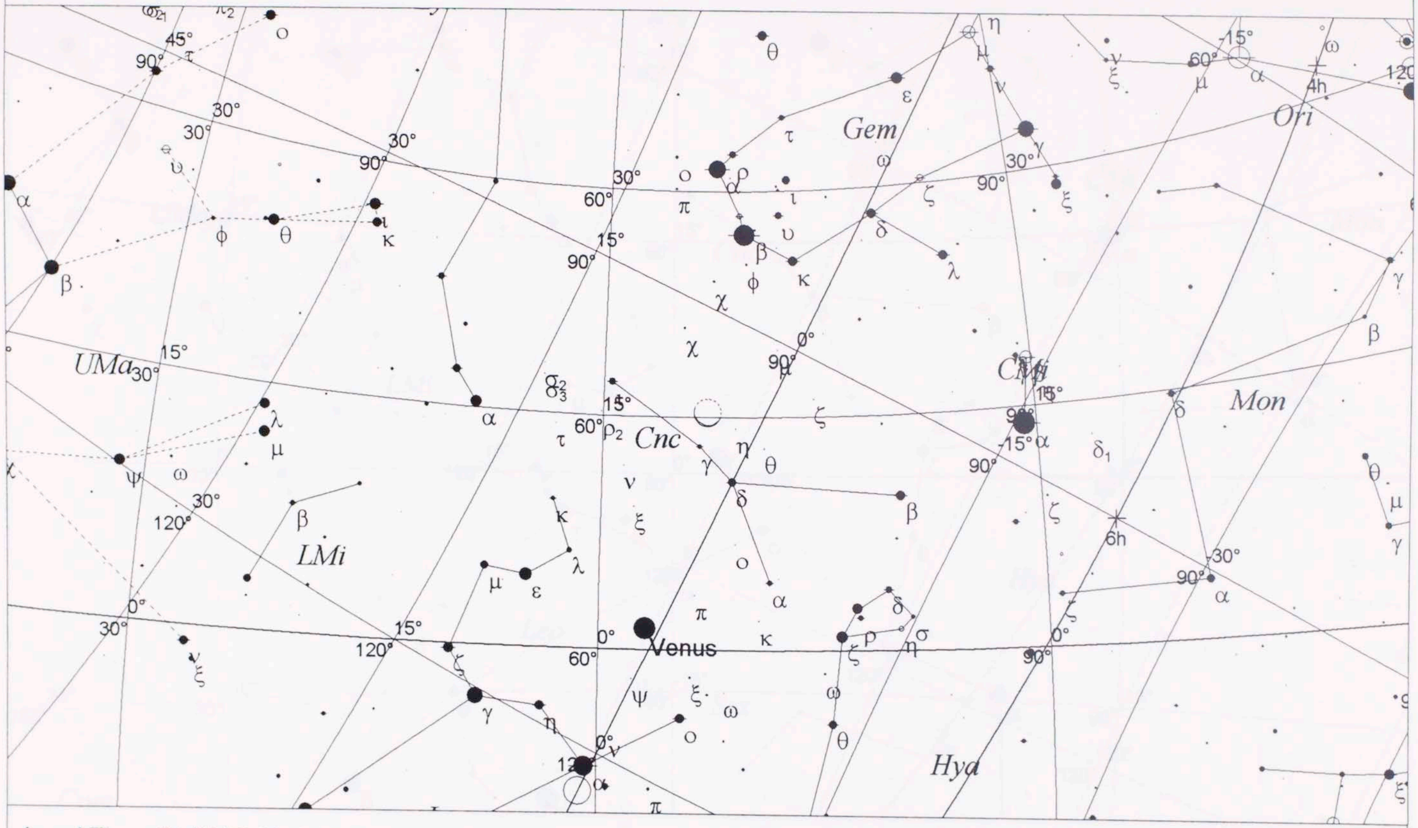


Local Time: 02:41:00 29-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 23:43:00 28-Jul-78BC
RA: 5h24m52s Dec: +27° 37' Field: 90.0°

Sidereal Time: 22:53:22
Julian Day: 1693142.4882

-77 IV 27

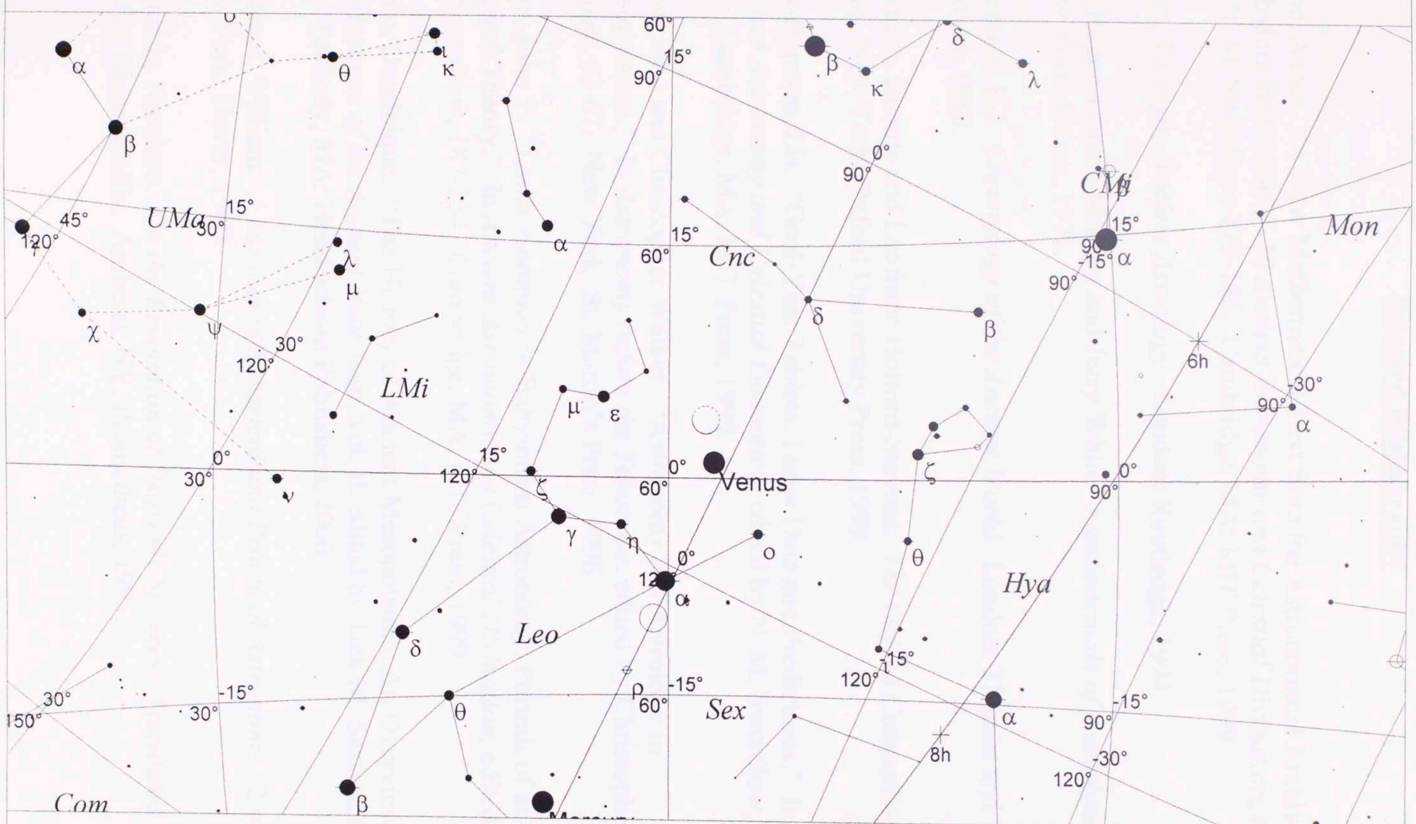


Local Time: 04:18:00 30-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:20:00 30-Jul-78BC
RA: 6h28m55s Dec: +27° 08' Field: 90.0°

Sidereal Time: 00:34:34
Julian Day: 1693143.5556

-77 IV 28



Local Time: 04:18:00 31-Jul-78BC
Location: 32° 33' 0" N 44° 24' 0" E

UTC: 01:20:00 31-Jul-78BC
RA: 7h29m00s Dec: +24° 48' Field: 90.0°

Sidereal Time: 00:38:31
Julian Day: 1693144.5556

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