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Costellazione Manga: Explaining Astronomy Using Japanese Comics and Animation

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Comics and animation are intensely engaging and can be successfully used to communicate science to the public. They appear to stimulate many aspects of the learning process and can help with the development of links between ideas. Given these pedagogical premises, we conducted a project called Costellazione Manga, in which we considered astronomical concepts present in several manga and anime (Japanese comics and animations) and highlighted the physics behind them. These references to astronomy allowed us to introduce interesting topics of modern astrophysics and communicate astronomy-related concepts to a large spectrum of people. In this paper, we describe the methodology and techniques that we developed and discuss the results of our project. Depending on the comic or anime considered, we can introduce general topics such as the difference between stars, planets and galaxies or ideas such as the possibility of finding life on other planets, the latest discoveries of Earth-like planets orbiting other stars or the detection of complex organic molecules in the interstellar space. When presenting the night sky and the shapes of constellations, we can also describe how the same stars are perceived and grouped by different cultures. The project outcomes indicate that Costellazione Manga is a powerful tool to popularise astronomy and stimulate important aspects of learning development, such as curiosity and critical thinking. We show through our experience that Costellazione Manga has attracted a broader and more diverse public than traditional planetarium activities and astronomy lectures.

Introduction: The Role of Comics and Animation in Education

Walt Disney argued that animation is a flexible and stimulating tool that is well suited for the purposes of explaining and teaching, provided that an educator knows how to use it (Disney, 1948). Although it may seem unusual to make use of fantasy characters to popularise astronomy or other general science subjects, such use is in fact a long-standing practice that started in America in the early 1940s. During World War II, Disney started to produce many animated films aimed at popularising the practical and technical aspects of war, for example the workings of US aviation. These movies were followed by many others that promoted everyday topics such as the importance of good nutrition or good hygiene for disease prevention. Other films, based on the scientific knowledge of the time, described human anatomy and behaviour, including *Reason and Emotion* (1943), a precursor of sorts to the recent Pixar movie *Inside Out*.

We also find examples of the use of cartoons in education and learning in Japan.

One of the most famous authors currently is Leiji Matsumoto, creator of several comics and animated series such as *Galaxy Express 999*, *Captain Harlock*, *Queen Millennia* and *Space Battleship Yamato* (also known as *Star Blazers*). Some of the characters and plot lines of these sagas were reused and adapted into shows to be projected inside a planetarium. Leiji Matsumoto himself is active in popularising astronomy and in collaborating with universities and magazines to create special lectures and outreach conferences (Murakami, 1997).

Unfortunately, in some countries (including our own country, Italy), comics and animation have traditionally been seen as a lower type of art, mostly aimed at young individuals, and they are not considered worthy of the interest of adults or professionals. However, the market for comics and animation is changing and has expanded to include many authorial works and translations of world-known classics. Italy, France and Germany are the three largest markets for manga in Europe (Bouissou et al., 2010). An encouraging sign of change is that at the beginning of 2017, the magazine

Le Scienze (the Italian edition of *Scientific American*) started to print a series of comics made for outreach purposes that include several works originally published in Europe, Japan and the USA. The topics of these comics range from astronomy, physics and biology to computer science and mathematics.

Effectiveness of Comics and Animation in Education

Several fantasy and science fiction comics and anime contain references to physics and astronomy. Most of these references are not fully explained but instead used as plot devices; other times, they are just embellishments. Following the path already proposed by Walt Disney and the example given by Leiji Matsumoto, we set out to create a planetarium show and other activities that would delve further into the science alluded to in our favourite manga and address the questions that arose from them. These questions not only act as a starting point to generate curiosity about astronomy but also ignite a passion for asking questions and looking for



Figure 1. Front of the flyer for the first edition of *Costellazione Manga*, held in 2011 in Ravenna, Italy. The subtitle may be translated as “Stars in Japanese comics and animation”. Credit: D. Dall’Olio

answers, thereby connecting the pleasure of reading science fiction to the process of discovery. In the following sections, we describe some of the pedagogical premises on which our project is based.

Many formal and complex concepts can be easily transmitted to the public with the help of cartoons and comic books that support the learning process (Tatalovic et al., 2009; Hosler & Boomer, 2011). Using references from comics and animation is a way to reduce formality and break the wall between scientists and the public. Such an approach includes most of the “dimensions of change” that identify modern and effective science communication¹: storytelling, humour, artistic expression, science as part of everyday life and emotion (since adults from the general public probably have childhood memories of several of the series). Moreover, it has been shown that learning is deeply connected to previously acquired knowledge: students connect the new things they learn to what they already know, and the same happens for the general public when they learn new things (Hemminki et al., 2013).

There are two possible approaches to using comics and animation for teaching purposes. One follows in the footsteps of Disney’s seminal work and includes works produced with the main purpose of explaining a subject. Historical examples are Bruno Bozzetto’s prize-winning animations for the Italian science outreach TV programme *Quark*. Sweden also has a tradition of animated documentaries. A number of comics dealing with many varied fields are nowadays on the market and

under production to satisfy the curiosity of the public. The second approach takes an opposite stance, where no new material is produced but what people have already seen and is already part of their backgrounds is instead built upon. The main examples of this approach are L. Krauss’s book *The Physics of Star Trek*, J. Kakalios’s book *The Physics of Superheroes* (more pertaining to comics and animation) and T. Handa’s book on understanding astronomy *Space Battleship Yamato 2199*. These books take something most people know, at least superficially (in *Star Trek*, spaceships travel faster than light; Superman flies; etc.), to introduce a topic and discuss the underlying science (Why is the speed of light a limit? What is gravity?). Since this approach builds on pre-existing knowledge, by choosing the right cultural reference, it can directly hook people’s emotions and memories. Our project *Costellazione Manga*² follows this latter approach and, in the next sections, we will give an account of how and why it works.

The Birth of Costellazione Manga

Japanese animation started to be imported to Europe at the end of the 1970s. In Italy, the breakthrough happened in 1978, when the national TV broadcaster RAI imported the anime *UFO Robot Grendizer* (localised as *UFO Robot Goldrake* and also known in several other countries as *Goldorak*, from the French adaptation). *Grendizer* — a show so different from the Italian production, Disney and Hanna-Barbera styles and even from the European/Japanese co-productions of the time³ — was met

with huge success. New songs for the opening and closing titles, written by some of the best Italian composers of the time, probably contributed to the success: their disc sold more than one million copies. *Grendizer* even had an impact on the older generations, not least because of the controversies that arose when it was first aired (Nicora, 2017; Montosi, 2007).

A combination of the liberalisation of TV broadcasting and availability of cheap imports made Japanese animation the dominant form of children’s entertainment throughout the 1980s and 1990s, with non-Japanese animation soon becoming the minority. This created a shared system of imagery and cultural references for at least one generation, whose members are now in their thirties and forties, although the most popular shows are known by younger and older generations, too (Pellitteri, 2018). It is on these shared cultural references that we based the development of our planetarium shows, seminars and nightly observations.

The *Costellazione Manga* (Manga Constellation in English) adventure started in October 2011 (Figure 1), during the 9th Edition of “Japanese October”, a cultural event organised by the Association for Cultural Exchanges between Italy and Japan (ASCIG) in Ravenna, Italy. In the initial stages of the project, the authors collaborated with and benefited from the expertise of Marco del Bene, the President of the ASCIG and associate professor at the Department of Oriental Studies, La Sapienza University in Rome, and Alessandro Montosi, a freelance writer and expert on Japanese animation and its impact in Italy. Since the first conference, hosted by the Planetarium of Ravenna (Figure 2), we have been collecting ideas and materials from several manga and anime (Dall’Olio, 2015), considering both works that are famous worldwide and the more avant-garde ones. The proposed stories are often pure fantasy or science fiction. From these, we built an outreach show that aims to take the public through an unusual universe: not just an imaginary and fictional travel across the bizarre and funny adventures narrated in manga and anime but also an astrophysical journey exploring the starry sky.

Costellazione Manga: How to Build a Space Journey through Manga and Anime

In this section, we will describe the methodology that we used to create one of the Costellazione Manga shows. We will provide some examples of the manga and anime used, tips on how to use astronomy-related references and descriptions of how we develop them during the show.

Methodology

All the planetarium shows, seminars and activities related to Costellazione Manga have been offered as educational activities. The Planetarium of Ravenna has a Zeiss ZKP 2 analogue projector that is able to project more than 3000 stars in the two hemispheres and seat 60 people inside the dome (Figure 2). In general, the show is organised as a space journey across the starry sky, starting with a brief introduction to basic astronomical concepts and then simulating the sunset and the lighting up of the first evening stars. This introduction is needed to give first-time visitors the opportunity to understand how the planetarium works. Moreover, having time to let the eyes adjust to the darkness is useful for everyone. After the introduction, we recall the plot of the first manga or anime in our schedule and then start to highlight the astronomy-related references and peculiarities. We organise a guided tour between constellations and objects in order to cover



Figure 2. The Planetarium of Ravenna, Italy, in 2017. Left panel: The Zeiss analogue planetarium inside its dome. Right panel: Entrance to the planetarium building, showing the dome and the sundial panel. Credit: M. Garoni

several parts of the starry sky visible at that time of the year and connected to specific anime or manga. The maximum duration of a show is 60 minutes, so we typically touch on three anime/manga. Since these comics are so popular, the audience immediately recognises them and we need only a few minutes to describe the parts of the plot with astronomy-related references. Finally, we summarise what we have talked about and then leave time for questions.

A sample script can be found in Table 1.

When conducting activities outside the planetarium dome, such as seminars and lectures, we prepare slides with sky charts to show the constellations and the position of various objects in the sky instead of

using the dome-projected sky. The number of anime/manga used can be varied at the request of the seminar or lecture organiser, and we can also offer games, riddles and quizzes to generate a buzz. These devices also help the audience remember concepts, develop critical thinking and build links between topics.

When we organise night excursions, we use nothing but telescopes and a laser pointer to show the location of the object in the sky. In this case, the comics selection depends on the season, as some constellations or objects may only be visible at certain times of the year.

For both seminars and night excursions, the format can remain similar to that of the planetarium show or it can be modified on the basis of specific requests. For example, if the night excursion is organised in a nature reserve, we usually alternate the observations of the sky with other sensorial activities such as listening to the calls of night birds or smelling the scent of night flowers or other plants. At the end of the activities, we always leave time for questions and feedback (oral or written anonymous feedback).

Examples of Manga and Anime Used in Costellazione Manga

Galaxy Express 999: A Variety of Extra-Solar Planets

Leiji Matsumoto's *Galaxy Express 999* (Figure 3) tells of a future in which Earth has changed. Wealthy people live in mechanical bodies capable of surviving

| Example script of a planetarium show | Duration (minutes) |
|--|--------------------|
| Introduction. | 5 |
| Manga/anime 1 (e.g., <i>UFO Robot Grendizer</i>): description. | 5 |
| Astronomical references in <i>Grendizer</i> : Vega, M57 (Ring nebula), difference between planetary nebula and planetary system. | 10 |
| Manga/anime 2 (e.g., <i>Galaxy Express 999</i>): description. | 5 |
| Astronomical references in <i>Galaxy Express 999</i> : feasibility of space travel, comparison between artist impressions and real images. | 10 |
| Manga/anime 3 (e.g., <i>Saint Seiya</i>): description. | 5 |
| Astronomical references in <i>Saint Seiya</i> : constellations, objects inside the constellations. | 10 |
| Conclusions and questions. Feedback. | 10 |

Table 1. Sample script.



Figure 3. The cover of the Japanese edition of *Galaxy Express 999*, by Leiji Matsumoto. We see the two protagonists and Andromeda galaxy, the final destination of the fictional train. Credit: Leiji Matsumoto

for hundreds of years, immune to diseases and ailments. Poor people face the most abject conditions. It is rumoured that in a distant planet in the Andromeda Galaxy, a mechanical body can be obtained for free. However, finding the money for a ticket to get there is a problem. The ticket is for the *Galaxy Express 999* intergalactic train. This is how the adventure begins for the two protagonists, the young Tetsuro and his mysterious guide Maetel, who travel to unknown and bizarre planets and stars. On this journey, we do not have precise astronomy-related references as Matsumoto invents almost all the saga's astronomical places, apart from the Andromeda galaxy and the Solar System. This comic gives us the chance to talk about observations of other planetary systems and the possibility of finding rocky planets, water and other molecules. We can also discuss the recent discoveries of Earth-like planets that orbit low-mass stars and how they can shed new light on the origin and evolution of planetary systems with more than two or three bodies (Gillon et al., 2017).

In *Galaxy Express 999* we find several images of the planet Mars. The images taken from the comic can be compared with real images observed by the satellites in orbit around Mars or by the robots on its surface. Thanks to this comparison, we can highlight the differences and the

similarities between the artistic impressions and real scientific images, which stimulates the learning process. Quizzes can also help: for example, we show several pictures of Mars and of the Atacama Desert on Earth, and we ask the audience to figure out which pictures are from Mars and which are from Earth and why they think so. Thanks to the recent discovery of water on Mars (Orosei et al., 2018), another possible topic is the history of water in our Solar System, from the chemical processes involved in the protostellar cloud to the presence of water on the planets. Moreover, since *Galaxy Express 999* features intergalactic travel on board a train, we usually discuss the feasibility of space travel, showing the difficulties of building a spaceship and the challenges that engineers face.

2001 Nights: A Realistic View of Space Travel

Written and drawn by Yukinobu Hoshino, *2001 Nights* (Figure 4) is an anthology, with the first three issues published between 1984 and 1986 and the last one in 2006. Unlike most other comics mentioned in this paper, its main characters are neither heroes nor villains but just representatives of humanity. In a number of short stories, 400 years of space exploration and evolution by human beings are narrated. Stories cover a range of advancements, from the first steps in space to a possible future colonisation of the Universe. Topics include fear, dreams and awareness of the solitude and fragility of human presence in space. Space exploration is analysed from both a physical and psychological point of view. The comic has a lot in common with science fiction films and books, with some atmospheres and settings closely resembling those of Arthur C. Clarke and Stanley Kubrick's *2001: A Space Odyssey*; other references include *Matrix* and *Avatar*. The title of the comic itself is not only a reference to Kubrick's masterpiece but also to the *One Thousand and One Nights* collection of tales, with which the comic shares the narrative structure. In *2001 Nights*, the Universe is perceived as slow: no fast chases, no spaceships rushing in battle, but a slow and difficult quest. It may even happen that after 400 years in the cosmos, humans realise they are not cut out for life in space after all. Despite having founded colonies and having many more worlds to explore, humans feel homesick and decide

to go back to Earth. This manga can give us the chance to discuss the topic of space travel in a more realistic way than the previous example of *Galaxy Express 999* does. We can discuss the history of space exploration and talk about the recent successes of aeronautics, such as the Space X program. Moreover, we can illustrate the discoveries made thanks to probes and satellites launched to reach planets and other objects in our Solar System, such as *Juno*, *Rosetta*, *New Horizons* and *Cassini*.

We are still in the early phase of space exploration, which is mostly conducted using robotic probes. In the show, we use the example of the *Voyager 1* probe to show how difficult it is to programme a space mission and how long a satellite has to travel to reach other planets or the edge of our Solar System. Indeed, at several times during the last decade, we have had updates on the status of the *Voyager 1* probe, which is thought to have reached the heliopause (the point where the solar wind meets the interstellar medium). Forty years since its launch, it has travelled 120 au⁴, making it the human-made object that has gone the farthest from Earth; it has gone beyond the heliosphere and is now travelling towards the Oort Cloud. However, for it to exit the Solar System, it has to travel another 100 000 au, which will take more than 30 000 years⁵. This probe is also



Figure 4. Cover of the Italian edition of *2001 Nights* by Yukinobu Hoshino, published by Flashbook. A hard science fiction work describing the human venture of exploring space. Credit: Y. Hoshino

mentioned at the beginning of the manga in a very realistic sequence that illustrates the famous plaque that carries images of two humans and the Solar System. In one of Hoshino's stories set in the far future, technical developments allow faster-than-light travel, and humans reach *Voyager 1* to recover it.

This manga can also be used to introduce the topic of international collaborations under the common objectives of sustainable development and wellness for everyone. It is important to make the public aware that people of different cultures and nationalities can fruitfully work together in science, especially for the younger generations. Both in reality and in Hoshino's work, humanity is aware of its limits but wants to overcome them in a continuous quest for knowledge and growth. With this spirit, astronomy can help to create a better society by promoting peace and collaborations and making people aware that we are living under the same sky and that our planet is a small blue dot in a very big Universe.

Hokuto No Ken: Asterisms, Constellations, and the Traditional Chinese–Japanese Sky

Fist of the North Star (Hokuto no Ken) is a saga by Buronson and Tetsuo Hara (Figure 5). The plot starts with a nuclear war that has destroyed the planet and left humanity confined in small groups fighting each other for the small supply of remaining food and water. The main character, Ken, is the master of a deadly martial art called Hokuto Shinken. Opposing him are many members of the Hokuto and Nanto schools of martial arts. Both schools take their names from asterisms of the Chinese/Japanese sky: while Hokuto corresponds to the Big Dipper, known in Japan as Hokuto shichi sei (meaning “seven stars of the North”), Nanto is a group of six stars in Sagittarius whose shape is a mirrored image of the Big Dipper and that is part of a larger asterism known as the Teapot (Hokuto and Nanto literally mean “north star” and “south star”, respectively, although the character used for “star” in both words may also mean “asterism”). On Ken's chest is a scar resembling the stars of Hokuto and, for this reason, he has the nickname of “seven-star man”.

The purpose of the Hokuto school of martial arts is to guarantee peace, and Ken



Figure 5. The cover of the Japanese manga *Hokuto no Ken*, by Buronson and T. Hara. The scars shaped as the seven stars of Hokuto are visible on Ken's chest. Credit: Buronson-Hara

is forced into a long struggle to be able to finally bring peace into this dystopian world. During his trip, Ken has to fight against other martial arts masters, risking his life several times. While the manga has many references to Bruce Lee's films and the *Mad Max* saga, the plot dates back to an old Japanese legend that tells the story of seven brothers involved in a war

against each other in order to conquer the entire country. Only the youngest of them succeeds in stopping the war and bringing peace to his brothers in heaven, where they become the seven stars of the Big Dipper.

The above references allow us to explain that the word constellation has a much more precise meaning than the word “asterism”, because a constellation identifies not only the stars but also an area of sky whose boundaries are fixed by the International Astronomical Union (IAU) (Figure 6). We discuss what a constellation is, how they came about in history and the role of the IAU in standardising them. An important idea that we try to explain is that while the official constellations of the Northern sky come from Western tradition with roots in ancient Greece and Babylonia, all cultures have their own ways of looking at the sky. Within a constellation, we can find one or more asterisms. Asterisms are sometimes easier to observe and are well known traditionally. The most striking example in the northern hemisphere is the Big Dipper within the constellation of Ursa Major. In the same patch of the sky, the stars can be arranged in the constellation of Sagittarius, in the asterism of Nanto or in the asterism of the Teapot (Figure 6, right panel). There are also interesting astronomical objects in Ursa Major, such as the binary system consisting of the stars Alcor and Mizar.

On the basis of the comparison between Hokuto and Nanto, another possibility is

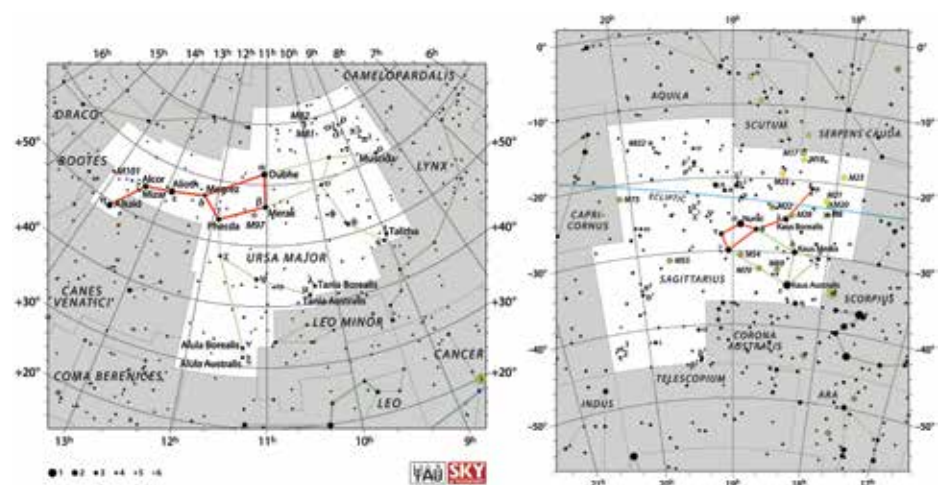


Figure 6. Charts of the Ursa Major and Sagittarius constellations. The asterisms of Hokuto (in Ursa Major, left panel) and Nanto (in Sagittarius, right panel) from the traditional Japanese sky have been highlighted in red. While Hokuto corresponds to the Big Dipper, Nanto is a part of an asterism known as the Teapot (shown in green) and looks like a rotated version of Hokuto. Credit: IAU and Sky & Telescope

to describe the Sagittarius constellation where besides Nanto, we find the galactic centre. Looking in that direction, we observe the central areas of the Milky Way, rich in stars and clouds of dust and gas where many new stars are formed.

Inside Ursa Major, there is the well-known asterism of the Big Dipper. In the planetarium, we can point to the stars composing the constellation. We can describe how in different cultures, these stars are grouped under different shapes. For example, in the USA and Iran, the seven stars are seen as a sort of big ladle; in Italy, Germany, Sweden and Spain they form a chariot; in France they are a big pot; and in the UK, they are a plough. Talking about asterisms provides the opportunity to connect the history of some populations with their mythology and traditions. Macro asterisms, which include stars belonging to several constellations, can be shown to illustrate nearby stars, for example, the Summer Triangle that groups Vega (α Lyrae), Deneb (α Cygni) and Altair (α Aquilae).

The presence of Alcor and Mizar in Ursa Major also allows us to explain how the stars are seen as projected onto the celestial sphere and how some stars appear close to each other only because of the effect of perspective, while other stars are physically near. In the case of Alcor and Mizar, they were born together from the same protostellar cloud and, like twins, they are similar but not exactly identical.

Talking about the galactic centre is a good way in to describe how a star is born and how a planetary system is eventually created. For example, we start by describing the star formation processes and discuss how star-forming regions are initially surrounded by a thick cloud, like a fog that prevents us from seeing anything. Over time, the cloud starts to fragment and the gas begins to collapse under the action of gravitational attraction. Dust and gas arrange themselves in a disc surrounding the protostar; their fate is to be either accreted or ejected away by violent jets. The young star begins to form, and the light of a new overwhelming dawn emanates from the dark cloud. Planetesimals are continuously formed in the disc through the collision of small dust grains (Andrews et al., 2016). This is probably the most important stage in the origin of life. With modern instruments such as The Atacama Large

Millimeter/submillimeter Array (ALMA), it is possible to identify complex organic molecules in star-forming regions (Fayolle et al., 2017; Jørgensen et al., 2012). Molecules such as glycolaldehyde, organohalogens and acetic acid are considered as the building blocks of life, and their detection can help answer several questions about the origin of life and evolution in space.

UFO Robot Grendizer: Difference between Stars, Planets and Planetary Nebulae

One of the first animes introduced in Europe and America during the 1970s was *UFO Robot Grendizer*, created by Go Nagai and Toei Animation (Figure 7). *UFO Robot Grendizer* tells the story of Duke Fleed and his friends, who with the aid of the giant robot Grendizer, try and stop the invasion of Earth by evil aliens. Coming from the Vega system and ruled by King Vega, the aliens want to exploit Earth and all its precious resources, slaughtering the human race in the process. Duke Fleed and Grendizer are also aliens from the planet Fleed, which was previously attacked and destroyed by the evil Vega troops. Miraculously escaping, Duke Fleed manages to land on Earth and organise a resistance.

In the Italian and French versions, the series was dubbed and the main characters were named differently from those

in the original Japanese (Montosi, 2007). While the original names were common Japanese names, the new ones were deeply connected to astronomical objects such as the stars Alcor, Mizar and Rigel and the planet Venus.

There are countless astronomy-related curiosities about this saga. For instance, Vega is of great importance in astronomy since it has long been used to calibrate observational instruments and as a reference for measuring the magnitude of stars. It is used as the zero point of the Johnson-Morgan photometric system. In the *Grendizer* saga, Duke Fleed's native planet belongs to the Vega system; we start from this to describe the elements that have been observed in this system to suggest the presence of a planetary system around Vega. One of these elements is a disc of dust, extending around 100 au, very similar to what is expected from an equivalent of a Kuiper belt (Su et al., 2005). Further investigations have shown the presence of condensations of material in the disc. This fact has led some researchers to assume the presence of giant planets, probably similar to Jupiter or Neptune, although they have not yet been directly observed and their presence is currently regarded as unlikely, at least in the inner few au of the system (Wilner et al., 2002; Piétu et al., 2011; Mennesson et al., 2011).



Figure 7. Cover of the Italian edition of the anime *UFO Robot Grendizer* published by Yamato Video. The powerful robot Grendizer, Koji Kabuto and the evil King Vega are depicted in the cover. Credit: Go Nagai, Toei Animation

In the constellation of Lyra we find the famous Ring Nebula (M57), a spectacular planetary nebula. M57 is a very good example to explain the difference between planetary nebulae and planetary systems. A planetary nebula is the final product of the life of a Sun-like star (from 0.8 to four times the mass of the Sun) that, at the end of its evolution, expels its outer layers in a series of explosions. The ejected gas forms a cloud of material around the parent star, which expands at great speed and generates a planetary nebula. The star continues its evolution as a white dwarf in the centre of the cloud, which diffuses incoming radiation. At this point, it is easy to understand that if there was a planetary system, it must have been destroyed much earlier than the planetary nebula phase.

Saint Seiya: Prominent Constellations of the Northern Hemisphere, the Zodiac and the Objects they Contain

Sagittarius and the other constellations of the zodiac are featured in *Saint Seiya* by Masami Kurumada (Figure 8). Five of the main characters in *Saint Seiya* are a group of knights (called “Saints”), valiant warriors who are faithful to the goddess Athena, protector of humanity. They fight against the dark forces that threaten Earth. Each character is linked to a constellation of the boreal or austral sky through the armour that they wear. The knights who wear armour representing zodiacal signs are the most powerful, although some of them are corrupt. The main heroes wear the less-powerful armour of the constellations Cygnus, Andromeda, Draco, Phoenix and Pegasus, and the plot follows their quest in fighting villain knights and becoming more powerful. Their fighting techniques are in some cases connected to the mythological and astronomical objects in these constellations. One example is that of the Andromeda knight. His armour has a chain that during the fight, may be disposed around the hero in a spiral shape resembling that of the Andromeda galaxy. *Saint Seiya* also has ties to Chinese traditions and Taoism. For example, heroes fight evil by widening their perceptions through the use of “the cosmos”, a seventh sense that enables them to gain knowledge of their own possibilities and to increase their strength. Using this comic, we can illustrate some peculiarities about these constellations.



Figure 8. Cover of the Italian edition of the anime *Saint Seiya*, published by Yamato Video. Seiya is wearing his armour connected with the constellation of Pegasus, which is visible in the background. Credit: Masami Kurumada, Toei Animation

We usually start by pointing to all of the relevant constellations in the dome and connecting them with the heroes of the manga. We then proceed by showing the constellation shapes and brightest stars and by giving further astronomical details. For example, the Cygnus constellation is also known as the North Cross, as opposed to the more famous Southern Cross. The reference to the North often recurs in the comic, since the knight of Cygnus has his power connected to ice and snow. The brightest star in Cygnus, Deneb, marks the swan's tail; its name comes from Dhanab, which in Arabic means tail. Albireo is the star that marks the head; it is a double system like the aforementioned Alcor and Mizar. Close to Albireo, we find a famous and quite different source: Cygnus X-1, one of the first X-ray sources to ever be discovered (Bowyer et al., 1965). Cygnus X-1 is a binary system where the X-ray emission is due to the phenomenon of stellar cannibalism. During its evolution, one of the two components has become a black hole and is slowly eating its sister. The pulled material is attracted by the black hole and it arranges itself in an accretion disc surrounded by a hot corona. The material in the disc is compressed and heated, and it emits radiation whose energy is subsequently increased by the corona. It is this

high-energy radiation that we observe in the form of X-rays (Webster et al., 1972; Young et al., 2001).

Another example is the constellation of Andromeda, which houses one of the most famous and beautiful objects of the northern hemisphere: the Andromeda galaxy. In *Saint Seiya*, this object appears often associated to the special fight moves of the knight of Andromeda, who has a chain that resembles the shape of the spiral galaxy. This reference gives us the chance to point to the Andromeda galaxy in the sky (it is barely visible with the naked eye but can be observed with small binoculars) and to explain that it is a spiral galaxy very similar in shape and size to our Milky Way. Andromeda is traveling in our direction and its eventual destiny is to merge with the Milky Way.

Close to Andromeda in the sky, we find Pegasus, which is easily recognisable in the sky because of its square shape. The first extrasolar planet orbiting a Sun-like star was discovered around the star named 51 Pegasi (Mayor & Queloz, 1995). It was also the first discovery of a hot-Jupiter planet: a very big, very hot, gaseous body orbiting extremely close to its star.

Discussion

Effectiveness of Costellazione Manga Compared to Traditional Outreach Methods

Compared to the traditional shows and lectures held at the Planetarium of Ravenna that mostly cater to people already curious about astronomy, Costellazione Manga seems to attract a broader and more diverse audience. While the usual audience often includes a good fraction of regular patrons, we have observed that for Costellazione Manga, most of the audience are first-time visitors to a planetarium. We have seen that the number of participants is larger by a factor of five or ten compared to the regular visitors at the Planetarium of Ravenna. In several cases, additional shows were needed because all the interested participants would not have fit in the room for a single show.

Costellazione Manga has also been presented as night excursions in natural parks in the area of Ravenna. The public had a

chance to discover the beauty of nature and learn more about astronomy. In particular, they appreciated the idea of learning astronomy using manga and anime references, both because of the novelty of the approach and the proximity of the references to their cultural experience; conversely, the traditional way of explaining constellations using Latin and Greek mythology was perceived as a somewhat school-like experience, probably because Latin and Greek culture has a significant share in the Italian school curricula.

Localising Costellazione Manga outside Italy: The Swedish Experience

Japanese cartoons may not be as popular everywhere as they are in Italy or perhaps a different set of shows may have been imported elsewhere. To try and export the Costellazione Manga format, one needs to tune the show to the public's knowledge and expectations. Compared to Italy, France and Spain, Scandinavian countries do not have as developed a market for manga and anime. In creating a Swedish version of our show for the 2018 Gothenburg Science Festival (Figure 9), we were helped by cartoonist Yvette Gustafsson and by the personnel of the SF Bokhandeln bookstore in Gothenburg to identify suitable works. Fewer anime have been broadcasted by Swedish television, so in several cases, the popularity of anime in this country is mostly because of VHS and DVD editions. The popularity of manga also seems to be hindered, to a

certain extent, by a lack of Swedish translations, with most manga being available only in English and by their distribution being limited to specialised bookstores. Under these constraints, we identified three suitable works: *Starzinger*, the first anime to be broadcasted in Sweden; *Sailor Moon*, a popular success for which a Swedish opening song was written; and *Dragon Ball*, whose manga was translated and whose anime and films were released in VHS and DVD format. The bulk of the Costellazione Manga show therefore relied on these three works, with *Starzinger* (a science fiction anime involving a quest through the Milky Way) being used to introduce the theme of space travel and extra-solar planets, *Sailor Moon* (a fantasy work where warrior girls have their powers linked to the planets in the Solar system) introducing a review of the planets and minor bodies in the Solar System, and *Dragon Ball* (a martial arts franchise featuring aliens) presenting the topic of life in the Universe. In the final part of the event, we also showed a few pages from the less popular *2001 Nights* and *Planetes*, with which we intended to encourage interested individuals to broaden their knowledge about the more mature and literary side of manga.

The Costellazione Manga event was held in the Sirius Café run by SF Bokhandeln in their premises and was a definite success, with the venue filled to capacity. We had provided feedback forms asking for the audience's feedback on the show; the

main result was that the audience appreciated the format and valued the interaction with the speakers.

The Audience of Costellazione Manga and their Reactions

Costellazione Manga has been proposed in several forms: as planetarium shows, night observations of the sky or seminars. For each format, we had enthusiastic reactions from the audience, which included both adults and children.

The format has been successful both in Italy — a country where anime and manga are mainstream forms of literature — and in Sweden — a country where they are not as popular. We have seen that tuning the format to the expectations of the public has been key for success.

Adults were familiar with the cultural references and enjoyed being able to connect their childhood memories to science. They also appreciated that the learning experience was markedly different from traditional lectures.

Children were less familiar with some of the material (Japanese animation is still being broadcast on television and is available on modern distribution channels; but most productions aired are contemporary with only some classics from the 1980s are also aired) but they showed immediate interest in our stories and were curious about the astronomy-related aspects of the



Figure 9. Daria Dall'Olio and Yvette Gustafsson presenting Costellazione Manga at the Sirius Café run by the SF Bokhandeln bookstore during the Science Festival in Gothenburg (Sweden) in 2018 (left panel). One playful moment during the conference, when we explain the Moon's tidal locking (right panel). Credit: P. Ranalli

series, once we introduced these to them. Children and their parents (and grandparents too!) were linked together by a common fascination for astronomy. A great and somewhat unexpected outcome was that they started sharing appreciation for their own favourite stories and heroes, therefore establishing a fruitful dialogue among the generations. Thus, Costellazione Manga has proven to be a truly efficient pedagogical tool to popularise and communicate astronomy. The use of comics and anime deeply engages the public. It also stimulates important aspects of learning development, critical thinking and curiosity; moreover, it motivates people to read more about the astronomy references and helps them to remember concepts and build connections between different topics and subjects, which is a fundamental part of the deep learning processes.

Future Development and Conclusions

In the future, we aim to increase and improve our offer of outreach events and material by making them available in more countries. Our plan is to expand our team, involving astronomers and artists from different countries. This will allow us to tune content and topics according to the expectations of the public and to the country where the events will be offered. A good opportunity to expand our team will be the "AHA! Festival — Art x Science 2018" to be held in November at Chalmers University of Technology in Gothenburg, Sweden, where we will present Costellazione Manga. Another idea is to form associations with other disciplines like chemistry, biology or physics, which are deeply connected with astronomy, and start collaborations with experts and teachers in those fields. The plan is to encourage people to be curious about science and show them that different scientific disciplines overlap and have profound connections.

To conclude, Costellazione Manga has been presented as a planetarium show, night observation of the sky and seminar. We have seen that our audience can easily include both adults and children. Compared to a traditional planetarium show or astronomy-related outreach activity, Costellazione Manga caters to a broader variety of people and can thus reach a new audience passionate about

comics and animation who may be curious about astronomy with the right framing. In our experience, adults are likely to understand the references and connect to childhood memories through them, while children soon get engaged after an initial introduction. A happy consequence is that children and their parents get to share their fascination for astronomy and appreciate the same stories. Costellazione Manga can be successfully used as pedagogical tool to explain astronomy in several countries, since the choice of anime and manga can be tuned to the needs and expectations of the public. We have reported our experience in two countries in Europe where the manga and anime markets are quite different: Italy, where the market is well developed and Sweden, where it is still nascent.

Costellazione Manga is based on stories that are part of our common background often associated to dear memories or funny moments. Therefore, it is perceived by the public more as a recreational activity than as a conventional lecture. Thus, the atmosphere is more relaxed, where the public is more inclined toward learning. The comparison between fiction and science stimulates curiosity and critical thinking. The novelty of the method seems to help people remember concepts and build links between topics and encourages people to discover and learn more about astronomy. Costellazione Manga can thus be considered an efficient pedagogical tool to popularise and communicate astronomy.

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Notes

- ¹ The Evolving Culture of Science Engagement: www.cultureofscienceengagement.net/
- ² The Costellazione Manga website: www.costellazionemanga.eu
- ³ European/Japanese co-productions of the time included Heidi — girl of the Alps and Vickie the Viking.
- ⁴ au is the measure astronomical units, roughly equal to the average distance between the Sun and Earth and defined to be 149 597 870 700 m exactly.
- ⁵ *Voyager 1* press release: www.jpl.nasa.gov/news/news.php?release=2013-278

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