England's first Copernican: a new text by Thomas Digges on the 'New Star' of 1572

Stephen Pumfrey with David Riley,
University of Lancaster.

Abstract.

Thomas Digges is famous as England's first adopter of physical Copernicanism and the author of an extraordinary heliocentric and infinite cosmology, his *Perfit Description of the the Caelestiall Orbes* (1576). Until now, his only other known astronomical treatise was the groundbreaking *Alae seu scalae mathematicae* (1573), which historians have wrongly assumed was occasioned by his observations of the so-called new star of November 1572. This article presents compelling evidence that another publication of 1573, a neglected and anonymous *Letter sent by a gentleman of England* was, in fact, written by Digges. We argue that it contains Digges' very early observations of and opinions on the new star, and the first unambiguous support by an English writer for the Earth's annual motion. Of more than antiquarian interest, the discovery adds to our understanding of the development of Digges' radical views on the star, Copernicanism, heavenly motion and the infinity of the universe.

1. Introduction: *A Letter sent by a Gentleman of England*.

On November 17th 1572[1] the puritan gentleman and leading English mathematician Thomas Digges observed a strange new light in the night sky in the constellation of Cassiopeia. He was not quite the first: the Danish astronomer Tycho Brahe saw it on November 11th. As November passed, it became extremely bright, reportedly outshining Venus: at its peak, with people seeing it in daylight. After a few months it began to fade, and had apparently disappeared to the naked eye by February 1574. Recently, Tycho's data has been used to rediscover the remnant of what is now called 'Tycho's supernova' but, since Digges's observations turn out to be the most accurate, we might also speak of 'Digges's supernova'.[2]

Of course, Digges and his contemporaries had no concept of supernovae. For them, the 'phenomenon' (the non-committal term often used by baffled observers) was a puzzling anomaly. It attracted the attention, observations and opinions of countless astronomers and astrologers, as well as natural philosophers, theologians and politicians, and provoked scores of printed and manuscript works in the following months.[3] It immediately precipitated a debate throughout Europe about its location, cause and significance. Most commentators assumed that it was a comet, albeit a prodigious one given that it had neither an obvious tail nor any proper motion through the sky. A typical response was *La déclaration d'un comète ou estoille prodigieuse*, published in Paris in 1573 by a Frenchman revealing himself only as I.G.D.V..

Digges rejected the cometary hypothesis because he was one of a handful of participants in the debate who were sufficiently skilled in new techniques of astronomical observation to be sure that the body exhibited no or negligible diurnal parallax.[4] Since the Moon exhibits a diurnal parallax of approximately 1 degree, any value of parallax smaller than that placed the phenomenon above the terrestrial world. This meant that it had to be above the Moon and in the Aristotelians' unchanging superlunary world. Thus, with others, Digges successfully displaced the popular explanation that it was a comet with the extraordinary explanation that it was a star. The

observations and deductions secured the international (and historical) reputations of both Brahe and Digges. Until recently, historians have assumed that Digges' *Alae seu scalae mathematicae* ['Mathematical wings or ladders'], an advanced treatise on parallax and its astronomical uses published in London in 1573, was work occasioned by the new star.

This view must now be revised, for two reasons. The first is our claim, developed in this article, to have discovered a hitherto overlooked tract by Digges specifically on the new star. This is the short, anonymous pamphlet, also of 1573, called *A Letter sent by a Gentleman of England, to his frende, contayning a confutacion of a French mans errors, in the report of the myraculous starre nowe shyning*. Its significance is three-fold. First, it adds to the small corpus of texts by Thomas Digges. Secondly, it sheds new light on Digges' work on the star. Finally, it contains the earliest support in a printed English work for the Copernican motion of the earth. We will return to this work, hereafter the *Letter*, shortly.

The second reason is related. If we were right that the *Letter* contains Digges' opinions on the star then what, we wondered, was the relation between the *Letter* and the *Alae*, which says surprisingly little about the star itself? As we wondered, Robert Goulding's illuminating answer was published, which proved our suspicions in detail: the spherical geometry of the *Alae* (and, indeed, a companion treatise by John Dee) was developed *before* November 1572, as part of a much more ambitious and general cosmological project.[5] To put the *Letter* in context, and to appreciate the circumstantial evidence for Digges' authorship, we must first consider the *Alae*.

2. The *Alae* and the new star.

The full title of the *Alae* spells out the bigger project: it offered *Mathematical Wings or Ladders, with which to ascend to the furthest Theatres of the Heavens and, with a new and unheard-of Method, to explore the paths of all the Planets, and then* [only then] *to find out the Distance, Position and immense Magnitude of that portentous Heavenly Body shining with remarkable brightness in the Northern part of the World*. The wings were the advanced spherical geometry developed in the *Alae*, and the superior observations made possible by better instruments. Digges conceded that any planetary parallaxes were so small that they could 'scarcely be perceived': he believed they were detectable because he accepted the conventional, low estimates of planetary distances, as did Brahe. Indeed there is some evidence that he may have been influenced by a model of the universe which, from the earth to the fixed stars, was considerably smaller than even the then accepted figures, thus making the parallax still easier to detect. If we take the figures for distances often used in Digges' time, deriving from al-Farghānī, the distance from the earth to the stars is 65,357,500 miles.[6] However, in his father Leonard Digges' *Prognostication Everlastinge of Right Good Effect* the distance from the earth to the stars can be computed as merely 358,463 miles – and a half. It is to this text, in 1576, that Thomas famously appended his Copernican treatise *A Perfit Description of the Caelestiall Orbes*, though he did not alter his father's figures for the distances computed for the Ptolemaic model of the universe.[7] Considering Thomas' engagement with the work of Regiomontanus, discussed below, he surely did not accept his father's curiously low estimates, but he might have been sufficiently influenced to hope confidently to measure planetary parallax.

What fascinated Digges about parallax, as it later fascinated Tycho,[8] was that Copernicanism required greater variations than did geocentrism in the distance from Earth of the planets, notably of Mars, and thus predicted different parallaxes. For Digges, this lack of observational equivalence meant that his method promised to bring to the dispute 'not merely probable arguments but perhaps the surest demonstrations.'[9]

As Goulding shows in detail, Digges' *Alae* (as, more sketchily, was Dee's *Parallacticae Commentationis Praxeosque Nucleus quidam*) was a sophisticated attempt to develop the mathematical analysis of observations of diurnal parallax beyond the level reached by Regiomontanus (1436-76) in a manuscript first published in 1531.[10] Digges believed on good grounds that more accurate observations, made possible by larger, graduated instruments, such as the ten-foot cross staff devised by Richard Chancellor and used by Dee and himself, had given parallax methods the potential to prove Copernicus right.

Digges' development had taken the approach of Regiomontanus beyond the German's original aim, which had been to locate and classify problematic lights in the sky. A century before the 1572 phenomenon, Regiomontanus had developed the geometry of parallax to determine whether the comet of 1471 was superlunary; he concluded, conservatively, that it was not. Claims that some comets had superlunary paths became a little more frequent during the sixteenth century, and in 1556 Johann Hebenstreit even suggested that two comet-like phenomena seen in that year were the same, celestial object.[11]

Thus, although Digges' grand project was developed before 1572, and the new 'phenomenon', was tangential to it, it was obviously tractable by the methods of the *Alae* even if the answer (that there was no discernible parallax) was, by the terms of that project, a null result. We agree with Goulding that passages in the *Alae* referring to the star were late incorporations, which do not, in fact, suggest a very thorough investigation. The main *loci* occur en passant in the *Alae*'s front matter, comprising an illustration, a table, dedication, preface and proemium. There follow 21 *problemata*, and nine practical *capitula* concerning proper use of the astronomical radius, which were developed before the star appeared. An additional tenth *capitulum* (followed immediately by a Conclusion) contains Digges' only specific, and brief, references to his observations. Indeed, as Tycho noted critically, and as Goulding emphasises, the *Alae* 'provided no numerical examples based on actual observation of the New Star.'[12] Goulding doubts that he had any to include, for he had established the absence of parallax using a simple rule of the staff. Digges wrote simply:

> 'By this means, on many nights, I noted that this miraculous Phenomenon appears in a straight line with the little star in the knee of Cassiopeia and the other star beneath the belt of Cepheus on the right-hand side.'[13]

Indeed, Digges went on to point out that anyone could 'see' that the phenomenon was superlunary 'using sight alone, without any instrument'. A simple check on its position with respect to the neighbouring star '*in sedis pede'* showed that any parallax must be less than 30 minutes.[14]

This does not mean that the new star did not give Digges and Dee the occasion to publish their works on parallax, for in November 1572 parallax clearly changed from a recondite astronomical problem into a key question for philosophers, theologians and politicians. Some of the new generation of post-Copernican astronomers, like Digges, Hayek and Brahe were especially open to new cosmological thinking, and their new hypotheses raised new religio-political questions. One suggestion was that it was an extraordinary comet of earthy origin that marvellously had crossed the lunar boundary and produced an alteration in the heavens; Dee suggested that it was a star that had approached the Earth and was now receding through planetary regions (which could not, therefore, be filled with solid spheres). Digges and Dee inclined favourably to the view that it was the first new star since the birth of Christ foretelling, perhaps, His second coming. The implications of such interpretations elevated parallax, and expertise in it, into key resources, and we might conclude that Digges and Dee seized the opportunity to publish their pre-existing work.

Whether the phenomenon was an extraordinary comet or a new star, rulers were troubled that it presaged some remarkable event in the sacred history of the world. Tycho reported to his lord, Frederick II of Denmark. It is worth noting here that the author of *La déclaration d'un comète ou estoille prodigieuse* has been identified as Jean Gosselin de Vire (1510-1604), who held the position of royal librarian to Henri III, and who probably performed a similar service for his lord.[15] Likewise, less than month after he first observed the phenomenon, Digges was consulted by his patron William Cecil, Baron Burghley and Elizabeth I's Lord Treasurer.

Digges wrote up his observations and advice in a letter to Burghley of December 11th, 1572. It shows that Digges was considering the possibility that the phenomenon was a star and not a comet, but that he was not sure about either its nature or its astrological significance. Digges advised Cecil that he had 'waded as far as ancient grounds of astrology and authors' precepts of approved credit will bear me, to sift out the unknown influence of this new star or comet.' Thus, a month after the star's appearance, Digges had not acquired his later confidence that the object had little or no parallax. The uncertainty, and pull of the traditional meteorological explanation, is further reflected in the fact that Burghley or his clerk wrote on the outside of the document, for filing purposes no doubt, 'comet'.[16]

The phenomenon clearly created opportunities for mathematical clients to present their patrons with very technical work, which nevertheless had great utility. Digges did so as part of his attempts in the 1570s to promote himself as an exponent of more philosophical, 'Platonic' cosmology as well as practical mathematics. He was already well known and valued as the developer of his father Leonard's advanced, humanist style of practical mathematics. But, in his first publication in 1571, a completion of his father's *Pantometria*, he appended his own *Mathematicall Discourse of Geometricall Solids*. Johnston's recent biography describes this as 'the most self-consciously advanced and novel work on geometry published in sixteenth-century England.'[17]

Simultaneously, Digges was seeking to transform the epistemological status of astronomy from a primarily predictive discipline to one that helped to determine cosmological realities, a transformation urged by Copernicus and secured by Galileo. This is manifest not merely in the aims but also in the rhetoric of the *Alae*, which is full of Platonic allusions to mathematics as a source of '*Sophia Coelestis*', a phrase that expresses Digges' Copernican view that mathematics was integral to natural philosophy. Indeed, the opening sections of Digges' letter to the reader of the *Alae* mentions approvingly, indeed twice, Plato's maxim that '*Astronomia causa oculos hominibus esse datos*' ['Astronomy is the reason why men were given eyes.'][18] The *alae* themselves are an allusion to Plato, although probably filtered through Melanchthon, a favourite author for Digges the devout Protestant.[19] In *Phaedrus*, Plato had written of winged versus base and wingless souls. Melanchthon commented:

> those souls from which the wings [*alae*] have departed wander on the ground and seek impure pleasures from terrestrial things; for they do not see the most beautiful light of celestial things. Although Plato interpreted the wings as the heroic impulses of the mind, these impulses alone do not bear the mind upwards: indeed skills are necessary to sustain those impulses. Arithmetic and geometry are, therefore, the wings of the human mind.... Raised to heaven by their might, you will be able to illuminate with your eyes the natural universe of things, to perceive the distances and measurements of the greatest bodies, to see the fateful conjunctions of the stars, in short to perceive the causes of the greatest things which happen in this human existence.[20]

In *Capitulum* X, the *Alae*'s apparent addition on the new star, Digges declared a deep frustration that in 1573 mundane concerns were frustrating his lofty goals. The star demanded new instruments, observations and other work and, fearing that the star might not shine for much longer, he wanted urgently to provide them:

> if the short period of time and my other concerns allow. But currently I am forcibly dragged away and diverted from these celestial contemplations by several lower human affairs. I should have considered my good fortune during that time and forced myself to complete the book without alteration, and to draw up the tables by hand. ...However, once the obstacles of fortune and mundane matters have been sorted out and overcome, I will (with God's favour) return to my most pleasant mathematical sources. [21]

One reading of the *Alae*, then, is that Digges hoped it would lead to time and support for his 'Platonic' astronomical work. Studies of new physical astronomers from Tycho to Galileo show how important was courtly patronage to their innovative, expensive, time-consuming and controversial work. For an innovative text like the *Alae*, that would raise for an international Latinate audience the distinct possibility that Copernicus was right, Digges needed the legitimacy provided by a letter of dedication to his patron. Digges opened his letter to Burghley (conventionally) by saying that he had been looking for a way to show his gratitude. 'Then a suitable occasion happened when (at your command) I attempted to measure the place, size, distance and magnitude of the shining new star, or very rare phenomenon.'[22] The letter then moves via Digges' attempt to measure its parallax (and his astonishment that it had none), to the more general cosmological significance of improving upon Regiomontanus. Having enrolled Burghley's protection of his 'first ventures into astronomy', he concluded with his hope that the question of whether or not the 'inharmonious (not to say monstrous)' world system of antiquity 'has been sufficiently corrected and fully reformed by Copernicus, that divine and altogether more than human genius'.

In the event, Burghley appears to have been unwilling to promote this aspect of Digges' research. Digges offered him a further astronomical treatise in 1574[23], an approach that brought no fruit. The [vernacular] *Perfit Description* of 1576 was Digges' last published contribution to the new astronomy and, although he continued to express interest in cosmology, he moved to the patronage of the Earl of Leicester and to publications in practical, especially military mathematics. A lack of English interest in his *Alae* surely played into his recollection, in the Preface to the *Stratioticos* of 1579, dedicated to Leicester, that he had

> spent my younger years, even from my cradle, in the sciences liberal, and especially in searching the most difficult and curious demonstrations mathematical… yet finding none, or very few, with whom to confer and communicate those my delights, (and remembering also that grave sentence of the divine Plato, that we are not born for ourselves, but also for our parents, country, and friends), after I grew to years of riper judgement, I have wholly bent myself to reduce those imaginative contemplations to sensible practical conclusions of those my delectable studies, as also to be able, when time is, to employ them to the service of my prince and country.[24]

If the *Alae*'s dedication to Burghley emphasised its relevance to the star, Digges nine-page letter to his international readership focussed on the larger cosmological questions. To be sure, over sig. A1v and sig. A2r he included a brief excursus on the star. This simply states that skilled mathematicians consider it a star high in the heavens, and asserts, on Aristotle's authority, that comets do not belong in this region of 'the purest Aether, where there can be no naturally occurring changes, novelties or alterations'. Digges' position was that those who say it is a comet

'either condemn or devalue this rarest sign, God's true miracle or messenger.' Beyond this, he was:

> determined not to write anything more on the history of this star, because that extraordinary man John Dee (most learned in these studies and a prodigy in the rest of philosophy, whom I esteem as my second Mathematical Father…) has taken on the task of expounding this material… [and] I have no doubt that it will soon be published.[25]

In this matter, as in others, confidence that Dee would bring his work to the press was misplaced. Digges was probably thinking of the theory that Dee discussed with Christoph Rothmann, and which we can also infer from Dee's own reference to an unpublished Latin work of 1573 'On the marvellous star in Cassiopeia, sent down from heaven all the way to the orb of Venus, and then drawn up again perpendicularly into the depths of the heavens sixteen months after its first appearance.'[26]

Fortunately, positioned very incongruously at the front of the *Alae*, between the title page and Burghley's coat of arms and without comment, Digges placed a table of the exact positions of the thirteen stars in Cassiopeia, which he described as those recorded by Copernicus, after correcting typographical errors in *De Revolutionibus*. We know that he did indeed make these corrections: they form some of the very few marginalia recorded by Gingerich in Digges' copy.[27] As well as a fine diagrammatic representation locating the star near the base of Cassiopeia's seat, Digges included a table of the distances from some of them of what he called a 'Mirandum Phenomenon' which, he thought, might 'recede before its orbit is dissolved by order of the Most Powerful'[28]

It is not surprising that modern readers, who may not have read much beyond the title and this double spread, assume that the *Alae* is about the star. Yet nowhere in the *Alae* does Digges refer to these pages, nor does he discuss how he arrived at his revised positions for the thirteen normal and the one extraordinary star. Nor, until now, have historians suspected that he discussed the matter anywhere else. He had, it seemed, in deference to Dee, 'determined not to write anything more'.

3. The *Letter*, the new star, and Digges' authorship.

We believe that we have discovered something more. The discovery was serendipitous. In October 2004 Pumfrey began to inspect the 'front matter' or prefatory pages of the hundreds of works published in England between 1570 and 1625 whose content could loosely be called scientific. This was research for a major AHRC-funded research project, based at Lancaster University, on 'Science and Patronage in England, 1570-1625'.

Proceeding alphabetically by author, he soon encountered the short pamphlet listed under 'Anon[ymous]' in the Short Title Catalogue (STC), *A Letter sent by a Gentleman of England, to his frende, contayning a confutacion of a French mans errors, in the report of the myraculous starre nowe shyning*. It was printed in London by Thomas Marsh in 1573, and bears the STC number 155253-1797. A bibliographical search indicates that the only extant copy of the pamphlet is to be found in the library at Lambeth Palace, London, where it is bound with a miscellaneous collection of pamphlets on diverse subjects. Unfortunately there is no provenance history for this volume and it does not appear to be in its original binding.[29] The book seems to have been completely ignored by historians perhaps because, from the title alone, it seems to be a piece of third-rate astrology.

If, however, one is familiar with the diagram of Cassiopeia in Digges' *Alae*, then the cruder but almost identical diagram on the title page of the *Letter* immediately raises strong suspicions of Digges' authorship.[30] (The diagrams are reproduced at the end of this article.) Who else in England was capable of producing such a diagram? There are other candidates, notably John Dee, and Digges might have offered his diagram to, or had it copied by, a third party. The uncanny similarity of the diagrams is perhaps insufficient evidence, but there is plenty of corroboration.

Besides the title page with the depiction of Cassiopeia, the *Letter* consists of nine pages of text, unpaginated after the first page A.iii,[31] and a final page declaring Marsh as the printer. It begins: 'Misopseudolugos Philomathei, salutem'. Misopseudolugos is presumably a typographical error for 'Misopseudologos', or a hater of false or lying doctrine. The liar or *pseudologos* alludes to the original Greek text of *1 Timothy* 4:2 where, significantly perhaps, Timothy predicts that 'in the latter times some shall depart from the faith… speaking lies in hypocrisy'.[32] Claims that an extraordinary celestial phenomenon was a sign of the Last Days were not unusual, but both the claim for the star's significance, and the typically Protestant concern with eschatology, are at least consistent with what we know about Digges' theological interests.[33]

The conceit that legitimised publication was that Philomathes[34], i.e. a lover of mathematics, had required 'my opynion touching the French Pamflet of a blasing starre latelye Englished.'[35] However, Misopseudologos gives insufficient information easily to identify the original French pamphlet: he nowhere names the author. We suggest that it may have been the very rare work, *La déclaration d'un comète ou estoille prodigieuse* mentioned above, by I.G.D.V., alias Gosselin.[36] Fortunately, it is the nature of Misopseudologos' epistolary response, and not the original pamphlet, that is of interest.

That the French original was also anon- or pseudo-nymous is further suggested by the *Letter*'s reference to Apelles and the shoemaker. Apelles, of course, was the supreme Greek painter who hid in the shadows in order to gather public reaction, such as the shoemaker's, to his work.[37] Misopseudologos' jibe is that the unmathematical author should have taken the ignorant shoemaker's role and 'content himself to loke on, and geve others leave to play the part on the *Mathematicall* stage'. One reason, therefore, for the *Letter*'s anonymity might be that Misopseudologos-Digges was casting himself as an expert in the manner of Apelles. Indeed, one complaint of the *Letter*, again consistent with Digges' views on Elizabethan mathematicians like himself, is:

> 'the ill opynion [the English translator] seemed to have of his owne countryemen, that amonge the abundant choise of so many excellent Mathematicians, would rather publishe such a toye, than use thadvise of suche as mighte have taughte a veritye.'[38]

Interestingly Digges makes use of the story of Apelles elsewhere in a similar manner. When discussing navigation and navigators in the short sections he added on the subject to his father's *Prognostication Everlasting* in 1576, he suggests navigators should leave it to mathematical experts to discern the difficult questions of navigation; 'let them learn Apelles's lesson *Ne Sutor Ultra Crepidam.*'[39]

At this point, a brief summary of the *Letter*'s main arguments is in order. It alerts readers to the 'manye errors and that of all sorts, Geometricall, Astronomicall, Physical, Cosmographical and Historical' made by the French author, but above all that the star was a comet. It criticises in detail the author's poor knowledge of spherical geometry, his inaccurate depiction of the stars in Cassiopeia and, in particular, his location of the new star within the constellation. But his cardinal mistake was 'to discover a Parallaxe' where there was none, indeed a parallax that contravened

basic geometrical principles.[40] Moreover, the author contradicts himself because his own value for parallax puts the body above the Moon, so such basic mathematical errors mean that one can ignore the author's gloomy prognostications, although the *Letter* accepts (as did the *Alae*) that the body is 'a forewarning of God's inscrutable pleasure'. All social ranks had 'greate cause to stand in horrour of this myraculous signe, as a forerunner of Gods just Judgemente'.[41]

That the Frenchman had inadvertently put his comet above the moon allowed Misopseudologos to remind him of basic Aristotelian meteorology: 'unlesse he will make warre with Naturall Philosophers and explode Aristotle, he cannot terme hym a Comet.'[42] Once again, this is consistent with Digges opinion in the *Alae* where, as Goulding notes, Digges rejected 'the possibility that the star could be composed of cometary matter somehow carried up into the celestial realm: Aristotle had shown that terrestrial matter could never stray outside its own, sublunar sphere.'[43] This combination of a radical astronomy with a conservative sublunary philosophy would also figure in Digges' *Perfit Description*, where he depicted the Earth in solar orbit but as part of a sublunary and elemental 'great orbe carrying this globe of mortalitye'.[44]

As we move to more positive evidence, we should recall that the *Letter* was printed by Thomas Marsh, Digges' regular publisher at the time. Marsh had been a prolific printer of innovative astronomical and astrological works since a *Right Excellent Treatise of Astronomy with a Prognostication* of 1554-5, going on in 1556 to print John Field's Reinholdian *Ephemeris*, the first English book to mention Copernicus' theory.[45] Digges probably used Marsh because of his reputation, and entrusted him not only with the *Alae* (and *Letter*) in 1573, but also with his famous Copernican tract, the *Perfit Description of the Celestiall Orbes*, appended to his 1576 edition of the *Prognostication Everlasting*. Marsh continued to print Digges' 1578, 1584 and 1585 editions.

More evidence comes from the *Letter*'s praise for the *Zodiacus Vitae*, by Marcellus Palingenius Stellatus (usually taken as the pseudonym of Pier Angelo Manzolli).[46] The *Letter* notes that, while the Frenchman has obviously not studied 'Ptolemey, Copernicus or other Mathematicianes, yet of Poetes as Palingenius he might have learned howe Cassiopea decem atq tribus stat lucida flammis.' Digges was a great admirer of Palingenius; he learned Book XI of *Zodiacus Vitae* 'bie hart' and took 'much delight to repeat it often', not least because it was one inspiration for his belief that the stars were at different distances from the Earth.[47] In *The Perfit Description* he quoted some twenty lines in support of his infinite, Copernican cosmology.[48] Published in Basle in 1543 and banned for its heterodox rationalism in the first *Index Librorum Prohibitorum* of 1559, the 'Stellifyed' and 'Christian' poet's *Zodiacus Vitae* rapidly became popular among English Protestants. Volumes of Googe's English translation began to appear in 1560, and England's first Latin edition was printed in 1569 - by none other than Digges' printer Thomas Marsh.[49]

A very strong clue is contained in the *Letter*'s closing advice. Despite the French author's shoddy work, Misopseudologos urged Philomathes to 'proceede in the passinge, pleasaunte studyes of the noble sciences Mathematical fit onely for fre[e] and noble minds that stoup not at filthy lucre'.[50] At a time when Digges was self-fashioning an image as a gentlemanly, humanist (even 'Platonist') scholar, he distanced himself from the growing number of commercial mathematical writers and practitioners for whom mathematics was a livelihood. On the title page of *Alae* Digges styled himself 'Stemmatis Generosi' (from a well bred genealogy), reproducing his own family's coat of arms as well as Burghley's. It is, then, significant that, in his dedication to Burghley he contrasts his imagined mathematical critics with those whose minds are most noble and dignified and '*quae nihil vile sapiant lucrum'* (who are not acquainted with base lucre).[51] Again, in the *Pantometria* of 1571 he had presented himself as a mathematician in the mould of Euclid and

Archimedes, and not one of 'those [practitioners] given only to lucre'.[52] We are not aware of any Elizabethan mathematician other than Digges who deployed this specific trope.

The strongest evidence, however, comes from similarities in the treatment of the new star between the *Letter* and the treatment that Digges provided in his *Alae*. Like other observers such as Tycho and Hajek, Digges brought a new exactitude to the constellation of Cassiopeia. His desire to locate exactly the new star made the positions of Cassiopeia's customary thirteen stars crucial. We saw how the *Alae* began with a table of unprecedented accuracy of those stars' longitudes, latitudes and magnitudes, compiled from Digges' own corrections of *De Revolutionibus*.[53] 'Misopseudologos' took the same great care to map precisely the positions of the key stars in Cassiopeia. For him, the Frenchman's errors were that '[f]irst in the portrayture of Cassiopeia the very starres are mistaken, and the new star misplaced.'[54] Thus, as in the *Alae*, Digges carefully establishes from Copernicus the longitudes of the two nearest stars, *in sedis pede* and *in coxa* (now called *kappa Cassiopeaie* and *gamma Cassiopeaie*), as 8 degrees 20 minutes and 10 degrees exactly. The new star being in between these values, the *Letter* finds it easy to conjecture 'by sighte without Instrumente within one degree' that 'nyne grades therefore [is] the longitude of this new starre in the eyghte sphere by sighte onely collected, as I have before declared.'[55] Digges proceeded to show off his expertise in technical Copernican astronomy by calculating the star's position with respect to the ecliptic. This provided Digges with the opportunity to show that he had updated Copernicus' value for the precession of the equinoxes to '27. grades 49 minuts, which I have by certaine Calculation found to be *Praecessio Aequinoctio vera*, for the Nativitye of oure Saviour last past', i.e. 25th December, 1572. The adjustment 'produceth 6. grades 49 minutes in Taurus for [the new star's] longitude of place'.[56]

This exactitude is, of course, a prelude to refuting the Frenchman's main error, that the prodigious star exhibited sufficient parallax to be a 'blasing starre' or comet. The Frenchman 'giveth his new starre severall distances from *Alrucuba* [sic] at his greatest heighte, (which in deede is nothinge so)'.[57] The question of any parallax for the star still being open perhaps explains why Digges saved his greatest scorn for the Frenchman's claim that the new star's 'greatest Parallaxe [was] above the Pole, and his lesser underneath, which is a matter so absurde, as our Mathematicall infants will laughe to scorne'. In any case, the small parallax the Frenchman claimed to observe would 'give [the body] to be above the Moone'.[58]

The *Letter* becomes less interesting in the second half, in which Digges disputes the Frenchman's prognostication of the phenomenon's likely effects. It is worth noting that Digges accepted that comets were portents, although he refuted the Frenchman's claim that they always signified 'horrible effects'. However, he insisted that 'unfitly are the significations of Comets applied to starres, or *Phaenomena* that are aboute the Region *Elementare*.'[59]

Finally, and in agreement with Digges view in the *Alae* that the star was a miraculous sign from God, he readily agreed with the Frenchman's conclusion. It was 'not to be disliked for that it contayneth both piety and veritie and no doubt it is as he sayth a forewarning of Gods inscrutable pleasure, which wil fall out to be no less straung and myraculous in effect, then this signe wherby it is forewarned is rare and supernaturall.' And so Misopseudologos concluded with Digges's signature trope:

> exhortinge you [Philomathis] to proceede in the passing pleasaunte studies of the noble sciences Mathematicall fit onely for fre[e] and noble mindes that stoupe not at filthy lucre I commit you to the protecting of the Almightye.[60]

4. Digges' *Letter* as England's first pro-Copernican text.

Confident, then, that Digges wrote the anonymous letter, we can identify him as the author of the statement contained in it that the Earth moves. To locate the new star in Copernican fashion, the *Letter* needed to allow for the precession of the equinoxes, in order to make

> accompte as Copernicus doth from the little starre in the horne of the Ramme, which in the olde Astronomers tyme stoode in the very intersection of the line Ecliptike and Equinoctial [i.e. at the Spring equinox], but sithens by the stealinge course of the starres fixed, or rather of the earthe as Copernicus with better reasons proveth, is removed since that time 27. grades 49 minuts.[61]

Of course, Copernicus' explanation of precession, which came to be rejected along with his commitment to solid spheres, involved the earth's annual motion in its sphere being almost, but not quite, countered by an opposite 'third motion' of the Earth. This acted to keep the Earth's axis pointing at the celestial pole, with the slight slippage generating the 26,000-year cycle of precession. To accept that Copernicus had a better or proven explanation, was to accept that the Earth orbited the Sun, as we know Digges did. Of course, the statement is a mere aside to discussion of the new star. Furthermore, in Digges' era, the verb 'to prove' did not always mean apodictic demonstration (the level of certainty Digges sought in the *Alae*). But the statement indicates the author's belief in Copernicus' *annual* motion of the Earth, and we believe that we have shown that Digges was that author.

If we are right, then this would be the first statement in support of Copernicus heliocentric cosmology (as opposed to his astronomy) to be published by Digges and, therefore, by any English writer. In making this claim we are not interested, as were some twentieth-century historians, in collecting early and heroic English adherents to 'the truth'. Over-enthusiastic claims, and consequent misreadings once led to John Dee, John Feild and, even earlier, Robert Recorde, as early adopters of heliocentrism in England. More sophisticated history of astronomy has, in any case, exposed the weakness of the evidence for these claims.

We are, however, interested in its value for re-assessing the development of Digges' astronomical thought, which is a central concern of the researches of one of us (Riley). Digges was most certainly a Copernican. Less certain is when he committed himself in print to the Earth's annual motion, and some reconsideration of this too is needed. He had not committed himself in the *Alae*: For all the pro-Copernican rhetoric, Digges awaited an empirical determination from parallax data. The same tension exists in the *Perfit Description*, by which time Digges' commitment to heliocentricity was even more obvious, but still not entirely explicit.

In the *Perfit Description*, Digges introduces his translation of, with occasional commentary upon, Book I of *De Revolutionibus* via a conceit. The conceit is that, while his father Leonard had employed a Ptolemaic 'theorick or model' in his *Prognostication*, English readers expert in neither mathematics nor Latin should have the opportunity to judge Copernicus' theorick for themselves. So he wanted 'to publish this, to the end such noble English minds (as delight to reach above the baser sort of men) might not be altogether defrauded of so noble a part of Philosophy.' Its description as philosophy, of course, signifies Digges other 'end [that] it might manifestly appear that Copernicus meant not as some have fondly accused him, to deliver these grounds of the Earth's mobility only as Mathematical principles, feigned & not as Philosophical truly averred.'[62]

Although Digges included phrases such as 'demonstrations mathematicall' or 'demonstratively approved' and, indeed 'perfit description', ultimately he left open the question of the physical

truth of heliocentrism. Thus, when discussing philosophical reasons for and against it, Digges writes:

> for my own part in this case I will only say: there is no doubt but of a true ground truer effects may be produced than of principles that are false, and of true principles falsehood or absurdity cannot be inferred. If, therefore, the Earth be situate immoveable in the Center of the world, why find we not Theorickes upon that ground to produce effects as true and certain as these of Copernicus?[63]

Digges promised to reveal his own arguments at a later date, and in a striking rhetorical form:

> God sparing life, I mean though not as a Judge to decide, yet at the mathematical bar in this case to plead, in such sort as it shall manifestly appear to the World whether it be possible upon the Earth's stability to deliver any true or probable Theorick & then refer the pronouncing of sentence to the grave Senate of indifferent discreet Mathematical Readers.[64]

Obviously, Digges doubted that it was possible but, although God spared his life until 1595, he never marshalled a printed refutation. What, then, might have been his argument? We suggest that it would have relied on the same parallax method for which Digges had great hopes in the *Alae*. This reading leaves Digges' first clear commitment in print to the Earth's annual motion not in the *Perfit Description* of 1576 but in the *Letter* of 1573.

This raises our final questions concerning the *Letter*: when was it written and published, and was it published before or after the *Alae*? Both appeared in 1573, within a few months of the star's appearance. We have no definitive answer at present, but we suggest that the *Letter* was first, and we make some tentative inferences about the development of Digges' work on the star and cosmology.

5. Dating the *Letter* and the *Alae*.

The *Letter* bears almost no evidence of dating beyond the 'Anno Domini. 1573' that appears on the title page, although the reference to 'the Nativitye of oure Saviour last past' (presumably Christmas 1572) means that it was written by December 1573. The *Alae*, and Dee's companion *Nucleus*, are more intriguing. Digges apparently worked at speed on the *Alae* until late February, 1573 and dated his 'Praefatio Authoris' accordingly. What Goulding describes as a 'friendly rivalry' between Digges and Dee led to his 'mathematical father' hurriedly preparing his own work for the press, and dating his prefatory letter March 5th, 1573, no more than 15 weeks after the star's appearance.[65]

Like Goulding, we found it incredible that Digges and Dee could have developed their complex parallactic methods in only a few weeks, and we were ready to agree with his argument that both works were substantially complete before November 1572. We find it preferable to another hypothesis we had considered, that the *Alae* actually appeared in 1574, not four but sixteen months after the star appeared. This is a possibility because of the different calendars in operation in Europe at the time. Calendar reform was a big issue in the sixteenth century.[66] In many countries the start of the year was moved back from 25th March, the Feast of the Annunciation of Christ, to January 1st, the start of the old Roman civil year. By 1572 countries such as Denmark and France had made the change, but England delayed until 1752. In England the legal year-end of 24th March continued to apply in most situations, including letter writing.[67] Digges' and Dee's letters, and the dates on their title pages could, therefore, refer to 1574 'new style'.

The crucial issue is whether the legal or calendar year was employed at the time by the Stationers' Company that oversaw the printing of the works. Little research has been done, especially for the sixteenth century, and confusion remains, not least because the Stationers' *Register* used the old style legal year: even A.F. Pollard was misled. Edgerton has made the most thorough study. He concluded that 'sixteenth-century printers customarily used the calendar year rather than the legal year', except for specialised classes of works that included official and some learned literature such as law books.[68] Our own checks on a few contemporary natural philosophical and mathematical works suggest that they too were dated new style.[69] Thus new style dating was very probably given to the *Alae*, *Nucleus* and *Letter* – although it is unfortunate that all entries for the years 1572-5 are missing from the *Register*.

It would seem, then, that the *Alae*, and the *Nucleus* were indeed printed in spring 1573 new style: we cannot infer the *Alae* appeared at the very end of the legal year 1573, and the *Letter* before Christmas and hence earlier. Moreover, by Christmas 1573, one year after the star's appearance, it was obvious that it was fading. It would have been clear to Digges that the extensive fading of the star was not an artefact of the annual revolution, which was one hypothesis that he had entertained.[70]

We are left with internal evidence, which mostly points to the *Letter* as the earlier work. In the first place, Digges' positional astronomy seems cruder. It mentions only naked eye observations, made without instruments and accurate only to the order of half a degree. As Digges explained in the *Alae*, this was sufficient accuracy to refute claims that the phenomenon was sublunary, and the *Letter* was a polemical work, hoisting the bungling Frenchman with his own petards. Nevertheless, the rhetorical argument depended upon Misopseudologos demonstrating his mathematical superiority, and it would have been odd had Digges suppressed the incomparably more accurate positional data of the *Alae*. Secondly, the depiction of Cassiopeia and her new star is much more crudely drawn: indeed, the *Letter* generally gives the impression of a work even more rushed than the *Alae*: witness the uncorrected presence of *Misopseudolugos* and *Alrucuba*.

Thirdly, the *Letter* confidently stated that the phenomenon was 'a new starre in the eyghte sphere'[71] (that is, the traditional sphere of the fixed stars). However, the *Alae* considered Dee's ingenious hypothesis that the star was among the planets and was increasing and decreasing in brightness as it moved nearer or further from the earth. Combined with Palingenius' opinion that some stars were too faint to be seen, Dee's hypothesis may have inspired Digges to the radical vision he would soon describe in the *Perfit Description*, of stars at different distances from the Earth in a stellar 'sphere' of infinite extension.[72] It is possible, then, that Digges got his radical inspiration in the few weeks of 1573 that separated his urgent drafting of the *Letter* and the completion of the *Alae*.

Fourthly, in the *Alae*, Digges declared that he would not write again on the new star, and leave the field open to Dee, which suggests that his *Letter* was already penned. His authorship would have been obvious to Dee, and hardly concealed by the pseudonym Misopseudologos. We have preferred to explain the *Letter*'s anonymity with reference to the trope of Apelles that cast Digges fittingly in the role of expert mathematician.

It is possible that the *Letter* (like, perhaps, the English translation to which it responded) was initially a manuscript with limited circulation. Even if it was completed before the *Alae*, Digges may have chosen to print it subsequently as an effective, vernacular refutation of the enduring interpretation that it was a comet. Indeed consideration of the *Letter*'s status as a response to the French tract might suggest a later date. Whether or not that tract was Gosselin's of (presumably)

early 1573 or another written very late in 1572, several weeks must have elapsed for it to have been printed in France, to have reached England, to have been translated and circulated, and for Digges to have penned and had printed his response. If the *Alae* was printed soon after February 1573, then the *Letter* could not have appeared much earlier. We can give no definitive answer, but we are inclined to read the *Letter* as Digges' early response to the phenomenon based on the initial observations he presented to Burghley late in 1572.

6. Conclusion: the evolution of Digges' work on the star.

We suggest that the anonymous *Letter sent by a Gentleman of England* was written by Thomas Digges some time after his December 12th report for Burghley, and before the appearance of the *Alae*. It was most likely compiled some time between December 25th 1572 and February 1573, new style. In December Digges had still not dismissed the cometary hypothesis, and was looking for classical precedents. The *Letter* confirms the suspicion that he first came to locate it as a star 'in the eighth sphere' on the basis of simple, even naked eye observations. He was now sure it was a miraculous creation and a portent from God. Digges himself dated the *Alae*'s more detailed observations and appended paragraphs concerning the star to February 1573. During this short period, during which Digges discussed publication with Dee, we suggest that he shifted his position again, now entertaining the older man's idea that the star had moved from deep in the stellar sphere towards the earth. This meant that it might yet exhibit some position-fixing parallax, and Digges now yearned in vain to conduct a thorough programme of observations when leisure permitted. He still thought of it as a marvellous sign although, as the end of the world failed to occur, he may have moved towards the more naturalistic explanation afforded by Dee's hypothesis. Indeed, Digges added to the plausibility of that hypothesis with his 1576 assertion that stars existed at many distances from the Earth, some of them so distant as to be invisible, in a stationary sphere of infinite thickness. To our knowledge, Digges never explicitly concluded that the 'new star' had naturally moved from and returned to a distant place and invisibility. But later Copernicans, notably Digges's contemporary in London William Gilbert, were to build on his cosmology and observations of the star to buttress radical claims that stars and comets had much greater and much more freedom of motion in an infinite universe stripped of solid spheres.[73]

Digges was influential in England as its first campaigning Copernican, and its first astronomer with an international reputation, which rested on the *Alae*. Yet, while the rhetoric of the *Alae* presented heliocentrism as a very interesting hypothesis open to a parallactic method of proof or refutation, the *Letter* shows that Digges was persuaded of the Earth's annual motion even earlier than historians have previously realised. If we may be allowed a closing value judgement, it is a shame that the fledgling cosmologist who, more than Thomas Harriot, might have been 'the English Galileo', never found the time fully to extend his *alae mathematicae*.

Figure 1.

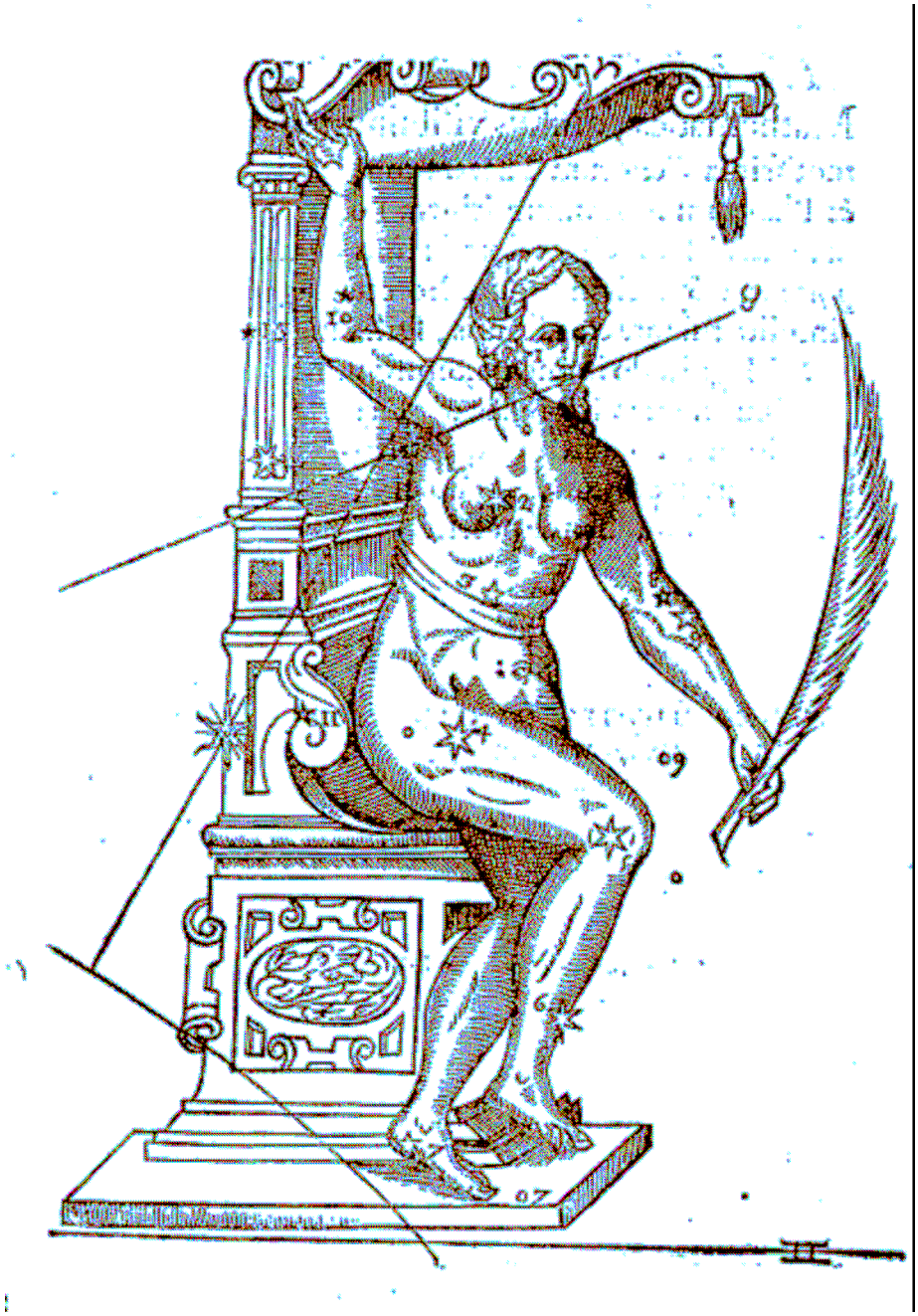
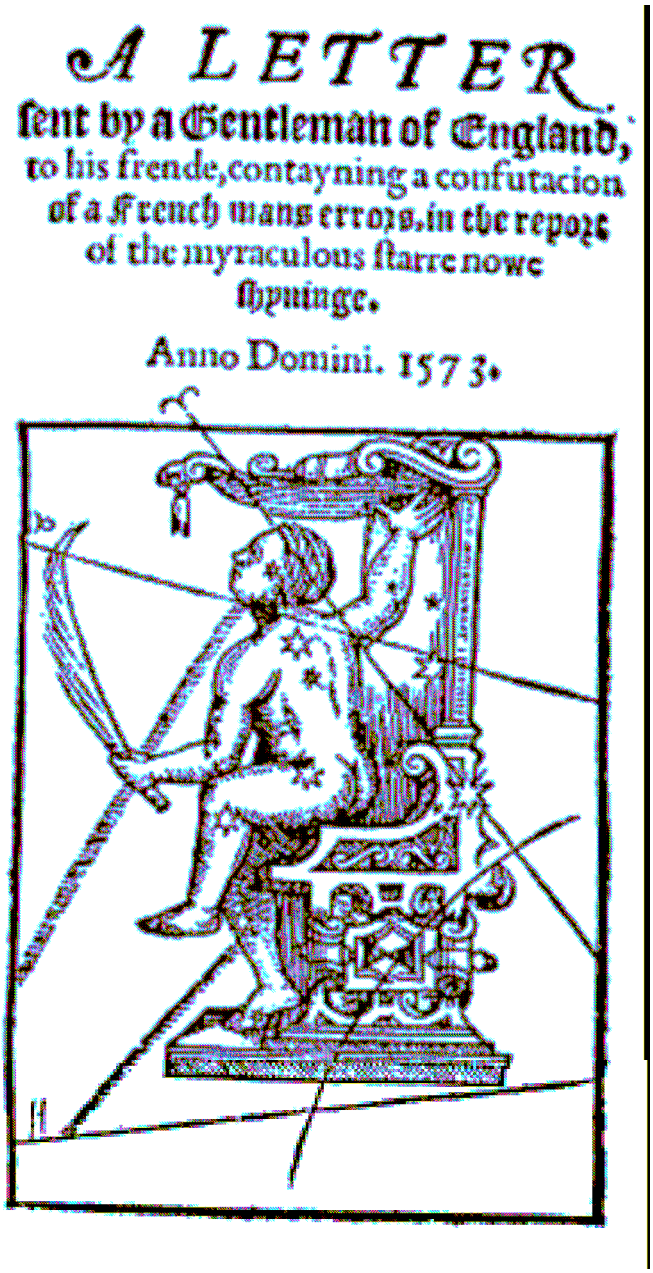


Diagram of the position of the constellation of Cassiopeia, showing the position of the new star in her seat, from Thomas Digges, *Alae seu scalae mathematicae* (Thomas Marsh: London, 1573), sig. A verso.

Figure 2.



A LETTER
sent by a Gentleman of England,
to his frende, contayning a confutacion
of a French mans errors, in the repoze
of the myraculous ſtarre nowe
ſhyninge.

Anno Domini. 1573.

Title page from Anon, *Letter sent by a Gentleman* (Thomas Marsh: London, 1573).

Notes:

We wish to thank Digges' biographer, Stephen Johnston of the Museum of the History of Science, University of Oxford for his helpful comments on an earlier draft, and Robert Goulding of the University of Notre Dame, Illinois, for communicating a pre-publication draft of his article on Digges *Alae* (op.cit (5).)

[1] See Anon., *A letter sent by a gentleman of England, to his frende, contayning a confutacion of a French mans errors, in the report of the myraculous starre nowe shyning*., London, 1573, 5. The evidence for Digges' authorship is presented in this article.
[2] D.W.E. Green, 'Astrometry of the 1572 Supernova (B Cassiopeiae)', *Astronomische Nachrichten* (2004), **325**, 689-701. The distance of the new star from κ Cassiopeiae ranged from Thaddeus Hajek's 1° 24' to Tycho Brahe's 1° 31'. In fact, it is Digges' value of 1° 28.5' that is the closest to modern computations of the supernova remnant.
[3] For the most complete collection of contemporary opinions on the new object, see Tycho Brahe, *Opera Omnia* (ed. J. Dreyer), Copenhagen, 1913-16, i-iii, *Astronomiae Instauratae Progymnasmatum*. For the most complete discussion in the secondary literature see D. Hellman, *The Comet of 1577: Its place in the history of astronomy,* New York, 1944. For a discussion which examines contemporary meanings of 'star' and 'comet' in this context see C. Methuen, ''This Comet or New Star': theology and the interpretation of the nova of 1572', *Perspectives on Science* (1997), **5**, 499-509.
[4] The history of post-Copernican astronomy normally discusses the annual parallax that heliocentrism predicted should be exhibited by the fixed stars as the earth orbited the Sun. Diurnal parallax, which is exhibited by heavenly bodies considerably closer, and irrespective of whether the Earth or heavens rotate daily, had been understood since the time of Hipparchus, but techniques were considerably advanced at this time, not least by Thomas Digges.
[5] R. Goulding, 'Wings (or Stairs) to the heavens: the parallactic treatises of John Dee and Thomas Digges', in *John Dee: Interdisciplinary studies in English Renaissance thought* (ed. S.Clucas), Dordrecht, 2006, 41-64.
[6] Computed by Roger Bacon, around 1266. See A. Van Helden, *Measuring the universe. Cosmic dimensions from Aristarchus to Halley*, Chicago, 1985. See especially 30-35.
[7] See the edition published by Thomas Digges of L. Digges, *A Prognostication Everlastinge of Right Good Effect*, London, 1576 edition, f.17v.
[8] It would be interesting to know more about Digges' influence on Tycho's programme. In an electronically published lecture Owen Gingerich has written:

> [Tycho] knew that in the Ptolemaic system, the epicycle of Mars always lay beyond the sun, whereas in the Copernican arrangement, Mars at its closest was only half that distance away. Because Tycho, like Copernicus and Ptolemy before him, accepted an erroneously small earth-sun distance (in fact, too small by a factor of 20), he believed that he had a chance to triangulate the distance to Mars using as his baseline the difference in viewpoint between an evening and a morning observation, the so-called diurnal parallax. We know today that this parallax is actually too tiny for naked-eye visibility, though if the solar distance had been as small as he believed, he could just have managed to detect it.
>
> Tycho's quest for the parallax of Mars was a driving factor during the golden years at his Uraniborg observatory, in the 1580s. At first, when he found no parallax, he believed that the Copernican arrangement had to be rejected since Mars seemed even at it closest approach to be farther than the sun. But he continued his assault on the problem

> and two years later discovered that he had to correct for differential refraction of the earth's atmosphere. As it subsequently worked out, his refraction table had an error exactly equal to the effect he was seeking, which led to a spurious result for the distance to Mars. Believing that he had proved that Mars came closer than the sun, he then declared against the Ptolemaic arrangement. Interestingly, however, he did not endorse the Copernican system, but rather, he adopted his own geo-heliocentric scheme [which he published in 1588].

See Owen Gingerich, 'Truth and Persuasion in Science', Section 3, 'Proof and Persuasion': http://www.st-edmunds.cam.ac.uk/cis/gingerich/index.html. Accessed: 30/6/2006.

[9] Thomas Digges, *Alae seu scalae mathematicae*, London, 1573, sig. A4v – sig. Br: 'non probabilis solummodo argumentis sed firmissimus fortasse Apodixibus'.

[10] Johannes Regiomontanus, *De cometae magnitudine, longitudineque ac de loco eius vero, problemata XVI*, Nuremberg, 1531.

[11] D. Hellman, 'The rôle of measurement in the downfall of a system: Some examples from sixteenth century comet and nova observations', *Vistas in Astronomy* (1967), **9**, 43-52. See 45.

[12] Goulding, op.cit (5), 45.

[13] Digges, op.cit. (9), sig. K3^{v}: 'Hac ratione plurimis noctibus animadverti Phaenomenon istud mirabile, in una apparere recta linea cum ea stellula quae in genu Cassiopeae, et altera quae in latere dextro Cephei sub Cingulo...' By contrast, in his *De Nova Stella* of 1573, Tycho gave an exact description of his method of diurnal parallax. For example, he observed the distance between the star and Schedir both when near the horizon and at the zenith, concluding that the distance was always 7° 55', to a claimed accuracy of 1'.

[14] Digges, op.cit. (9), sig. K3v: 'solo visu, absq: Instrumento ullo'.

[15] See note 36 below.

[16] National Archives (PRO) SP12/90/12. A record of his early observation, mentioned in the document, is unfortunately not extant.

[17] S. Johnston, 'Digges, Thomas (*c.*1546–1595)', *Oxford Dictionary of National Biography*, Oxford, 2004. [http://www.oxforddnb.com/view/article/7639]

[18] Digges, op.cit. (9), sig.A1r, -A2v.

[19] K. Tredwell, 'The Melanchthon circle's English epicycle,' *Centaurus* (2006), **48**, 23-31.

[20] Quoted in C. Methuen, 'The role of the heavens in the thought of Philip Melanchthon', *Journal of the History of Ideas* (1996), **57**, 385-403. See 393-4.

[21] 'si temporis brevitas & alia mea paterentur negotia. Sed violenter hoc tempore abductus sum, & vi quasi abstractus, ab his Caelestium contemplationibus, per nonnullas inferiores humanas causas: Ut Fortunae etiam bonis interea consulerem, adeoque coactus immutature librum claudere, & manu tollere de Tabula. …[p]osthac tamen compositis & superatis Mundanum rerum & Fortunae impedimentis: Rursum favente Deo ad placissimos nostros Mathematicos recurremus fontes.' Digges, op.cit. (9), sig. K4r-K4v.

[22] Digges presented the *Alae* to Burghley as a 'Monumentum', to Burghley's skill in mathematics and liberality because 'through your fruitful rays (like the rays of the Sun) you alone have made my mind, which was rather sterile, fertile again'. See Digges, op.cit. (9), sig. A4. R. Westman, 'Proof, poetics, and patronage: Copernicus's preface to *De Revolutionibus*,' in *Reappraisals of the Scientific Revolution* (ed., D. Lindberg and R. Westman), Cambridge, 1990, 167-206; For astronomy and patronage see M. Biagioli, *Galileo, Courtier: The Practice of Science in the Culture of Absolutism*, Chicago, 1991; V. Thoren, *The Lord of Uraniborg*, Cambridge, 1990.

[23] British Library Lansdowne, MS 19/30. Printed in *A Collection of Letters Illustrative of the Progress of Science in England* (ed. James Orchard Halliwell), London, 1841, 6-7.

[24] Thomas Digges, *Stratioticos*, London, 1579, 'Preface.'

[25] Digges, op.cit. (9), sig. A2[r]: 'Sed plura de huius stellae historia scribere non decrevi, quia eximius vir Iohannes Dee (quum in reliqua philosophia admirandus, tum harum scientiarum peritissimus, quem tanquam mihi Parentem alterum Mathematicum veneror...) hanc sibi tractandam assumpserit materiam [et]…. brevi prodeat, nihil dubito.'
[26] See Goulding, op.cit. (5), 52-53 and n.44.
[27] O. Gingerich, *An annotated census of Copernicus'* De Revolutionibus *(Nuremberg, 1543 and Basel, 1566)*, Leiden, 2002.
[28] Digges, op.cit. (9), sig. Aii.
[29] Lambeth Palace library classmark (ZZ)1572.1.04, hereafter *Letter*. It is also reproduced in *Early English Books Online*, stable url: http://gateway.proquest.com/openurl?ctx_ver=Z39.88-2003&res_id=xri:eebo&rft_id=xri:eebo:image:26242
[30] It is reversed, although this is not necessarily a printer's error. The reversed view of constellations became common on celestial globes, where the observer was looking into the celestial globe from the outside. The point is made in P. Whitfield, *The mapping of the heavens*, London, 1995.
[31] Given the lack of pagination and the short length, we refer to sig. A.iii as page 1, and the subsequent pages as pp. 2-10.
[32] *1 Tim.* 4:1-2 (King James Bible). The Vulgate has 'loquentium mendacium'.
[33] R. Hooykaas, 'Thomas Digges' Puritanism.' *Archives Internationale d'Histoire des Sciences* (1955), **8**, 145-159.
[34] If Misopseudologos was Digges, then Philomathes may have been an actual enquirer, such as Burghley. Equally, Philomathes may have been a conceit to legitimate Digges' publication of his opinion.
[35] *Letter*, op.cit. (29), 1.
[36] The full title of the French text that we propose as the original is *La déclaration d'un comète ou estoille prodigieuse , laquelle a commencé à nous apparaistre à Paris en la partie septentrionale du ciel au mois de Novembre dernier en l'an présent 1572 et se monstre encore aujourd'hui.Avecques un Discours des principaux effets des Comètes tant en français qu'en vers latins, extraicte des plus notables Autheurs qui en ont escrit , Avec textes de Manilius et de Pontanus*. Ten years later, in his *Histoires Prodigieuses*, Roderic Hoyer identified I.G.D.V. as Jean Gosselin de Vire (1510?-1604), a royal librarian under Henri III. See Jacques Halbronn, « Catalogue Alphabetique des Textes Astrologiques (C.A.T.A.F.) », http://cura.free.fr/docum/10catEK.html. Accessed: 30/6/2006.
We await an opportunity to inspect the sole extant copy of Gosselin's original pamphlet but, as we say above, it is Digges's response that is important.
[37] *Letter*, op.cit. (29), 8
[38] *Letter,* op.cit. (29), 1.
[39] L. and T. Digges, *A Prognostication Everlasting of Right Good Effect,* London, 1576, *The Addition. A Short Discourse Touchinge the Variation of the Compasse*.
[40] Absurdly, the author found the 'greatest [diurnal] Parallaxe above the Pole, and his lesser underneath', which was impossible. *Letter*, op.cit. (29), 5
[41] *Letter,* op.cit. (29), 10.
[42] *Letter,* op.cit. (29), 6.
[43] Goulding, op.cit. (5), 49.
[44] Digges, *A Prognostication Everlasting* op.cit. (39), fol.17v.
[45] Antonius de Matulind (tr. Fredericke von Brunswicke), *Right Excellent Treatise of Astronomy with a Prognostication,* London, 1556; John Feild, *Ephemeris anni. 1557. currentis iuxta Copernici et Reinhaldi canones fideliter per Ioannem Feild Anglum, supputata ac examinata ad meredianum Londinensem qui occidentalior esse indicatur a Reinhaldo quam sit Regij Montis, per horam. 1. Scr. 50. Adiecta est etiam breuis quaedam epistola Ioannis Dee, qua vulgares istos*

ephemeridum fictores merito reprehendit. Tabella denìq[ue], pro coelesti themate erigendo iuxta modum vulgariter rationalem dictum, per eundem Ioannem Feild confecta, Londinensis poli altitundini inseruiens exactissime, London, 1556.

[46] M. Palingenius, *Marcelli Palingenii Stellati poetæ doctissimi Zodiacus vitæ, hoc est, De hominis vita, studio, ac noribus optime instituendis, libri XII cum indice locupletissimo*, London, 1569. See also G. C. Moore-Smith, *Gabriel Harvey's Marginalia*, Stratford-upon-Avon, 1913, 161.

[47] See Thomas Digges' famous diagram, first published in the reprint of *The Prognostication* op.cit. (39), sig. M1. It precedes *A Perfit Description of the Caelestiall Orbs*. See also 'Marcellus Palingenius Stellatus', in *As the World Turned: A Reader on the Progress of the Heliocentric Argument from Copernicus to Galileo*. http://math.dartmouth.edu/~matc/Readers/renaissance.astro/4.0.Palingenius.html. Accessed 24/02/2006.

[48] T. Digges, op.cit. (39), sigs M1-M2.

[49] M. Palingenius, *The firste thre bokes of the most christia[n] poet Marcellus Palingenius, called the Zodyake of lyfe: newly translated out of latin into English by Barnabe Googe,* London, 1560.

[50] *Letter*, op.cit. (29), 10.

[51] Digges, op.cit. (9), sig. Aiiii.

[52] T. Digges, *Pantometria,* London, 1571*, "Preface to the reader*".

[53] Gingerich, op.cit. (27), 215. Digges' copy was the 1566 edition and among his few annotations were numbers added to the Cassiopeia star catalogue.

[54] *Letter*, op.cit (29), 1.

[55] *Letter,* op.cit (29), 3-4.

[56] *Letter*, op.cit (29), 4.

[57] Alrucuba (although an Arabic name sometimes used for a star in Cancer) was presumably a typographical error for Alrucaba, the Arabic name used in the *Alphonsine Tables* and later works for the Pole Star. See *Letter*, op.cit (29), 5.

Digges' final criticism was unfair. Digges denied that the Frenchman could have seen the star on 15th November, 1572, when others like him could not see it even on 16th November. However, we noted Tycho's report that he first saw it on 11th November.

[58]. *Letter*, op.cit (29), 5.

[59] *Letter,* op.cit (29), 8.

[60] *Letter,* op.cit (29), 10.

[61] *Letter*, op.cit (29), 2.

[62] Digges, op.cit (7), 'A Perfit Description', sig M, 'To the Reader'.

[63] Digges, op.cit (7), sig M1.

[64] Digges, op.cit (7), sig M3,

[65] Goulding, op.cit (5), 59.

[66] Mathematicians were, of course, at the cutting edge of calendar reform. Copernicus' *De Revolutionibus* itself had been occasioned by it. Pope Gregory XIII's calendar was introduced in 1582, though not adopted in England for another 170 years. Indeed, in 1583 John Dee was commissioned to develop an English calendar that was both reformed and Reformed, and Digges was one of the experts who assembled in Oxford to consider Dee's proposals. See M. Feingold, *The mathematicians' apprenticeship*, Cambridge, 1984, 130.

[67] Although we conclude below that this issue is not relevant, it has misled historians. For example, William Gilbert is widely said to have been made Elizabeth I's royal physician in 1600. The warrant is dated February 1600, but using the old style. He was therefore appointed in 1601, after the publication of his *De Magnete*.

[68] W. Edgerton, 'The calendar year in sixteenth-century printing', *Journal of English and Germanic Philology* (1960), **59**, 439-449.

[69] See *A Transcript of the Registers of the Company of Stationers of London, 1554-1640 A.D.* (ed. E. Arber), 5 vols, Privately printed, 1875-94. Many of the 'learned' titles we inspected in volumes 1 and 2 of the *Registers* were of foreign works with aspirants to translate them. The process of translation involved a delay of more than a year between registration and appearance in print. By no means all made it to the press.

[70] We thank Stephen Johnston for this point, made in a private communication.

[71] *Letter,* op.cit. (29), 4.

[72]M. Palingenius, *The firste thre bokes of the most christia[n] poet Marcellus Palingenius, called the Zodyake of lyfe*, London, 1565, 'Aquarius'.

[73] William Gilbert, *De Mundo Nostro Sublunari Philosophia Nova*, Amsterdam, 1651, Lib. II, Cap. X, 'Quod motus globorum sit ab ipsis globis non a sphaeris'. See p. 155:
'Nostri saeculi caudati quidam supra Lunam evecti.... Cassiopeiae admirabilis et prodigiosa stella magnis intervallis in Aristotelicum coelum evecta est, testibus nobilissimo Tychone Brahe peritissimo et indefesso Mathematico, Michaele Maestlin doctissimo, Thoma Diggessio [sic] et Johanne Dee Anglis...'