ASTROEDU

Peer-reviewed Astronomy Education Activities

Moving constellations

Let's learn how stars in constellations move through time using real astronomical images.

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KEYWORDS

constellation, gaia, hipparcos, software, stellarium, data analysis, big dipper, ursa major

CATEGORY

Observational astronomy, Scientific instrumentation, Stars

LOCATION

Computer Laboratory

AGE

10+

LEVEL

Middle School, Secondary

TIME

3h

SUPERVISED

No

COST

Free

SKILLS

Analysing and interpreting data, Asking questions, Communicating information, Developing and using models, Engaging in argument from evidence

TYPE OF LEARNING

Guided-discovery learning, Observation based, Technology-based

MATERIALS

- PC
- Stellarium software (it can be downloaded herehttps://stellarium.org)
- PowerPoint or similar software (Keynote, Libreoffice, Google Presentation, etc.)
- Introduction Presentation about Ursa Major (see attached material, in ppt and pdf)
- Output of this activity: the presentation of the evolution of Ursa Major in time simulated with Stellarium (see attached material, in ppt and pdf)

For additional activity

- Celestron Skyportal app (it can be downloaded here https://www.celestron.com/pages/skyportal-mobile-app)

GOALS

In this activity students will:

- be introduced in the observation of the night sky, understanding that stars are not fixed object, and the night sky appearance changes in time;
- learn what constellations are and the different cultures behind them;
- become more curious about Nature and science.

LEARNING OBJECTIVES

In this activity, students will:

- learn what constellations are;
- learn the different meanings of same constellation in different cultures;
- learn how to use of a professional astronomical software;
- understand how stars move in time.

BACKGROUND

Constellations

When we look at the night sky, we can identify some shapes: they are called *constellations*, and they are formed by stars that seem to be near. Ancient civilizations – and, more recently, astronomers – saw in these configurations different figures, often connected to mythology or deity. They gave a name to them, invented stories about them. They were – and still are – very useful to identify the position of planets and astronomical objects in the sky, and to find one's way during the night, when there is no Sun to be oriented.

In fact, stars in a constellation are not really near to each other; they only appear like that because in the night sky is very difficult to appreciate distances, and it seems to us like a flat dome moving according to Earth rotation.

Today we see the same constellations our ancestors saw in ancient times, as if stars are fixed in the sky. This is simply an illusion: stars have proper motions, and change their mutual position in time. These movements happen in a very long time, because stars are very far from us, and this is the reason why we cannot appreciate them until we were able to develop adequate instruments for measuring them.

The first scientist to measure a proper motion was Edmund Halley – the same that discovered the Halley comet, named after him – in 1719. He noticed that three very bright stars, namely Sirius, Arcturus and Aldebaran, were away from the positions measured by both Ptolemy, a Roman astronomer (c. 100-170 AD), and Tycho Brahe (XVI sec).

The Satellites Era

Now we have many instruments that can measure the slightest movements of stars. One of the most important was Hipparcos, a satellite launched by ESA (European Space Agency) in 1989 and that operated until 1993. The satellite has been named after the great Greek astronomer Hipparchus (190-120 BC), perhaps the greatest astronomer of antiquity. Hipparchus measured with great precision the position of the stars, and, comparing them with oldest measurements, he discovered the precession of the equinoxes, i.e. the apparent change in position of the stars due to the change of orientation of earth rotational axis. The satellite main goal was to measure with great accuracy the position of as much stars as possible; measuring these positions multiple time in different epochs, it was able to determine their proper motion too. Hipparcos produced a catalogue of 2.5 million stars.

In 2013, ESA launched a second satellite, Gaia, in order to extend the Hipparcos catalogue and perform more accurate measurements. It produced a catalogue of 1.8 billion stars, enhancing in meantime the measurement performed by Hipparcos. Data analysis is still ongoing, so more and richer catalogues are expected to be released.

Stellarium

In this actitivty, you will be using Stellarium (https://stellarium.org/), a free open source planetarium software that can be used with your computer. Stellarium can be used to simulate a realistic sky as seen from any place on Earth and at any time, just like what you would see with the naked eye, binoculars or a telescope. Stellarium is based on Hipparcos data, that is more than enough to evaluate stars constellations motion; these stars are in fact very bright, in general too bright for Gaia, that has been designed to observe fainter and less studied stars.

The Ursa Major Constellation

In this activity, we propose to work on Ursa Major constellation, one of the most famous and visible in the Northern Hemisphere. Here we provide you some historical and astronomical information about it and a power point presentation that you can use in classroom to introduce it.

Its name means "great bear" in Latin, and this asterism has been associated with this animal in many ancient cultures. This could be explained with an ancient tradition correlating the asterism with the bear that dates, according to come studies, 13000 years ago.

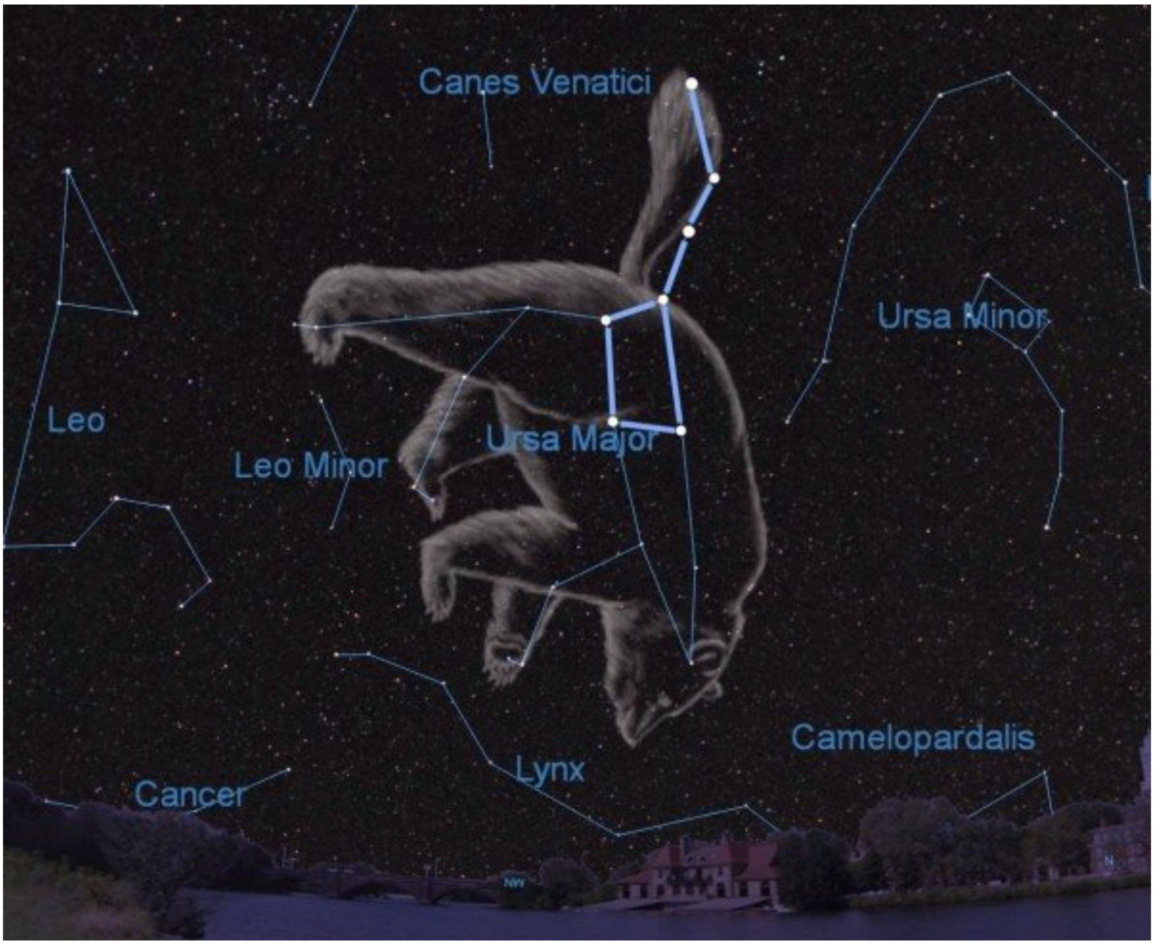


Image: The Ursa Major constellation Credits: Starry Night Software / A.Fazekas
Link

According to **Greco-Roman tradition**, it was believed that Zeus, father of all gods, lusted after a nymph (a minor Greek deity related to nature) called Callisto ("the most beautiful" in Greek). His wife Hera, jealous, decided to transform the nymph in a bear. One day, Callisto and Zeus' son, Arcas, met her mother in the woods and, not recognizing her, tried to kill her. Zeus avoided the tragedy whisking both of them in the sky, Arcas in the form of Boötes constellation, and Callisto as Ursa Major.

Jewish people too identified the constellation with a bear, and cited it in the Bible along with a few others; this is true for **Native American people** too, among them Lakota and Wampanoang. For Iroquois, the asterism represents a hunt scene, while for Wasco-Wishram it shows five wolves and two bears left in the sky by Coyote, a mythological animal.

Other civilizations saw in the asterism a wagon or a dipper; the first is the case of Norse tradition, in which the Ursa Major is known as the Woden's wagon, one of the Odin names, the latter of China and Japan, in which the constellation is known as the Big or North Dipper. In the Sami traditions, part of the constellation represents a bow.

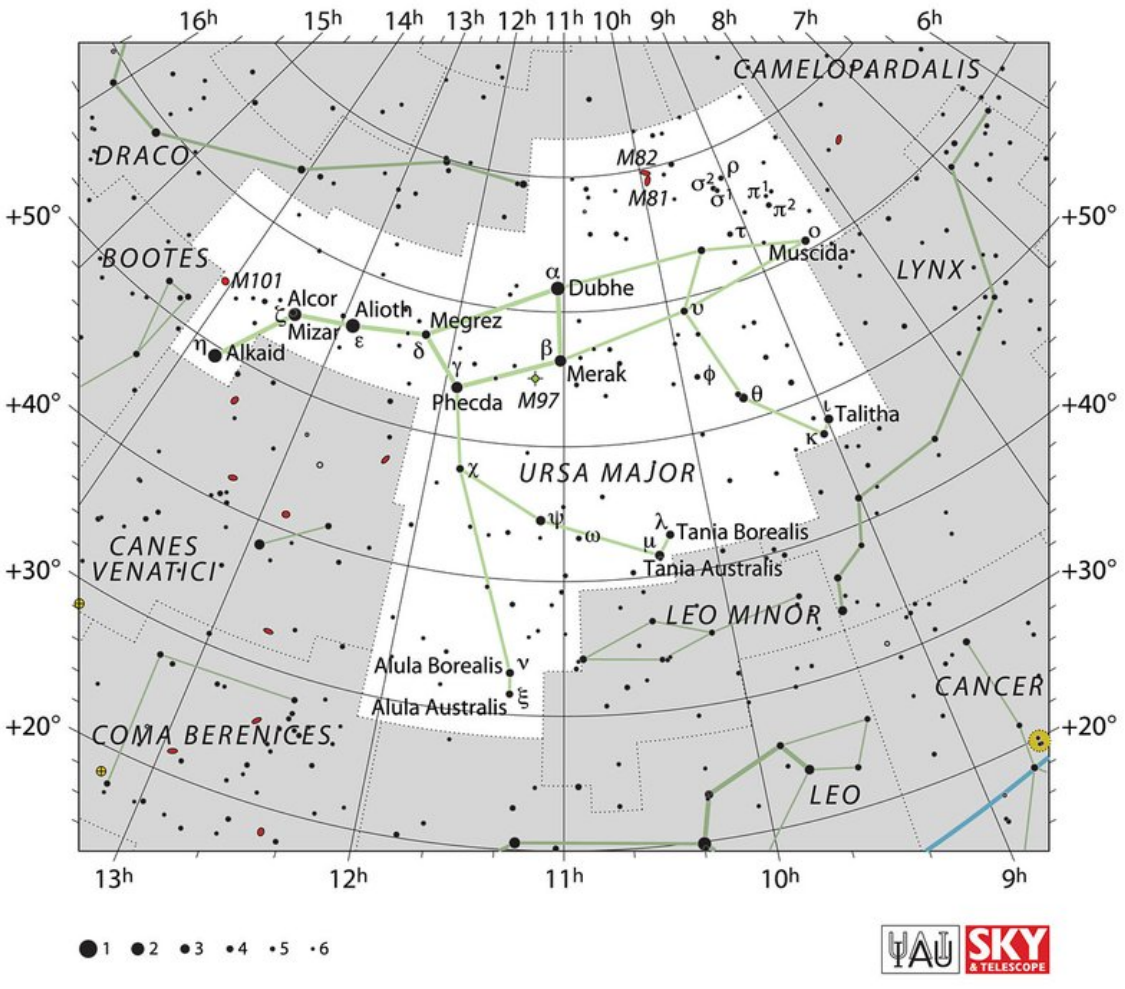


Image: Stars in the Ursa Major constellation. Credits: IAU and Sky & Telescope magazine (Roger Sinnott & Rick Fienberg) - [Link]

From an astronomical point of view, Ursa Major is one of the biggest constellations, and at medium and northern latitudes, it appears circumpolar, meaning that it never sets behind the horizon. Two stars, Dubhe (form the Arabic word “dubb”, meaning “bear”) and Merak (from the Arabic word al-maraqq, meaning “the loins” of the bear) could be used to identify Polaris the star that is now marking the north pole by simply connecting the two with a line, and multiplying their distance for five. Another star, Mizar, is a double star, because it seems to be very close to another one, Alcor; probably they are not gravitationally bounded, but the first one is a quadruple system (meaning it counts four stars that revolve around each other) and the second one a binary system (meaning it is formed by two stars gravitationally bonded); anyway, the two systems move together.

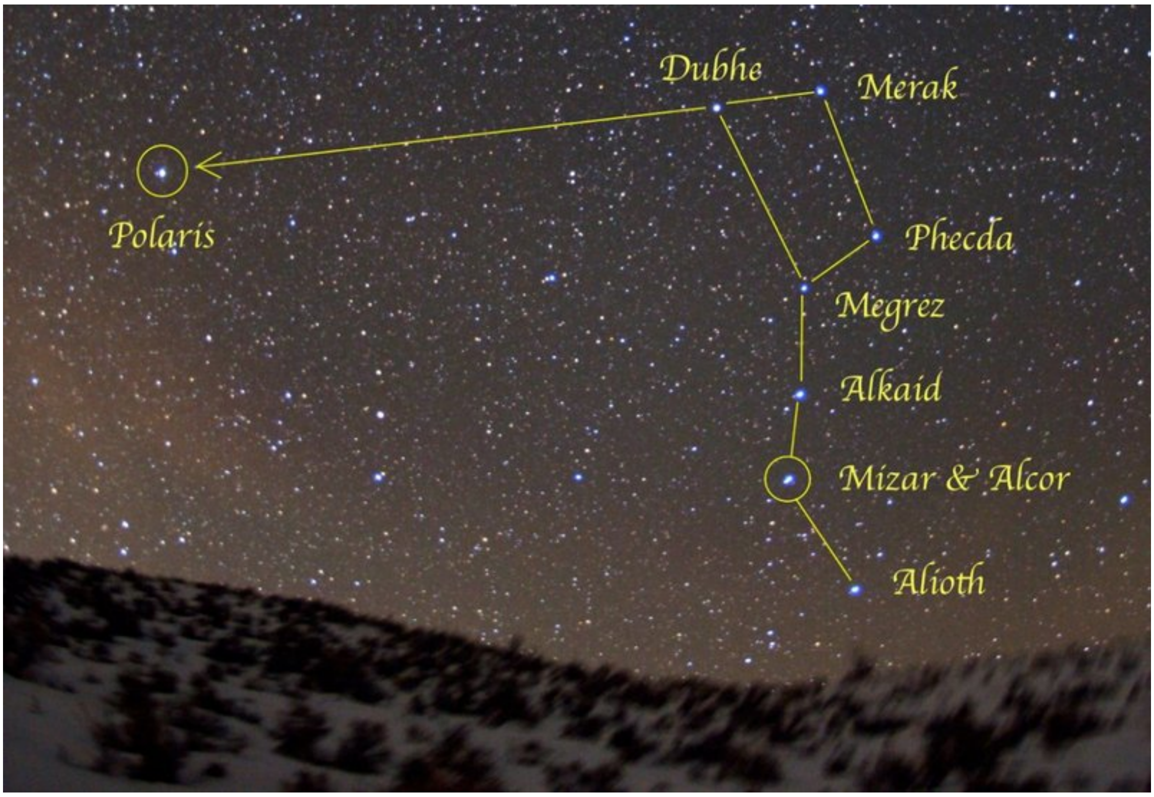


Image: How to find the Polaris using Ursa major. Credits: [Link]

Image: Alcor e Mizar Credits: sebastien lebrigand from crépy en valois, FRANCE, CC BY-SA 2.0*, Wikimedia Commons*

For each constellation, the IAU (International Astronomical Union) defines a region in the sky; all objects in this area are considered associated to the constellation. In this sense, there are many interesting object in Ursa Major Region:

- 47 Ursa Major is a star with three exoplanets, meaning planets that orbit around a star that is not the Sun;
- M81 and M82 are two interacting galaxies; a galaxy is collection of stars gravitationally bounded. M81 has a spiral form, while M82 is irregular. They are connected by filamentary gas structures.

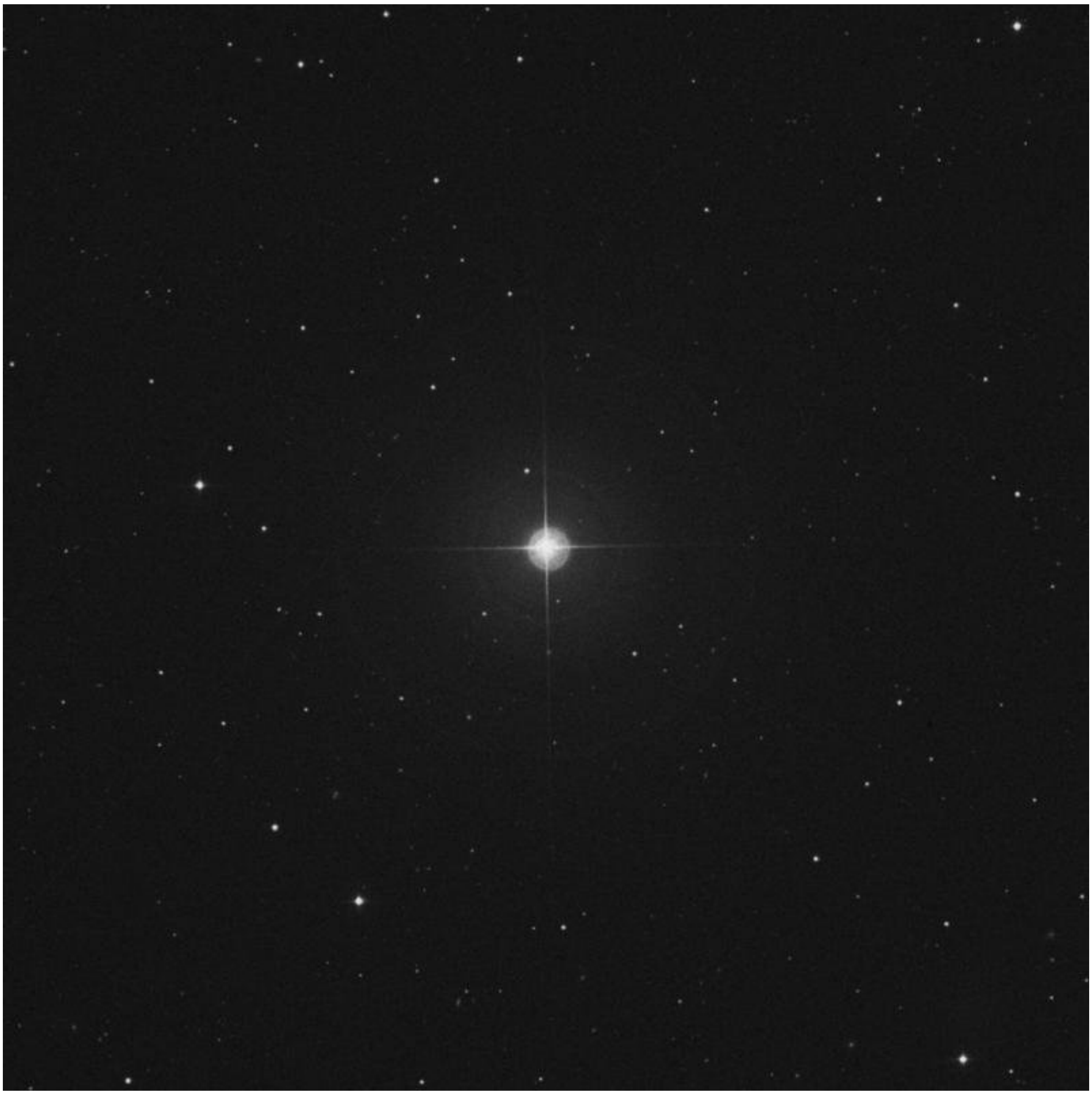


Image: 47 Ursa Major Credits: [Link]

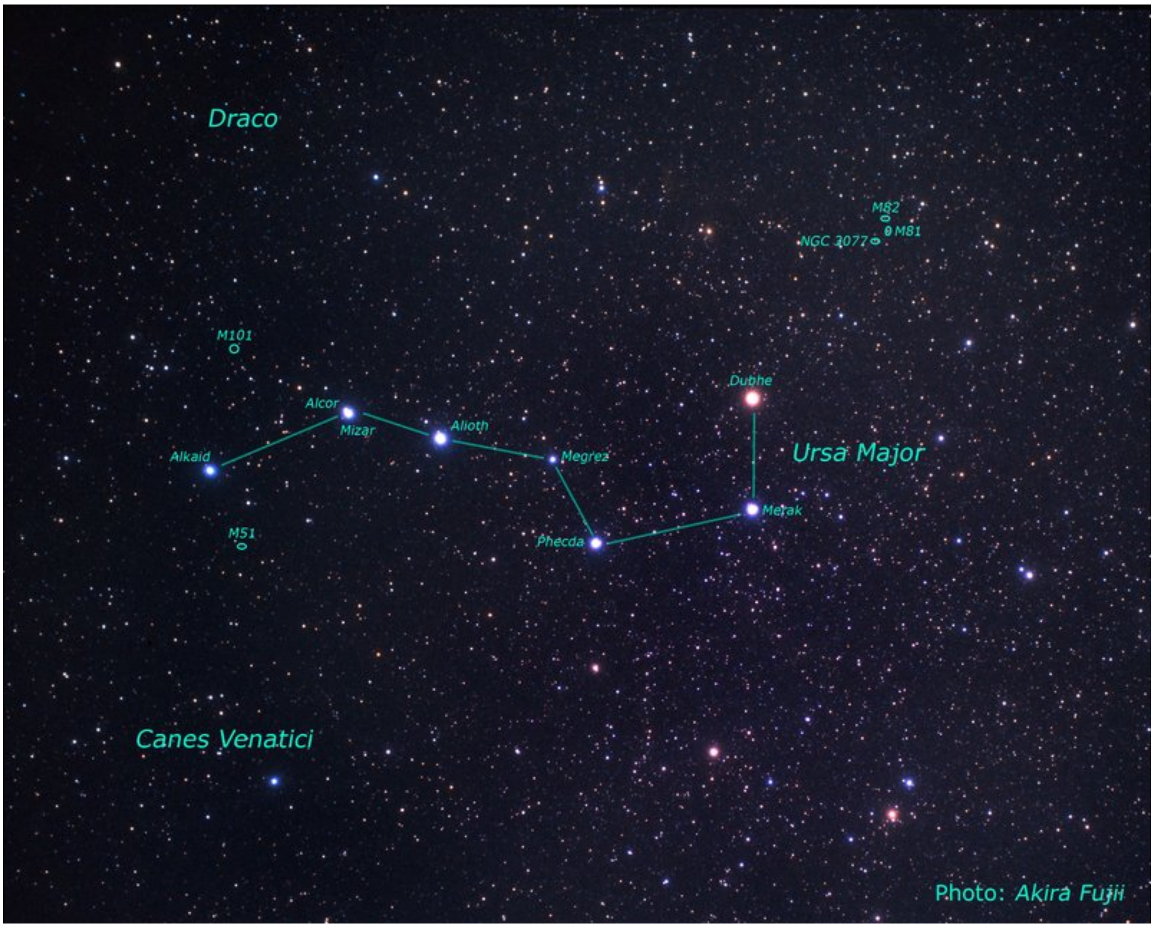


Image: M81 and M82 location Credits: NASA, ESA, Z. Levay (STScI) and A. Fujii
[*Link*]

Image: M81 and M82 Credits: NASA [*Link*]

Image: M81 Credits: Image Credits: Subaru Telescope (NAOJ), Hubble Space Telescope; Processing & Copyright: Roberto Colombari & Robert Gendler [*Link*]

Image: M82 Credits: NASA, ESA, STScI, AURA, Hubble Heritage Project (STScI, AURA)[Link]

FULL DESCRIPTION

Step 1

You can start by explaining to your students what a constellation is and illustrating the features of the Ursa Major constellation showing the attached presentation and discussing it.

Ask your students if they know any other version or myth.

NOTE: If you prefer, you can also use a different constellation, finding astronomical and mythological information about it. According to you position, this is a list of viable objects:

Northern hemisphere: Ursa Minor, Cassiopea
Southern hemisphere: Carina, Centaurus, Crux

Step2

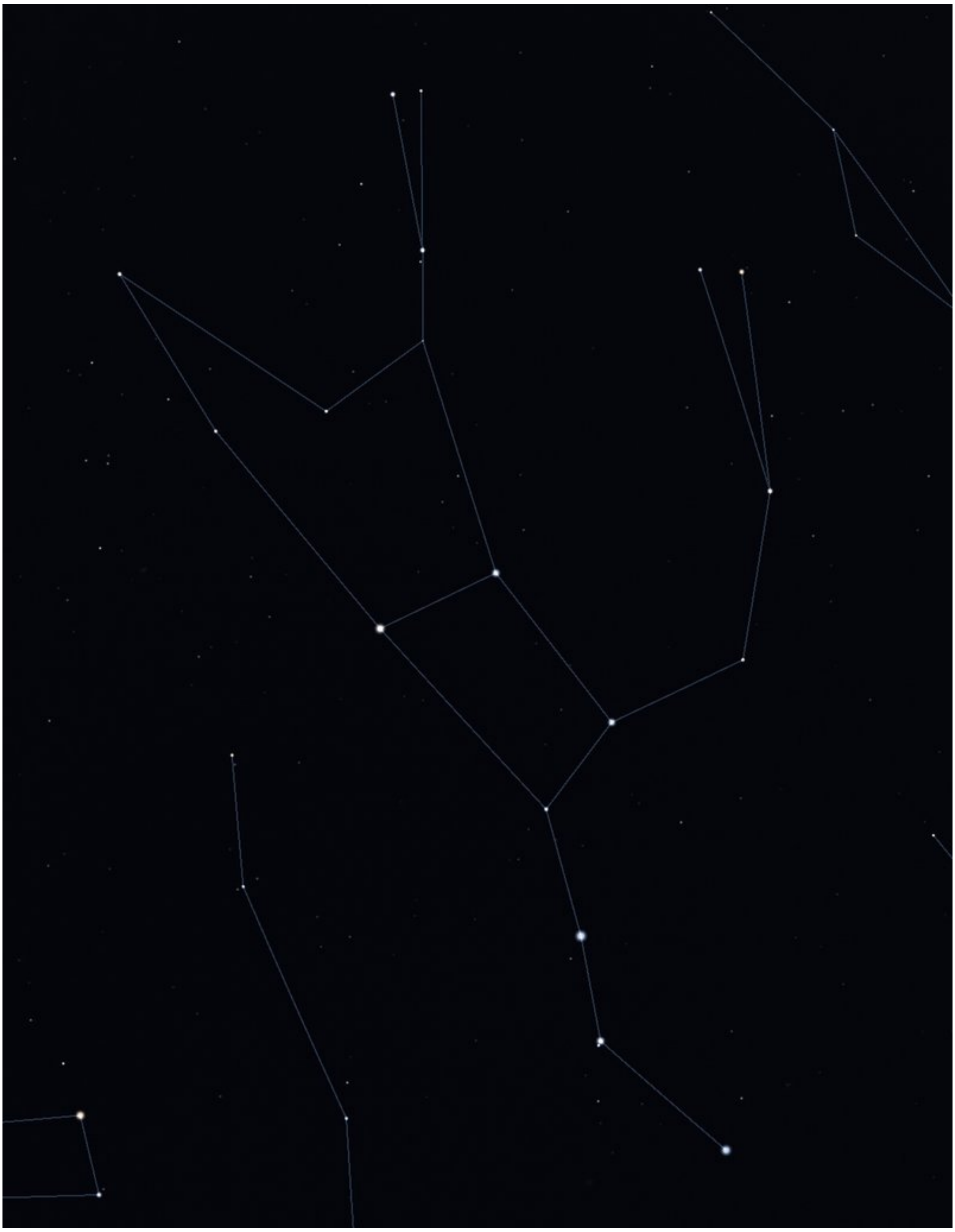
You now need Stellarium. Open it and set the time at night; you can do it using the pop-up menu on the left on the screen, clicking on the watch icon. In order to make things easier, set “date and Time” and not “Julian date”.

Images: setting time in Stellarium.

Then, from the same menu, select the magnifying glass icon and enter the name "Ursa Major". The software will show it to you. From the pop-up menu on the bottom of the screen select the first icon, corresponding to constellation lines. In this way, the software will show you the constellation shape.

Images: looking for Ursa Major in Stellarium

Images: how to see constellation lines in Stellarium



Images: Ursa Major today as seen in Stellarium

Now, it is time to evolve this constellation in time. In the same window you used to set the time, set a date. We suggest four different dates, that you have to put in the year space inside the window: 20 000, 40 000, 60 000, 80 000. In some cases, you will need to change the times accordingly.

Explain to your students that this means to look in the future, namely 20 000, 40 000, 60 000 and 80 000 years from now. Now, take a screenshot for each time, including present one (in the image you can see Ursa Major 40000 years from now).

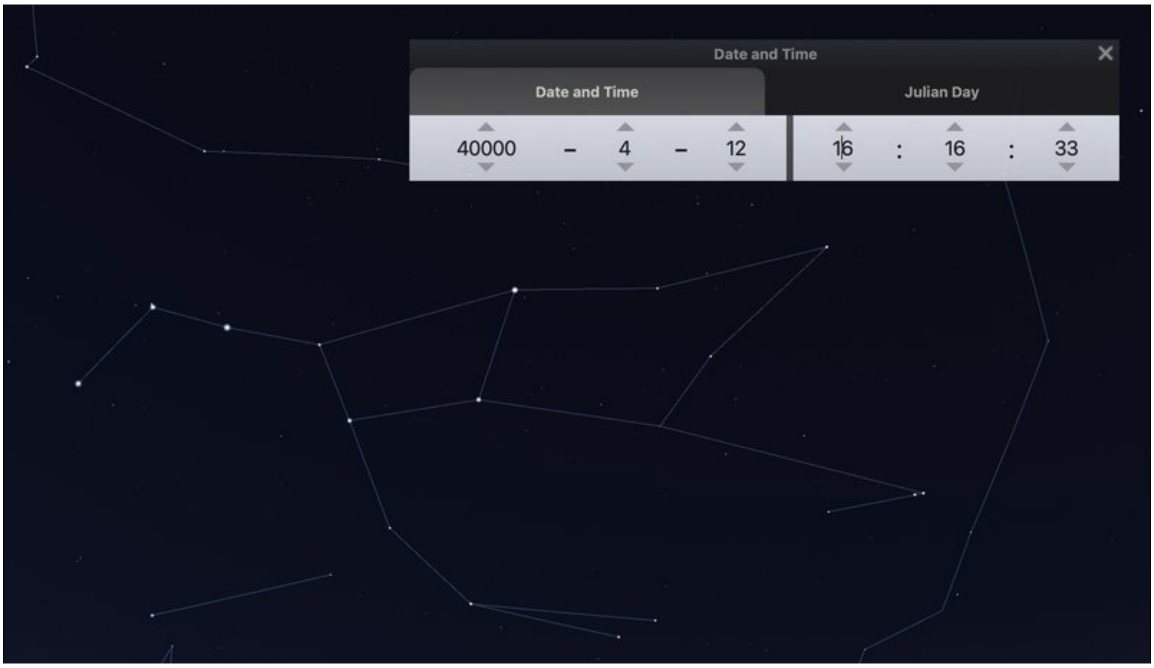


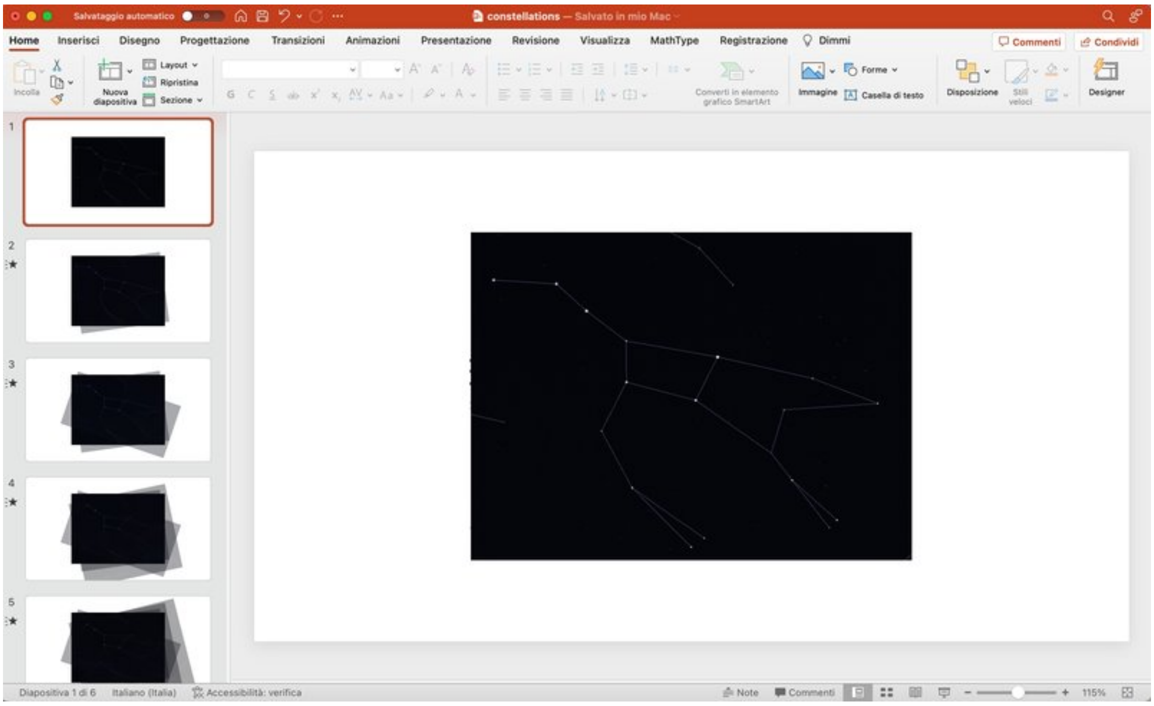
Image: Ursa Major 40000 years ago from now

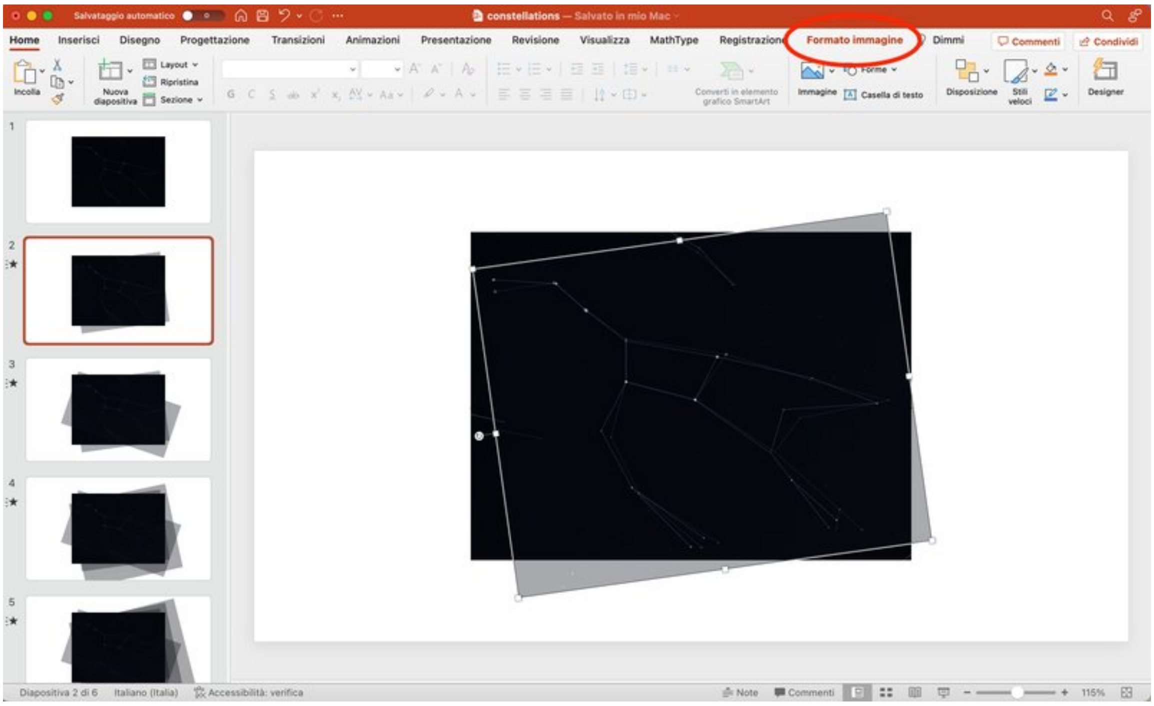
Step3

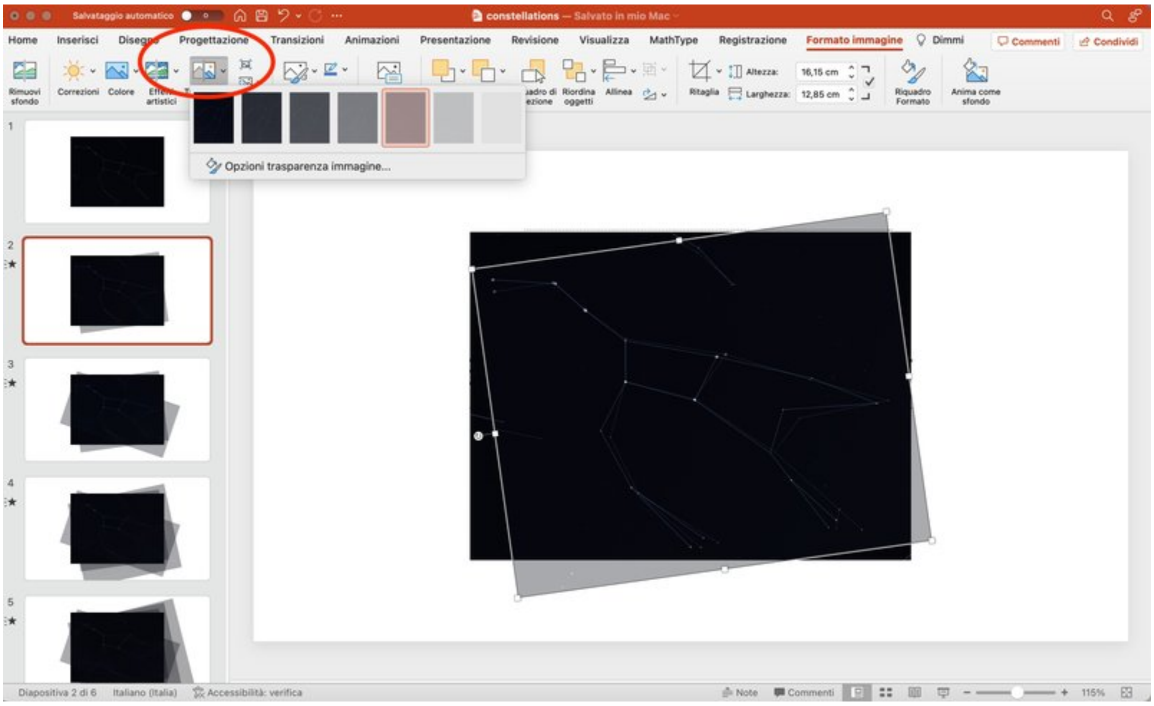
In order to obtain an animation showing the modification in time of the constellation shape, use a software that can produce presentation slides. Hereafter, we will explain how to go through the process using PowerPoint.

You need to superimpose the five images you have taken in the previous step; this could be easily done on a PowerPoint slide. Put the first image on it, and then add the second one, setting its transparency to the fifth available option in the menu. In order to superimpose the second image on the first one proceed as follows:

- Choose a star and a constellation line as reference. The line must connect the chosen star with another one;
- Align the second image to the first one superimposing the chosen line and star;







Images: how to superimpose images in the Power Point presentation

You can proceed in this way with all the remaining images. Set eventually an animation for all the images you have stacked together. In this way you will obtain an animation showing how the constellation modifies during a time span of almost 80 000 years. See in the attached material the Power Point presentation you will obtain.

Show to your student how each star has a different velocity, as shown by the different distances between each star in the resulting image, and how each star moves in different direction, a prove that stars in constellation are not physically near.

Step4

Show to your student the following video (https://www.youtube.com/watch?v=pTtbaq5MgwA) realized using Gaia data, showing exactly what they obtained with their animation.

Then, show them this video (https://www.cosmos.esa.int/web/gaia/edr3-startrails), with proper motion of some stars of our galaxy as measured by Gaia. Again, stress that each star has a different velocity.

Additional Activity

You can also organize a night of observation to watch and identify constellations in the sky.

An easy tool to help you find these constellations is Celestron Skyportal, a mobile phone app; you simply open it, and it automatically recognizes your location. You need to click on "compass" in the lower part of the screen; in this way, by simply moving your phone on the sky, the app will show you what you are looking at, including stars and constellations. The screen is in red because in this way, the light from the phone will not blind you and you will be able to watch all the stars visible in your location.

EVALUATION

Students can be asked to answer to the quiz below to verify what they have learned:

- What is a constellation?

1. A collection of stars physically near to each other
2. A collection of stars moving together
3. **A collection of stars that seem near in the sky**

- Why are constellations we observe today the same that our ancestors saw in the past?

1. **Because stars are very far from us and we are able to appreciate their movement only on a really long span of time**
2. Because their stars move all together
3. Because their stars are fixed

- What is the purpose of constellations?

1. To have fun drawing figures in the sky
2. **To identify the position of celestial objects in the sky**
3. To justify myths

- What are Gaia and Hipparcos?

1. **Two satellites that mapped the stars of our galaxy**
2. Two Greek mythology characters
3. Two famous astronomers

- Are stars fixed in time?

1. Yes
2. **No**
3. Only few of them

- What is proper motion?

1. **The movement of stars in regard to each other**
2. The night movement of the sky

3. The annual movement of the sky

- Do all stars move at the same velocity?
1. Yes
2. **No**
3. Star are fixed

- What is a circumpolar constellation?
1. A constellation only visible from North Pole
2. A constellation only visible during winter
3. **A constellation that never sets behind the horizon**

- What is an exoplanet?
1. **A planet orbiting around a star that is not the Sun**
2. An exotic planet
3. One of the external planet of the Solar System

- What is a galaxy?
1. A collection of planets
2. A collection of asteroids
3. **A collection of stars**

High School students can also produce a presentation slide explaining all that they have learnt during the experience, illustrating the work done together or trying to apply the learnt method to a different constellation they can choose.

CURRICULUM

The activity is well suited for upper and lower secondary school. It could be presented in the context of the science curriculum.

FURTHER READING

https://www.iau.org/public/themes/constellations/

https://www.space.com/ursa-major-constellation-great-bear

https://www.asi.it/en/planets-stars-universe/cosmology/gaia/

https://www.esa.int/Science_Exploration/Space_Science/Hipparcos_overview

CITATION

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