

IESO 2022



15th EDITION ITALY-AOSTA HOST COUNTRY

DATA MINING TEST N.3

STUDENT CODE.....

ASTEROIDS: SPACE ROCKS THAT ORBIT THE SUN

Asteroidit: Aurinkoa kiertävät avaruuskiivet

For an introduction to asteroid science, we suggest reading the "Background" paragraph of the article "Creating Asteroids" in astroEDU (astroedu.info/en/activities/1642/creating-asteroids/), the open-access platform for peer-reviewed (=vertaisarvioitu) science education activities supported by the Office of Astronomy for Education of the International Astronomical Union, with the participation of EduINAF:

1. Among the hundreds of thousands of asteroids known today (and according to models there are millions yet to be discovered), which is the largest group from the point of view of size?
 - a. Those with dimensions over 100 km
 - b. Those with dimensions from 10 km to 100 km
 - c. Those with size from 1 to 10 km
 - d. Those smaller than 1 km
2. In addition to asteroids, comets are also part of the so-called small bodies. Among the following options, which is one of the main differences between a comet and an asteroid?
 - a. None: they are the same, but the astronomers in the past did not understand it because their telescopes were not powerful enough, and for this reason they classified them under different names, which we still use today only because they have now entered the use even of those who are not specialists

- b. Brightness: asteroids are dark, and we see them because they reflect sunlight, while comets make their own light exactly like the stars (comets are smaller)
 - c. Orbit: comets circle the Sun generally following a greatly elongated trajectory (=pitkulainen kiertorata) from very far to very close to our star, while asteroids can be both far away and close to the Sun, but travel along an elliptical orbit more like an oval, and in several cases almost circular
 - d. The physical state: comets are made entirely of incandescent (=valohehkuinen) gas, asteroids instead are solid because they are made of rock, ice and metals in different proportions depending on the type of asteroid
3. We can find asteroids especially in some specific regions of the Solar System. Where?
- a. The Main Belt
 - b. The Oort Cloud
 - c. Geostationary orbit (=Maasta katsoen paikallaan pysyvä)
 - d. Van Allen Belts

So far, so good. Now we focus on a particular asteroid called (8558) Hack. Why? Because it bears the name of the great Italian astronomer Margherita Hack (1922-2013), whose 100th anniversary of birth we are celebrating this year. She was the first woman to direct an astronomical observatory in Italy, in Trieste; she made important contributions to the spectroscopic study of the stellar population of the Milky Way. She is very popular in Italy for her activity as a popularizer of astronomy. To honor Margherita Hack's scientific career, the International Astronomical Union dedicated an asteroid to her.

We propose some simple calculations concerning the asteroid (8558) Hack. To answer the questions, you should visit the very useful website In-The-Sky.org. It is an interactive online guide that allows you to understand what we can observe in the sky, acquiring information from different scientific databases, with an easy-to-use interface even for those who are not experts. The website is developed and maintained by the astronomer Dominic Ford, researcher at the Institute of Astronomy at the University of Cambridge, in the United Kingdom.

Click "Search site..." at the top right corner of the home page. Select the correct category (is it a constellation (=tähdistö), a celestial object (=taivaankappale), a spacecraft?). Enter the name of the asteroid, press the "Search" blue button, then click on the result. Et voilà, that's it!

In the asteroid (8558) Hack web page you can find data with the astronomical and physical properties of the asteroid, such as position, orbital period, and so on. You can also view the links to: the celestial map showing where the asteroid is located in the sky as seen from a certain location and at a certain time (*finder-chart*); the interactive scheme of its orbit around the Sun (*orbit diagram*); the celestial coordinates to observe the asteroid from a certain location and at a precise moment (*ephemeris*). Now you can answer the questions.

4. Remembering question 3 and the paragraph from astroEDU, where do you think that the asteroid (8558) Hack is located in the Solar System?
- The Main Belt
 - The Oort Cloud
 - Geostationary orbit
 - Van Allen Belts
5. Asteroids orbit the Sun, thanks to the gravity(=*vetovoima*) of our star. But as they move through space, they are affected also by the gravity of other bodies in the Solar System, such as the planets. Based on the previous answer, which is the giant planet that can have the most gravitational influence on the motion of the asteroid (8558) Hack?
- Jupiter
 - Saturn
 - Uranus
 - Neptune
6. The French astronomer François Félix Tisserand, who lived in the 19th century, developed a formula to describe the influence on the orbit of an asteroid due to the gravitational pull of a given planet. It's called, guess what, Tisserand parameter! This is the formula:

$$T_P = \frac{a_P}{a} + 2 \cos i \sqrt{\frac{a}{a_P} (1 - e^2)}$$

The quantity a is the semi-major axis of the asteroid orbit around the Sun; a_P is the semi-major axis of the orbit of the planet of interest around the Sun; e is the eccentricity (=epäkeskisyyss) of the asteroid orbit, that is, how far it is from being a perfect circle; i is the inclination (=kaltevuuskulma) of the asteroid orbit relative to the ecliptic plane, that is, the plane of the Earth's orbit around the Sun.

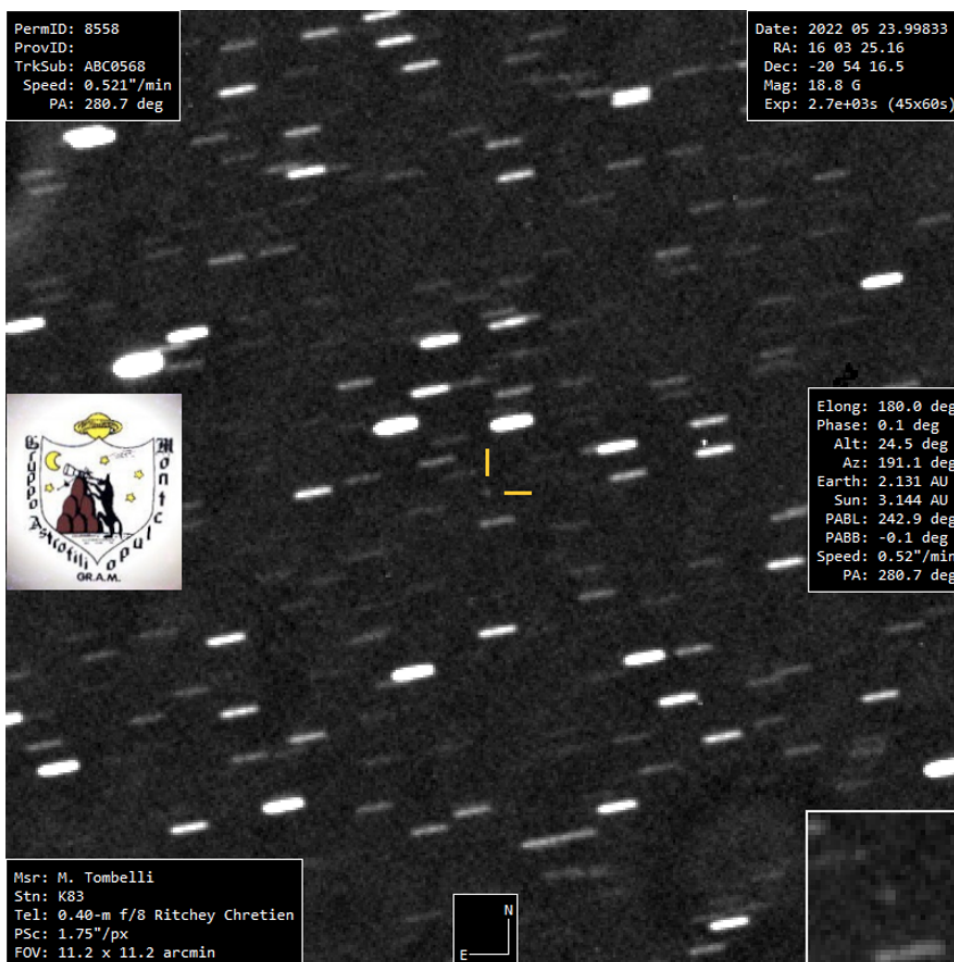
Let's find the Tisserand parameter for the asteroid (8558) Hack! Find via In-The-Sky.org the data for the asteroid (a , e) and for the planet (a_P). Which planet? The same that you indicated in the answer to question 5. The $\cos i$ function is a trigonometric function. It does not matter if you do not know it, because in this case we can consider $\cos i = 1$. Easy! Take the calculator and write your answer below.

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During 2022, the asteroid (8558) Hack was observable from Earth in late spring, by a lucky coincidence just before the date of birth of Margherita Hack (June 12). For the occasion, EduINAF, OAVdA, Unione Astrofili Italiani and AstroTeam Le Pleiadi launched a challenge, inviting professional and amateur astronomers to take pictures of the asteroid. Although (8558) Hack is more or less as big as Mont Blanc and the Matterhorn put together (two of the highest mountains of the Aosta

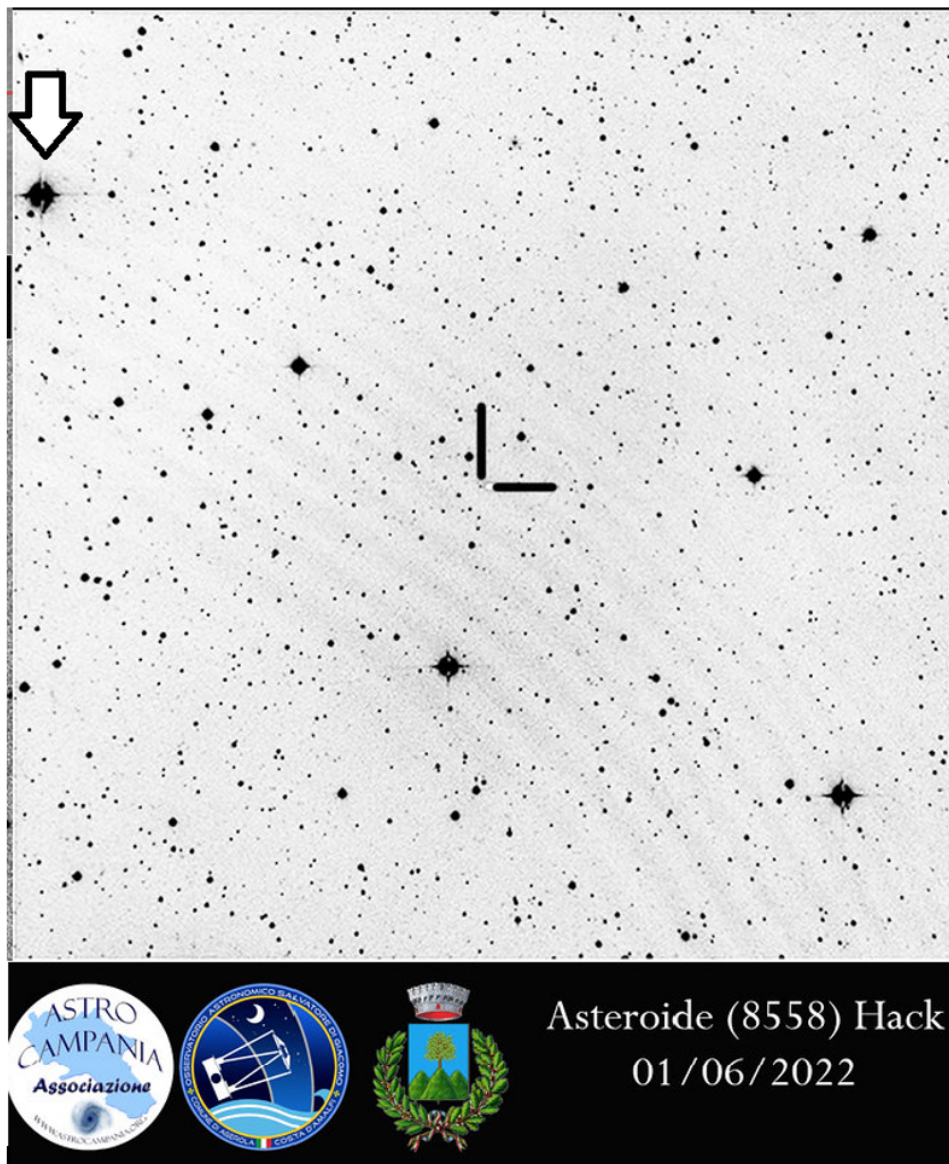
Valley Alps and in Europe, too), it is so far away that even with powerful telescopes it is seen as a tiny dot. However, several images were taken. We will analyse some of them.

7. The first photo was taken by the Gruppo Astrofili Montepulciano, in Tuscany, Central Italy, on the night between 23 and 24 May 2022. The asteroid is at the centre of the image, indicated by two yellow lines. The white stripes are the stars! They don't appear as dots because...
 - a. ... they are out of focus; it is definitely not easy to take pictures of this kind
 - b. ... the camera is centred on the asteroid, which is moving with respect to the stars in the background, so these are elongated
 - c. ... the photograph was taken during a 'rain' of shooting stars, let's make a wish!
 - d. ... all stars emit gas and lose mass in space: the phenomenon can't be seen with the naked eye, but it is clearly visible in the picture

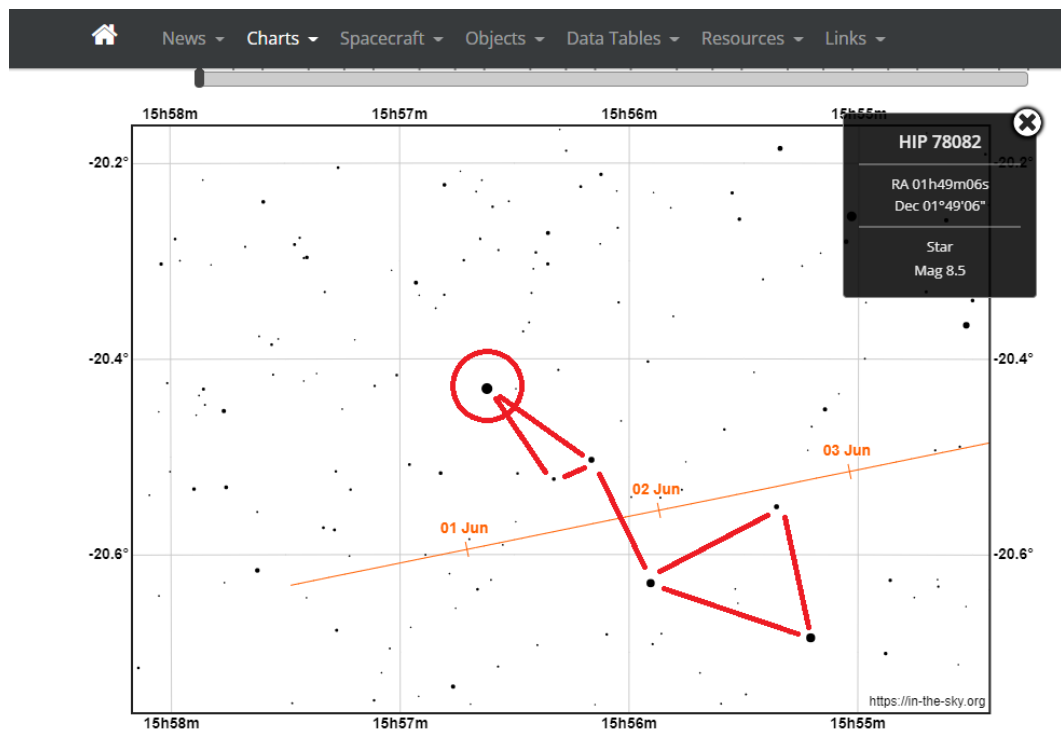
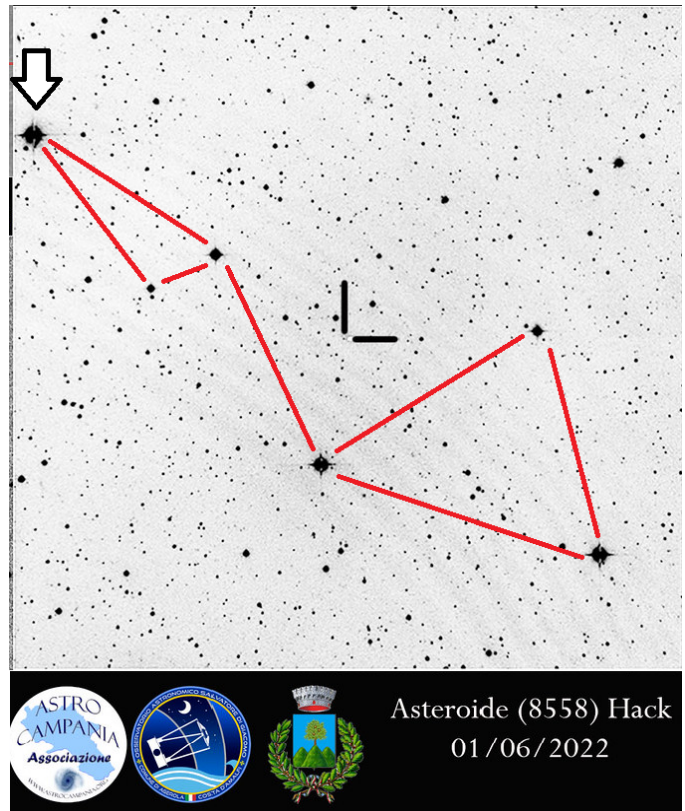


8. The second photo was taken by the Research Team of the AstroCampania Association (Southern Italy). The picture is negative, with inverted (=käänteiset) colours: the night sky becomes clear, the celestial bodies become dark. Again, the asteroid is the dot indicated with the two lines in the centre of the image. What is the name of the star at the top left, indicated by the arrow? Let's discover it by using the finder-chart for (8558) Hack provided by the In-The-Sky.org web-site.

The photo was taken near Naples on June 1, 2022, just before midnight. First, select the location. Produce the interactive chart (=tähtikartta)(not the downloadable ones) and check the motion of the asteroid for the duration of one week. Set the slider of the field of view, just above the chart, to the smallest size. Then, get back to the photo and identify the brightest stars: they are the ones that appear with the spikes (which does not actually exist: they are produced by the camera's shooting system). Now look for the same configuration of stars on the interactive map, where they are drawn as circles (the larger the circle, the brighter the star). Put the mouse over the star that you think is the right one in the map, click and the name will appear!



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(<http://simbad.u-strasbg.fr/simbad/sim-basic?Ident=HIP%2078082>)

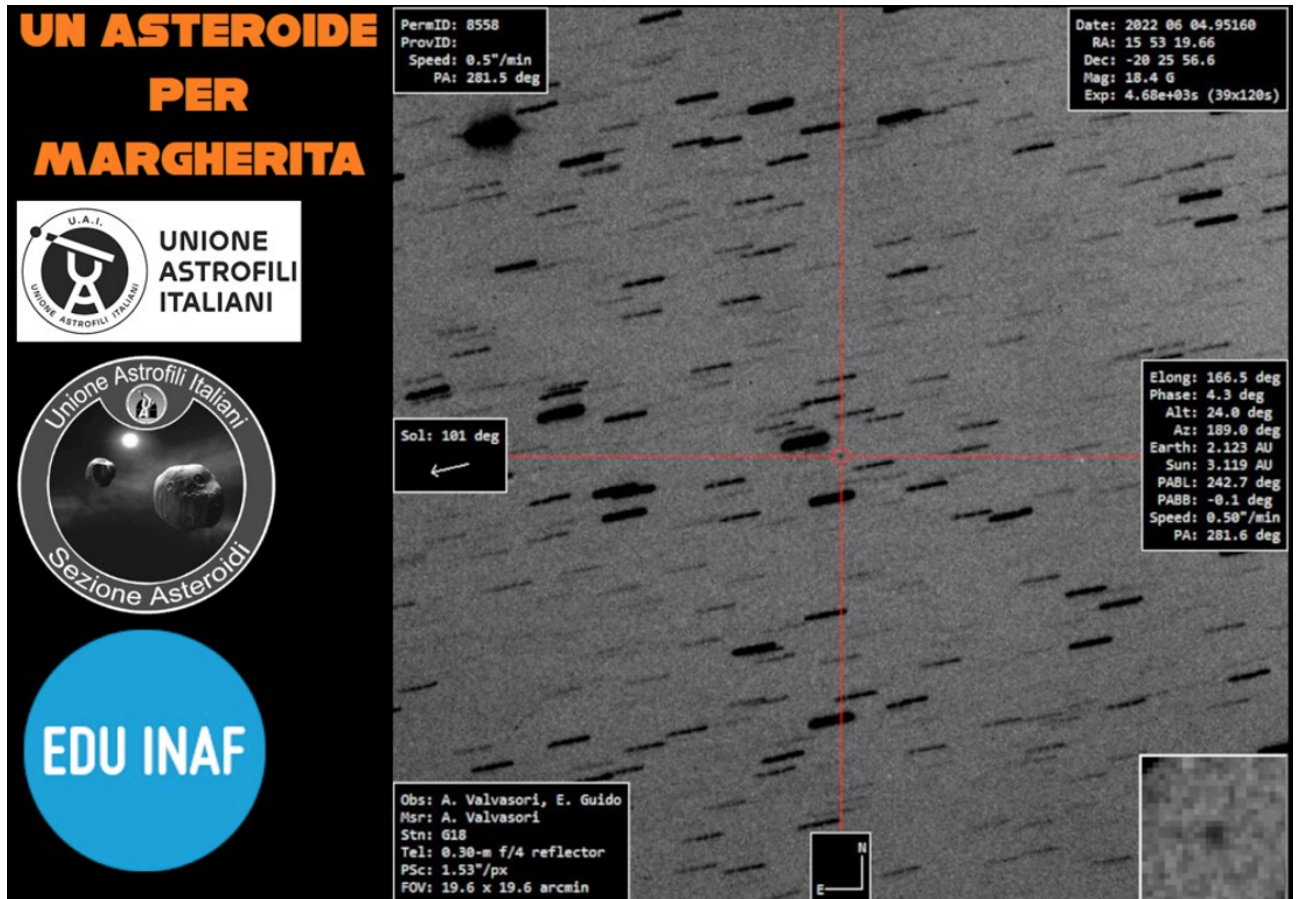


9. The third photo was taken from the ALMO Observatory near Bologna (Central Italy), on the night between June 4 and 5, 2022. Again, the asteroid is at the centre of the image. At the upper right corner, you can read its celestial coordinates at the time of the picture: right ascension (RA) and declination (DEC). The first indicates the position along the celestial equator, the second its

height between the celestial equator (=taivaanekvaattori) and the poles (positive towards the north pole, negative towards the south pole).

Use the In-The-Sky.org interface to calculate the ephemeris (=efemeridi) of the asteroid (8558) Hack and find RA and DEC at 00:00 UTC (not local time!) today, August 26, 2022. Compared to the value in the photo, how much has the asteroid moved, expressing RA in hours, minutes and seconds and DEC in sexagesimal (=kuusikymmen-) degrees, minutes, and seconds?

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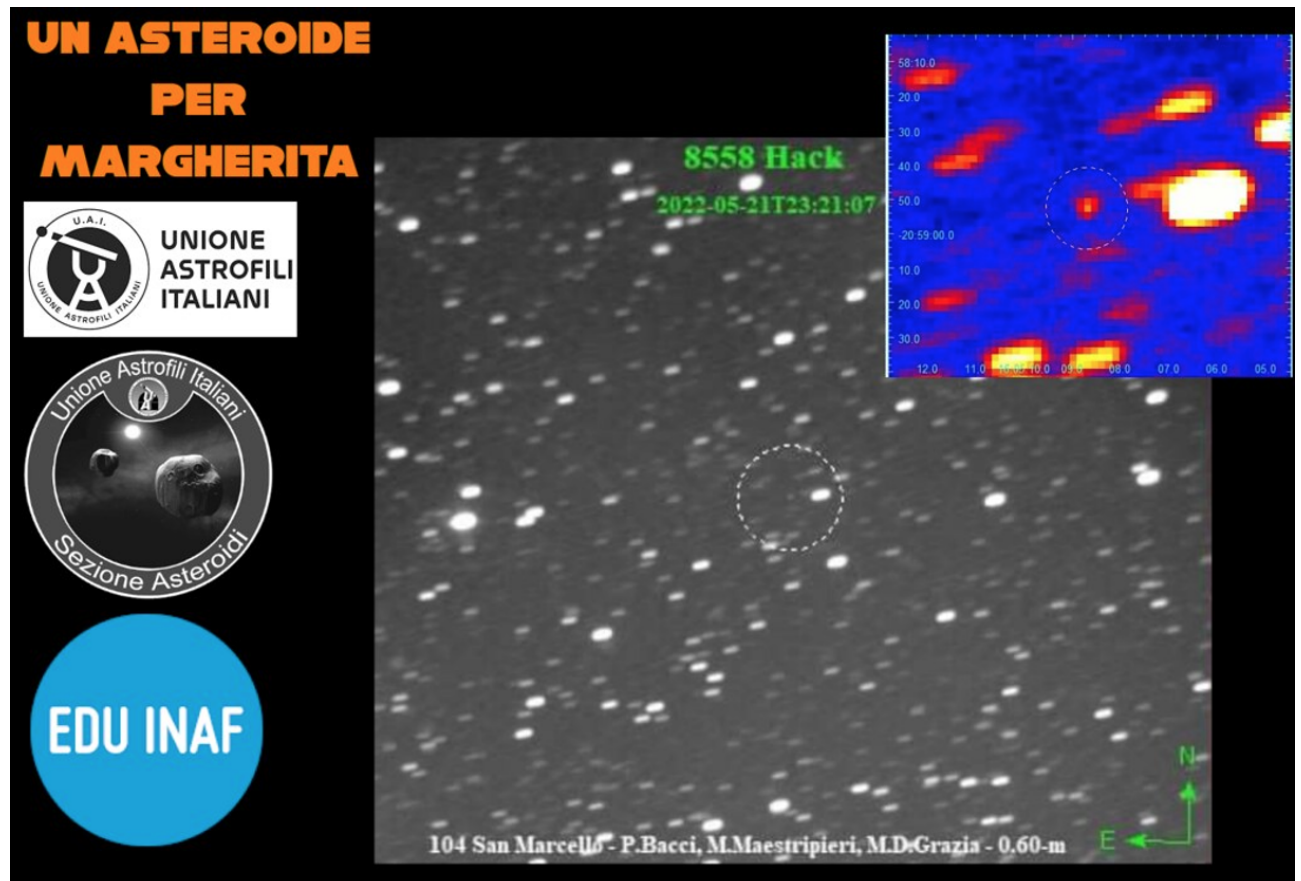


10. The fourth photo was taken by the Gruppo Astrofili della Montagna Pistoiese, near Pistoia, Tuscany (Central Italy), on the night between May 21 and 22, 2022. The asteroid (8558) Hack is the very faint dot in the centre of the circle. The asteroid does not shine with its own light: we see it because it is illuminated by the Sun. Light speed in the vacuum is about a billion km/h. That is a huge value, but it is not infinite (=ääretön)! This, it takes some time to travel through space. How long did it take a beam of light from the Sun to reach the asteroid, to be reflected to Earth and to reach our planet for this photograph to be taken? Will it be days, hours, minutes in your opinion?

Use the In-The-Sky.org ephemeris interface to derive information, setting the location and the time 00:00 UTC on May 21. Consider the speed of light of $c = 299,792,458$ m/s and the

Astronomical Unit of 1 AU = 149,597,870,700 m. Imagine the three celestial bodies – Sun, asteroid, Earth – being stationary (=liikkumaton) while light is travelling. Round to two digits after the comma (that is, two decimal places).

See the website <https://www.convertunits.com/from/au/to/light+minute>.



11. Let's go back to the astronomical data web page for the asteroid. Select today's date, August 26, 2022. Which constellation should we point the telescope to observe (8558) Hack tonight? Remember: the asteroid is in the Solar System, while the stars of the constellations are much more distant, thus it is only a matter of perspective!

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12. Let's see in which constellation the asteroid seems to be located on the 26th day of each month of the current year.

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13. What do all these astronomical constellations have in common?

- a. They belong exclusively to the southern hemisphere of the celestial sphere (=taivaanpallo)
- b. They belong exclusively to the northern hemisphere of the celestial sphere
- c. They bear the name of beasts, both real and fantastic
- d. They are zodiacal constellations (=eläinradan tähdistöt), that is, the constellations through which the ecliptic passes

NOTE: THE CELESTIAL EQUATOR PASSES THROUGH OPHIUCHUS (=käärmeenkantaja), THUS PART OF THE CONSTELLATION BELONGS TO THE NORTHERN HEMISPHERE AND THE OTHER TO THE SOUTHERN HEMISPHERE (AND WE FIND HERE THE ECLIPTIC).

14. Which parameter listed in the table of the orbital elements of (8558) Hack that you can consult on the In-The-Sky.org web page allows us to say that, from Earth, we will *never* be able to see the asteroid with the background of the constellations Ursa Major or Southern Cross?

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We conclude this test with some questions about the physical features of (8558) Hack.

15. No spacecraft has ever visited the asteroid up close. However, its shape probably is...

- a. ... long and narrow like a cigar
- b. ... round and solid like a ball
- c. ... irregular like a stone
- d. ... round and with a hole in the centre like a ring donut

16. Explain your answer to question 15. The shape probably is...

- a. ... round and solid because collisions with other asteroids, happened in billions of years, have smoothed all the corners
- b. ... irregular because its mass is not sufficient to acquire a round shape because of gravity
- c. ... round and with a hole in the centre because collisions with other asteroids, happened in billions of years, have dug deeper and deeper craters, forming the central hole
- d. ... long and narrow because it is modelled by the solar wind, like the tails of the comets

The last question is a bit scary. In many movies, asteroids are on a collision course with the Earth. This is unlikely, but not impossible. Asteroids potentially threatening our planet are called Near-Earth Asteroids (NEAs). Among the NEAs, there are three broad categories:

- Aten asteroids, whose semi-major axis (=isoakselin puolikas) is less than 1 AU and whose aphelion (the maximum distance from the Sun reached by the asteroid) is greater than 0.983 AU (Earth's perihelion);
- Apollo asteroids, whose semi-major axis is greater than 1 AU and whose perihelion (the minimum distance from the Sun reached by the asteroid) is less than 1,017 AU (Earth's aphelion);

- Amor asteroids, whose semi-major axis is greater than 1 AU and whose perihelion is between 1.017 AU (Earth's aphelion) and 1.3 AU (i.e. slightly within the orbit of Mars).

The three groups are collectively referred to as AAAs.

17. Which category of NEAs does (8558) Hack belong to? If you are not sure, check the orbit data in the [In-The-Sky.org](https://www.in-the-sky.org) web page of the asteroid.

- a. Aten
- b. Apollo
- c. Amor
- d. None of the above, it is not a NEA

Thanks for coming this far with us, flying through space with the asteroid (8558) Hack! To know more about the Italian astronomer Margherita Hack, a useful starting point is her entry in Wikipedia: https://en.wikipedia.org/wiki/Margherita_Hack

The Astronomy Data Mining Test for IESO 2022 has been developed by scientific researchers in a collaboration between the Astronomical Observatory of the Autonomous Region of Valle d'Aosta (OAVdA), managed by Fondazione Clément Fillietroz-ONLUS, in particular Dr. Andrea Bernagozzi, and the National Institute of Astrophysics (INAF), in particular Dr. Marco Castellani and Dr. Davide Perna from the INAF-Astronomical Observatory of Rome. Marco Castellani is also a member of the editorial board of [EduINAF](https://www.eduinaf.it), the web magazine for Public Outreach and Education of INAF.