ASTRO LASER SET

TASK COLLECTION AND MANUAL

KVANT®

www.kvant-laser.de

CONTENT

LIST OF OPTICAL MODULES

Earth

Moon

Albedo

Exoplanet

Earth's atmosphere (2 pcs)

Thicker pad under the Moon

Thinner pad under the Moon

Lens no. 1 (converging biconvex lens)

Lens no. 2 (converging biconvex lens)

Plano-concave lens

Semicircle (converging plano-convex lens)

Equilateral triangle (prism)

Convex mirror

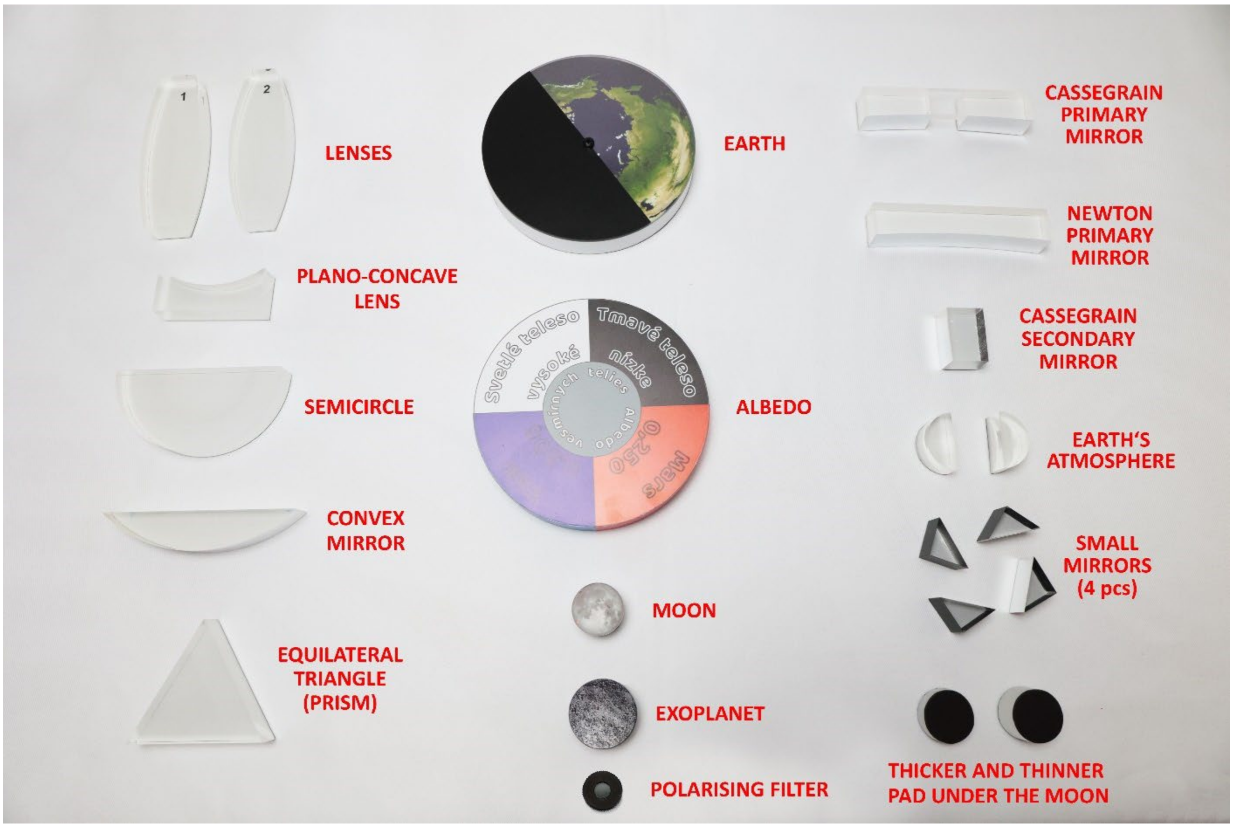
Newton primary mirror (concave mirror)

Cassegrain primary mirror (concave mirror)

Cassegrain secondary mirror

Small mirror (4 pcs)

Polarizing filter



LIST OF WORKING SHEETS

01 - The human eye

02 - Electromagnetic radiation spectrum

03 - Phases of the Moon

04 - Eclipses

05 - Albedo

06 - Galilei telescope

07 - Kepler telescope

08 - Spherical aberration and its correction

09 - Newton telescope

10 - Cassegrain telescope

11 - Primary mirrors of space telescopes

12 - Radio telescopes

13 - Exoplanets

14 - Variable stars

Note:

Some sheets are used multiple times for each task.

LIST OF LIGHT SOURCES

Laser light source - multi-colour beam laser light source (5 beam DUO laser ray box electronic), within which a white light source (1 white LED) is also integrated. Each task using a laser light source is designed with all 5 beams represented. The middle (green) laser beam represents the optical axis.

LED light source - a flat white light source with multiple pieces of white LED diodes.

Power supply (adapter) - It is the same for both light sources and is always used only to supply one light source. It is not possible to connect both light sources at the same time.

Note:

In each task, these light sources represent different views from Earth towards them - into space.

LIST OF TOPICS AND NUMBER OF TASKS IN THE TOPIC

1 - View of the sky (1 task)

2 - Electromagnetic radiation spectrum (1 task)

3 – Phases of the Moon (4 tasks)

4 - Eclipses (7 tasks)

5 - Albedo (3 tasks)

6 - Astronomical telescopes (9 tasks)

7 - Searching for exoplanets by eclipsing method (2 tasks)

8 - Variable stars (2 tasks)

Note:

The set contains a total of 29 tasks. All topics and tasks can be supplemented by the lecturer with related theory in the field of physics, optics, mathematics, geometry, etc.

ACCESSORIES

- magnetic board with a support rod for presentation in a vertical position
- magnets for attaching working sheets to a magnetic board (6 pcs)
- task collection and manual

<u>Note:</u>

Some modules are also used in various tasks as auxiliary modules that represent other objects or bodies. This set is structurally designed in 2D, so there are objects such as Earth, Moon, Exoplanet, etc. made in the shape of a circle and a cylinder, not in the shape of a sphere.

Some optical modules (e.g. lens, concave lens, semicircle, mirrors) can be used to explain and illustrate other optical phenomena (refraction of light, reflection of light, etc.)

<u>Related and recommended kits:</u>

Ray optics demonstration set

Ray optics demonstration set PLUS

TOPIC: VIEW OF THE SKY

TASK 1: HEALTHY EYE

Task number: 1

Equipment:

Sheet no. 1, laser light source, lens no. 1, lens no. 2

Preparation:

Position the laser light source outside the sheet as close to its left edge as possible. Its exact position is determined by the optical axis in the sheet, which corresponds to the middle (green) beam.

Activity 1:

Attach lens no. 1 to the marked place on the sheet. The laser light source is a view of a point at infinity (star). Turn on all 5 beams. Adjust the position of the laser light source so that the centre (green) beam shines in the optical axis. Observe the point of focus (star) on the retina.

Summary 1:

The healthy eye focuses an infinite point directly on the retina in the optical axis (not in front of or behind the retina). With a healthy eye, you should see binary star Alcor and Mizar in the night sky. (Alcor is a faint star near the star Mizar, which is the second star of carriage beam of the Big Dipper - the tail of the constellation Ursa Major).

Activity 2:

In the sheet, add lens no. 2 to the marked place. Observe how the focal length of the optical system (lenses 1 and 2) and the direction of the rays' change.

Summary 2:

If we insert a contact lens (or lens system) in front of the eye with a focal length less than the conventional visual distance (d = about 25 cm), an optical system is created together with the eye, which has greater optical power than the eye itself. When an object with a height (y) between the focus and the lens is observed, the eye sees the image at a greater angle of view (τ') than the original angle of view (τ) (see: bottom image in the drawing). The ratio of these angles is called angular magnification. The image is unreal, magnified and straightforward. This is how the magnifying glass works.

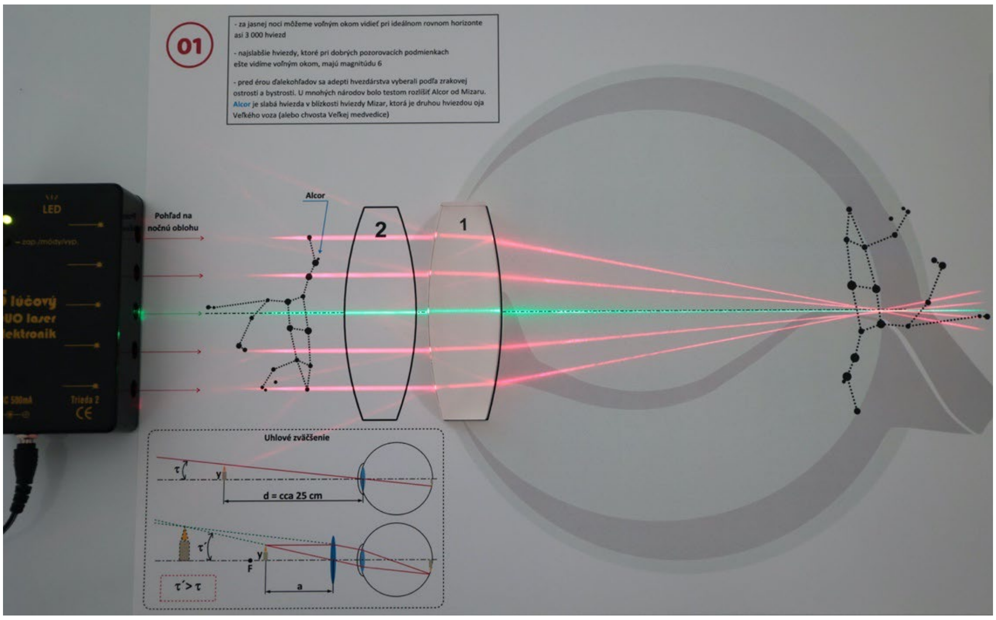
The same principle is used in binoculars, where the lens of the object-glass focuses the rays from the observed object in front of the eyepiece and we look at this reduced image through the eyepiece lens as through a magnifying glass.

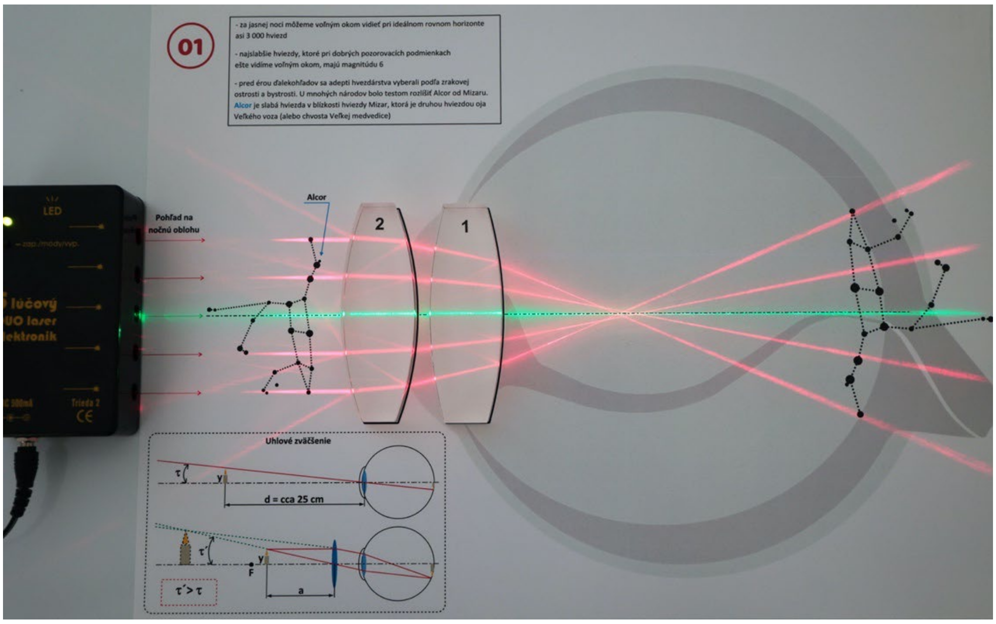
Activity 3:

Use your finger to cover the upper beam from the place where it radiates and which passes through the "nose" of the constellation Ursa Major. Observe that the lower beam is obscured on the retina.

Summary 3:

Although the image on the retina is inverted, the brain inverts the image and we perceive it as real (direct). Accommodation (focusing) is very important for astronomical observations.
With the eye not accommodated, a sharp image is created on the retina for distant objects, and close objects form an image behind the retina. With the accommodated eye, a sharp image is created for close objects and the distant ones are projected in front of the retina.
Visual acuity decreases with the intensity of light, therefore scotopic (night) vision occurs during night observations.
Adaptation to darkness is one of the most important parts of preparation before night observation. Sufficient adaptation occurs after about 30 min. staying in the dark and the eye is more sensitive to light than on a clear day.
You can see a low-light object better if you do not look at it directly. This is lateral vision, which is the most commonly used form of astronomers.





TASK 2: VISIBLE PART OF THE SPECTRUM – DISPERSION OF LIGHT

Task number: 2

Equipment:

Sheet no. 2, white LED in laser light source, equilateral triangle (prism), lens no. 1, convex mirror, Newton primary mirror - white surface

Preparation:

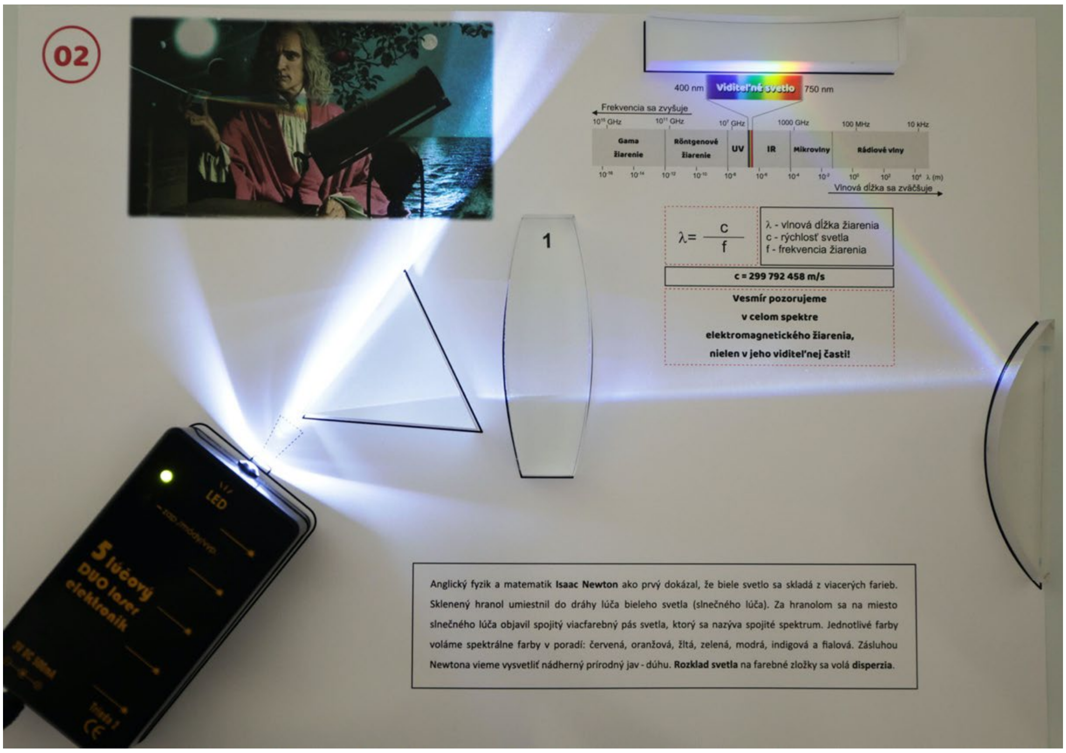
Attach all modules and the laser light source to the marked places on the sheet.

Activity:

On the laser light source, turn on the white LED, which is a beam of white light. On the white surface of the Newton primary mirror, observe the visible spectrum of electromagnetic radiation - the dispersion of light into its coloured components (rainbow).

Summary:

We observe the universe in the entire electromagnetic spectrum, not just in its visible part. However, with the eye, we see only a small part of it.



TASK 3A: DAY AND NIGHT, NOON AND MIDNIGHT, SUNRISE AND SUNSET

Task number: 3

Equipment:

Sheet no. 3, LED light source, Earth

Preparation:

Attach the LED light source, representing the Sun, to the marked place on the sheet. Attach the Earth module, with the black part of the rotating disk always on the right, which shows where the shadow is (the far side of the Earth from the Sun). Always turn only the Earth module and hold the rotating disk in place with your fingers, or turn the whole module and turn the rotating disk to its original position.

Activity 1:

The first part of the task presents day and night.
Place the Earth module so that the marked position of Eastern Europe (red dot on the map) faces the Sun and the opposite side of the module is covered by the black part of the rotating disk. Observe that there is the day in our hemisphere and night in the opposite direction.

If the position of Eastern Europe is marked on the Earth module anywhere under the translucent part of the disk, there is a day in Eastern Europe. If the position of Eastern Europe is marked on the Earth module anywhere under the dark part of the disk, it is night in Eastern Europe.

Activity 2:

The second part of the task presents noon and midnight.
Attach the Earth module so that the marked position of Eastern Europe (red dot on the map) points to the Sun and is exactly in the middle of it. When the Sun is in the zenith (directly above the head), it is noon. Rotate the Earth in the direction of its rotation by 180 degrees so that the position of Eastern Europe is covered by the black part and so that it is exactly in the middle of the black part. When the Sun is on the opposite side of the Earth, it is midnight.

Help you to precisely set the marked position of Eastern Europe on the Earth module by turning the upper rotating disk and then always return it to the correct position - the black part of the rotating disk is always located on the right, which shows where the shadow is (the far side of the Earth from the Sun).

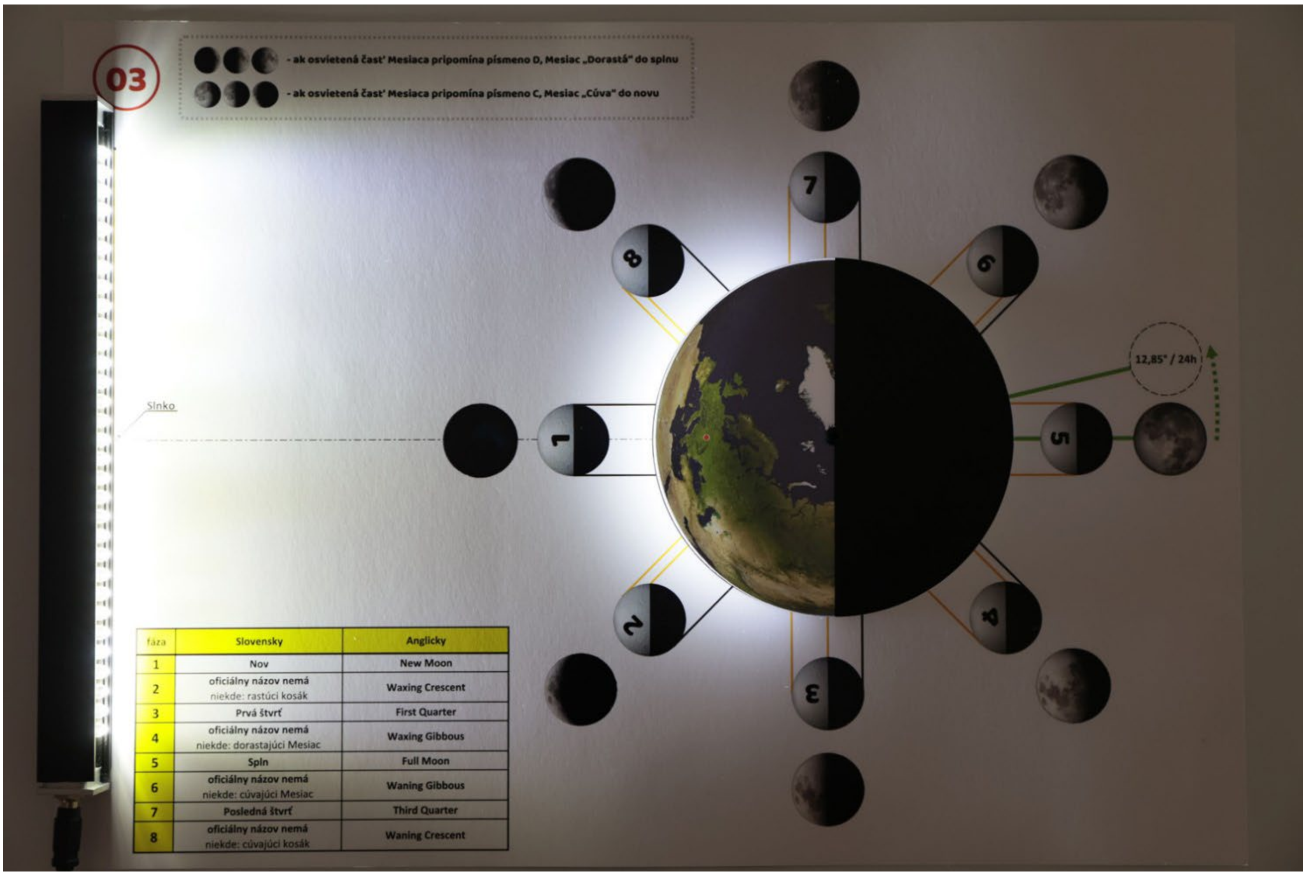
Activity 3:

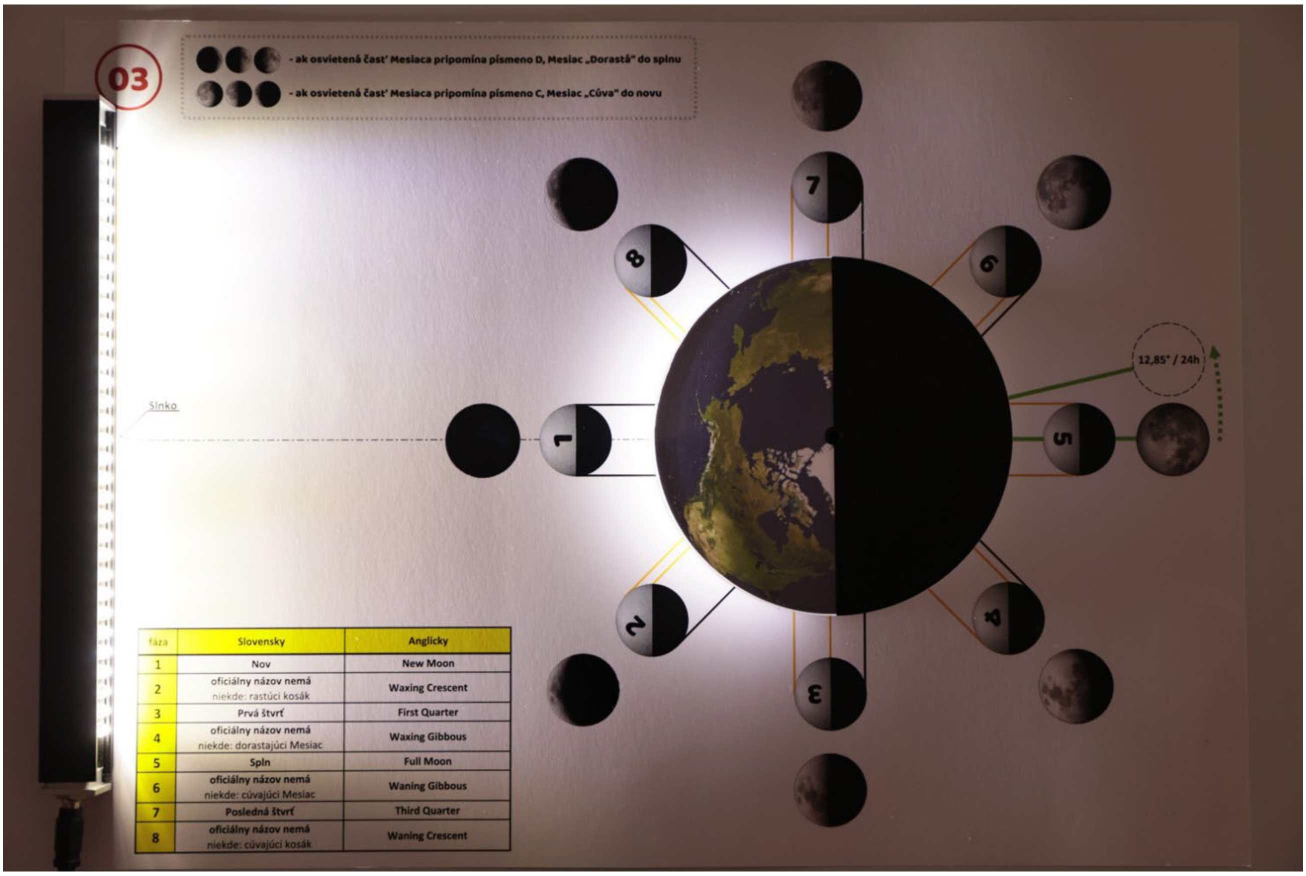
The third part of the task presents the sunrise and sunset.
Sunrise - turn the Earth in the direction of its rotation so that the marked position of Eastern Europe is at the turn-about of day and night and the Sun shines from the east (on the map area of Russia). In the morning the Sun is rising.

Sunset - turn the Earth in the direction of its rotation so that the position of Eastern Europe is again marked on the border of day and night and the Sun shines from the west (on the map area of America). In the evening the Sun is in the west.

Summary:

By rotating the Earth around its own axis, there is an appearent movement of the Sun across the sky. In the morning the Sun is rising in the east. At exactly noon the Sun is heading south and is highest in the sky. It proceeds further west, where it sets in the evening. At night, the Sun shines on the opposite side of the globe. At midnight it shines exactly on the opposite side from the observer. In the morning it rises again in the east.




03
- ak osvietená časť Mesiaca pripomína písmeno D, Mesiac „Dorastá" do spinu
- ak osvietená časť Mesiaca pripomína písmeno C, Mesiac „Cúva" do novu
Slnko
12,85° / 24h
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8
fáza | Slovensky | Anglicky
1 | Nov | New Moon
2 | oficiálny názov nemá niekde: rastúci kosák | Waxing Crescent
3 | Prvá štvrť | First Quarter
4 | oficiálny názov nemá niekde: dorastajúci Mesiac | Waxing Gibbous
5 | Spln | Full Moon
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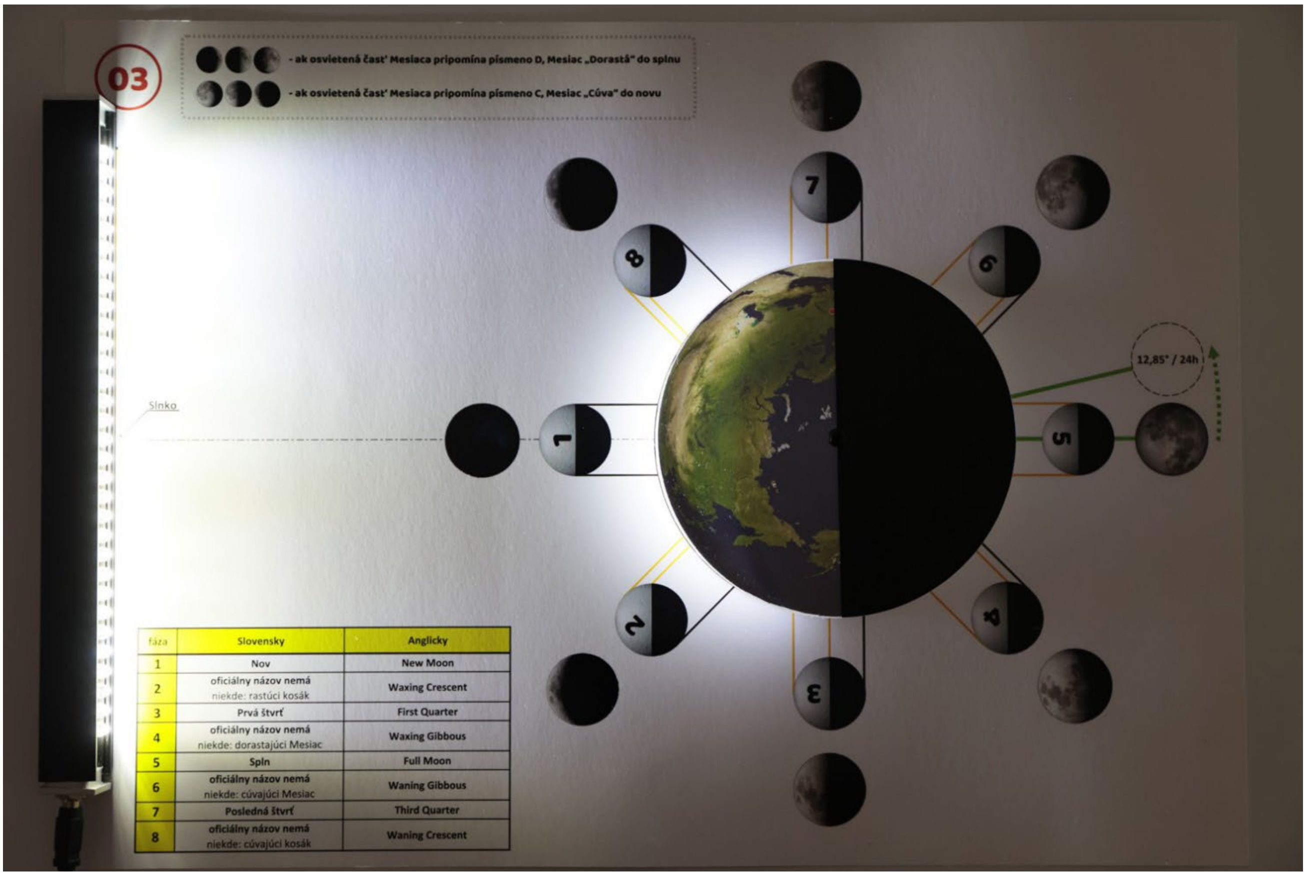
8 | oficiálny názov nemá niekde: cúvajúci kosák | Waning Crescent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TASK 3B: MOVEMENTS OF THE MOON

Task number: 4

Equipment:

Sheet no. 3, LED light source, Moon

Preparation:

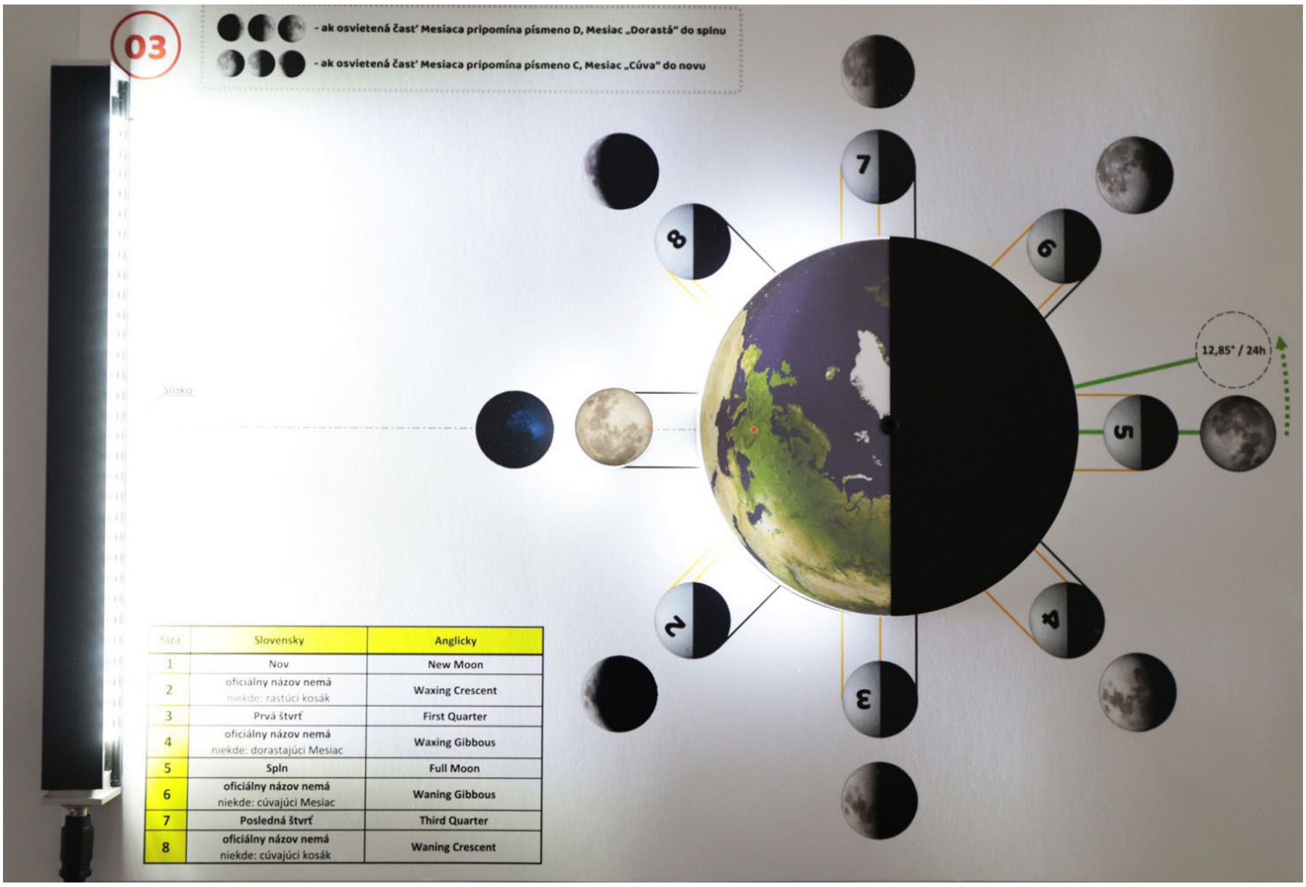
Attach the LED light source, representing the Sun, to the marked place on the sheet. Place the Moon on position no. 1 so that the red line on its surface points to the drawn Earth in the sheet (the Earth module is not used in this task).

Activity:

Move the Moon gradually in all positions from 1 to 8 so that the red line always points to the drawn Earth in the sheet.

Summary:

The Moon performs two movements - it rotates around its axis and around the Earth. It rotates around the Earth by bound rotation, and therefore only its counter side is still visible, which represents the position of the red line. The Moon will return to the same position relative to the Sun for an average time of 29.530588 days - the synodic Moon.


03
- ak osvietená časť Mesiaca pripomína písmeno D, Mesiac „Dorastá“ do splnu
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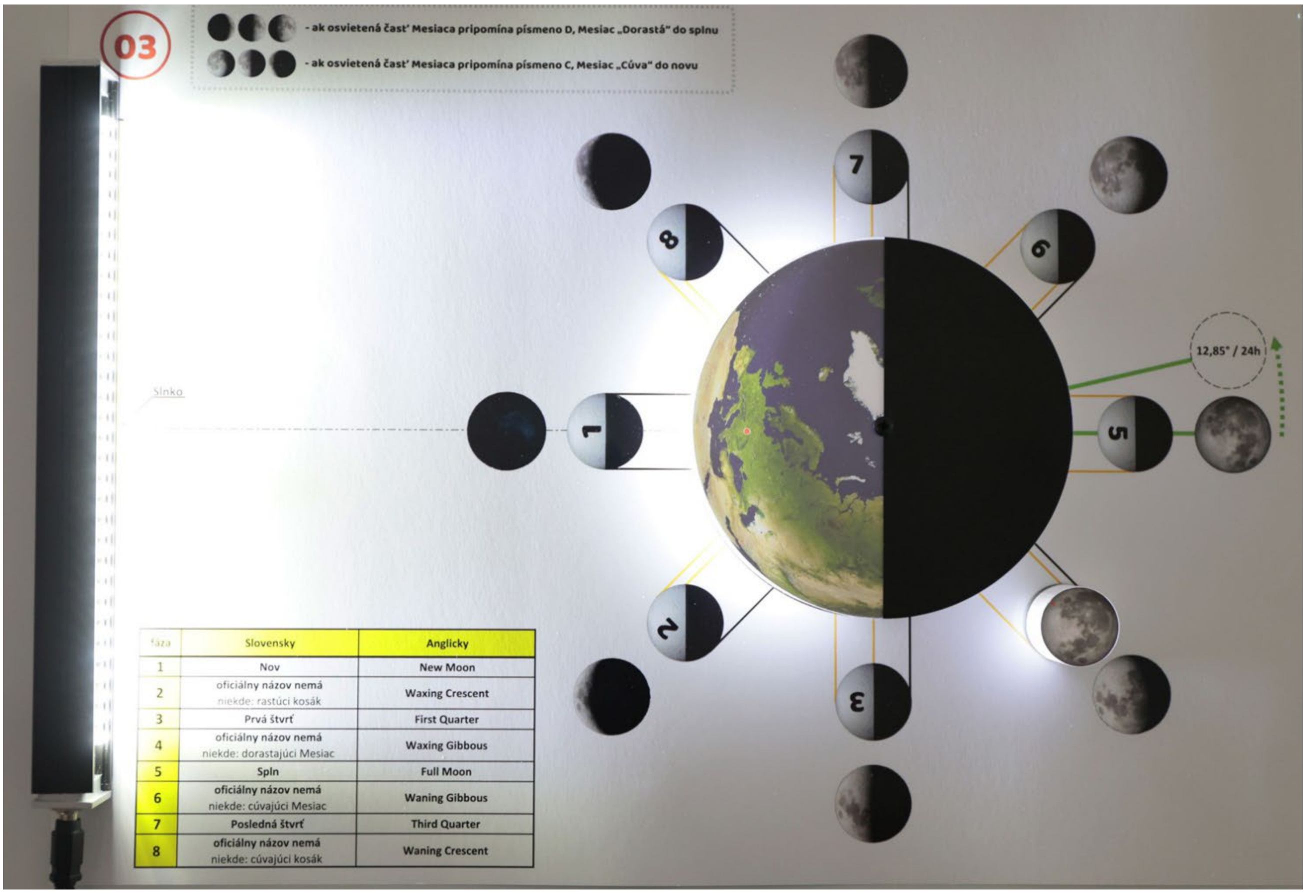
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7 Posledná štvrť Third Quarter
8 oficiálny názov nemá niekde: cúvajúci kosák Waning Crescent

TASK 3C: INDIVIDUAL PHASES OF THE MOON

Task number: 5

Equipment:

Sheet no. 3, LED light source, Moon

Preparation:

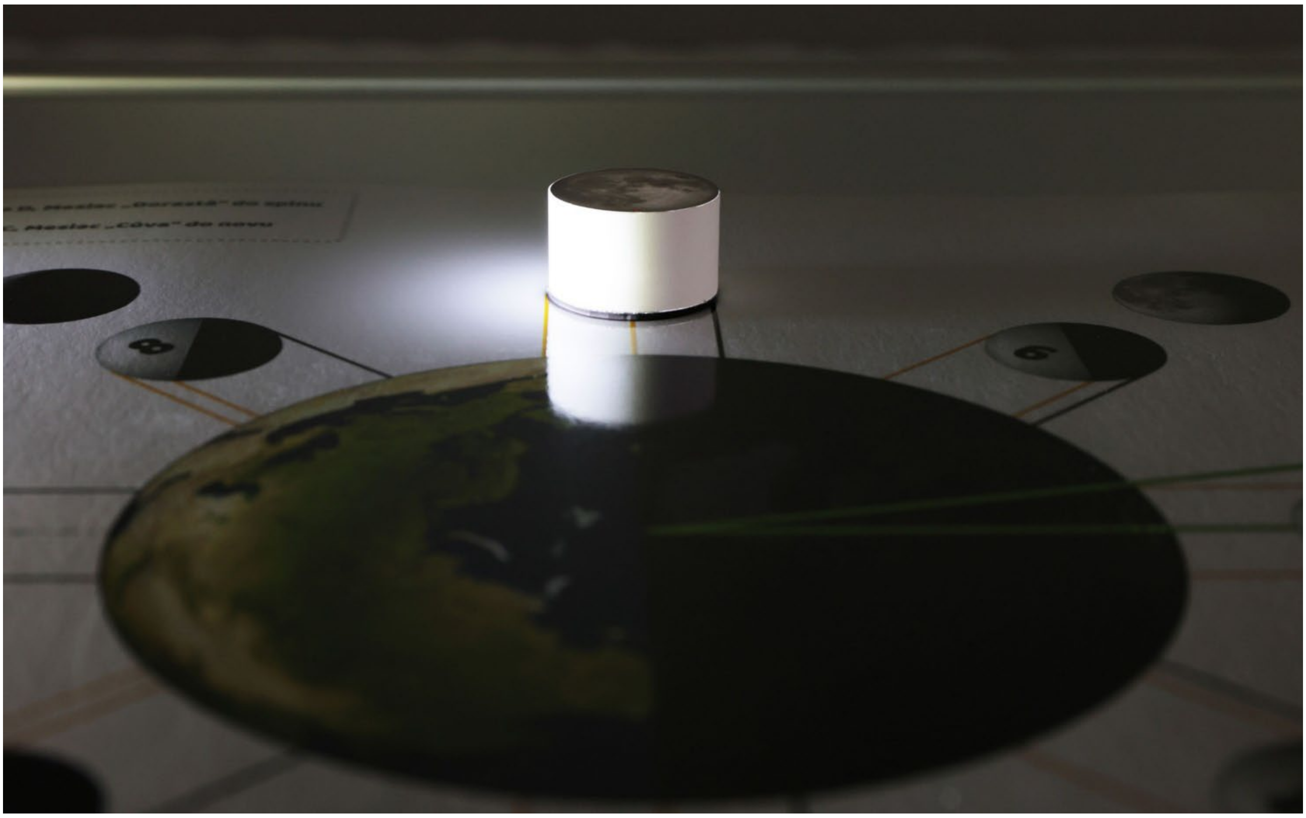
Attach the LED light source, representing the Sun, to the marked place on the sheet. Place the Moon on position no. 1 so that the red line on its surface points to the drawn Earth in the sheet (the Earth module is not used in this task).

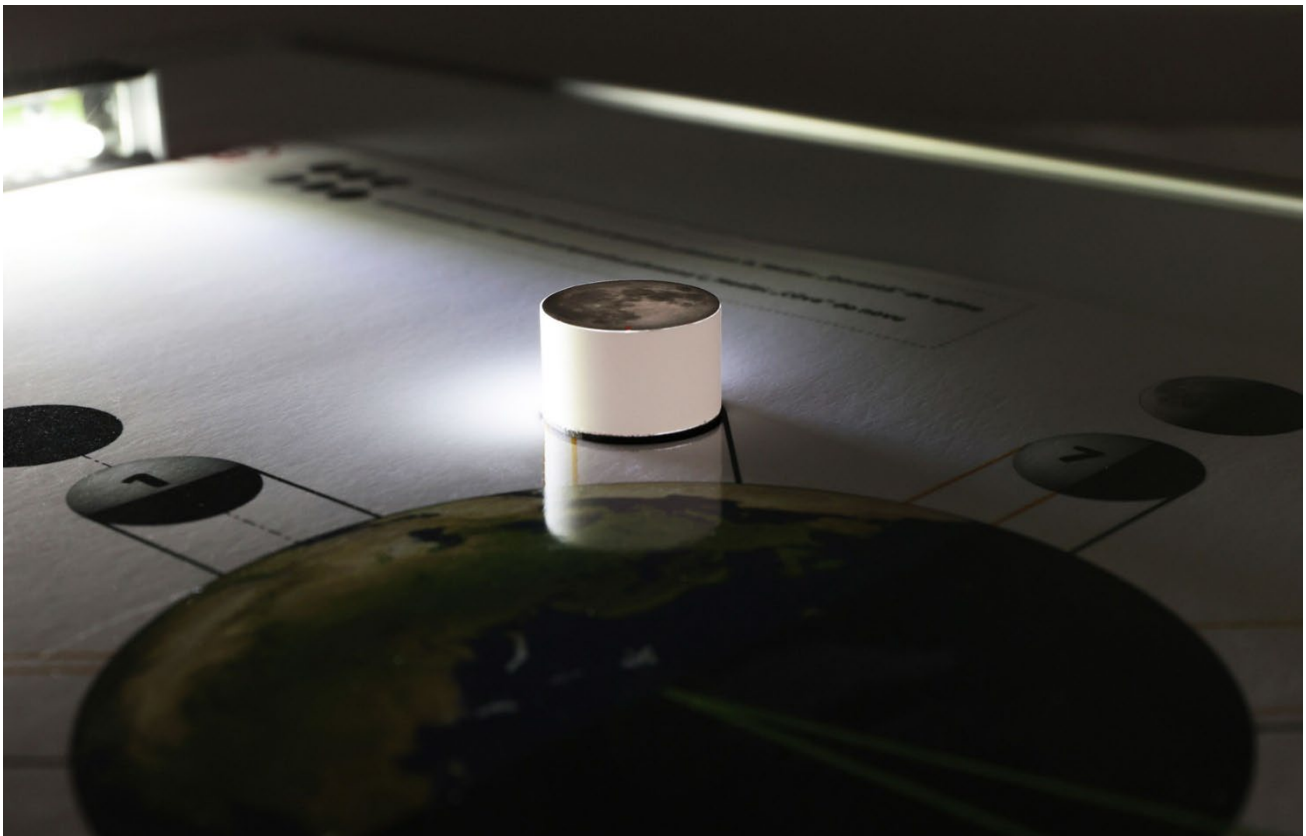
Activity:

Gradually add the Moon to the individual positions of the phases of the Moon from 1 to 8. Always look at the Moon from the center of the Earth towards it. Observe gradually the illuminated part of it, which shows the given phase of the Moon.

Summary:

The yellow lines in the sheet show in which part the Moon is illuminated by the Sun. The pictures above the numbers of the individual positions show its real appearance, as seen in the sky. The table in the sheet shows the names of its individual phases.





TASK 3D: VIEWS OF THE PHASES OF THE MOON FROM DIFFERENT LOCATIONS ON THE EARTH

Task number: 6

Equipment:

Sheet no. 3, LED light source, Moon, Earth, thicker pad under the Moon, thinner pad under the Moon

Preparation:

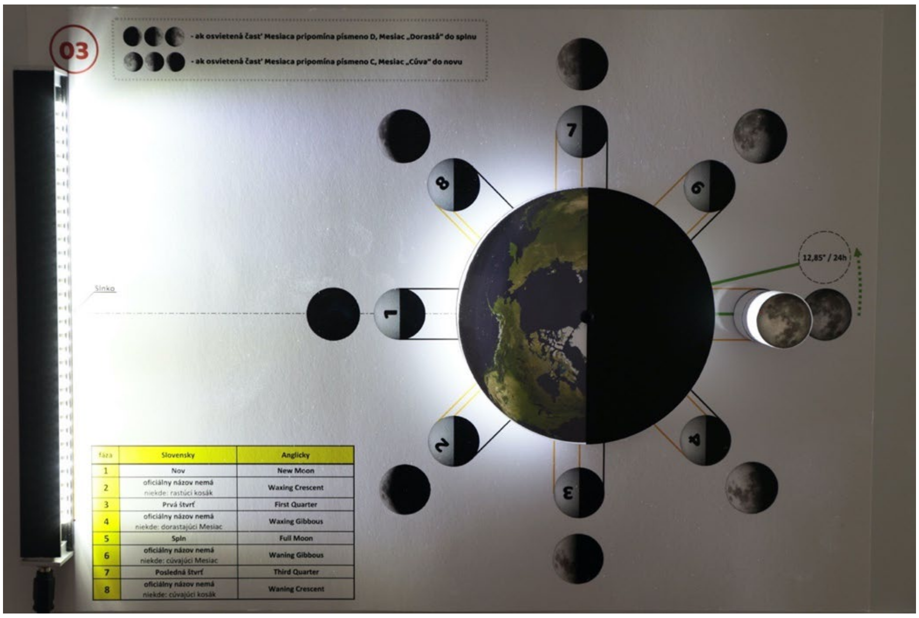
Attach the LED light source, representing the Sun, to the marked place on the sheet. Attach the Earth so that the marked position of Eastern Europe (red dot on the map) points to the full moon, while the position of Eastern Europe is covered by the black part of the rotating disk. Help to set the exact position of Eastern Europe on the Earth module by turning the upper rotating disk, and then always return it to the correct position - the black part of the rotating disk is always located on the right, which shows where the shadow is (the far side of the Earth from the Sun). First, place a thicker pad under the Moon in position no. 5 (full moon), then place a thinner pad under the Moon on it and finally place the Moon on them. From the position of Eastern Europe, you can see the full moon.

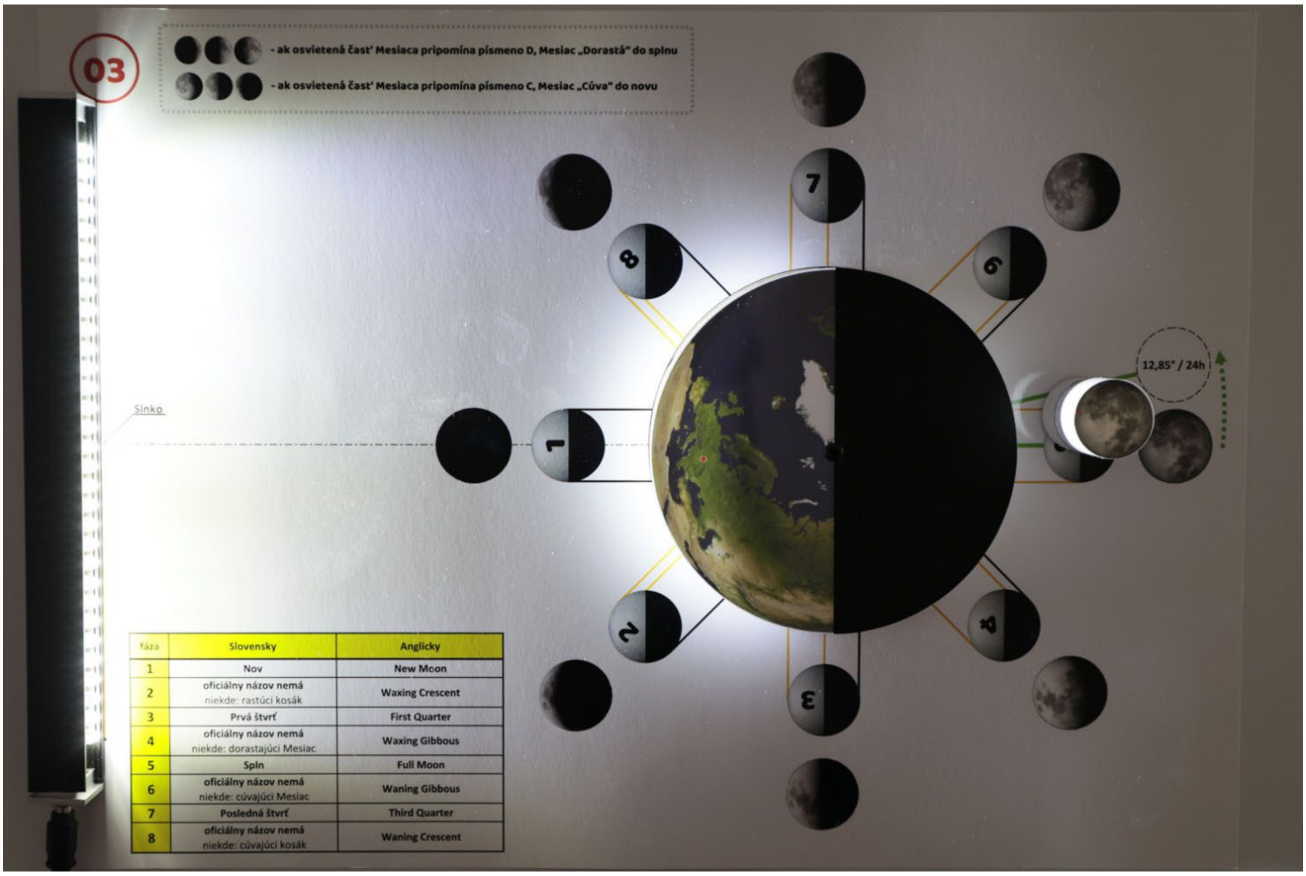
Activity:

According to the task no. 3 we already know that the position of the modules in the sheet means that in Eastern Europe is night, more precisely midnight and the Moon is in full moon phase. Rotate the Earth 180 degrees, which represents 12 hours. It's noon in Eastern Europe. During that time, the Moon will move only 6.42 degrees from its original position.
Observe that people on the opposite side of the globe also see about the same phase of the Moon (in this case full moon), but only slightly shifted.

Summary:

The green lines in the sheet show the movement of the Moon against the stellar background (12.85 degrees in 24 hours).

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TASK 4A: TOTAL SOLAR ECLIPSE

Task number: 7

Equipment:

Sheet no. 4, LED light source, Moon, Earth

Preparation:

Attach the LED light source, representing the Sun, to the marked place on the sheet. Attach the Earth to the marked place.

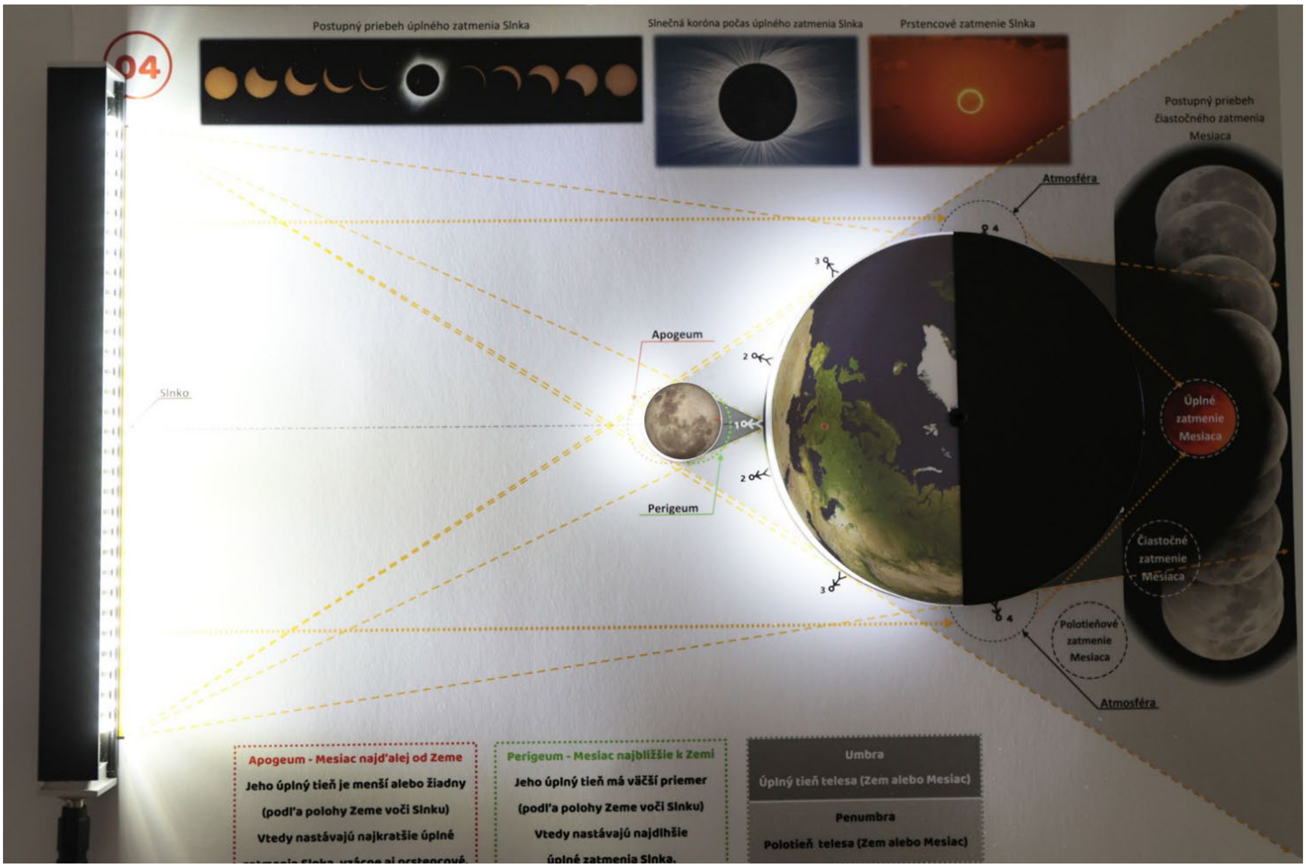
Activity:

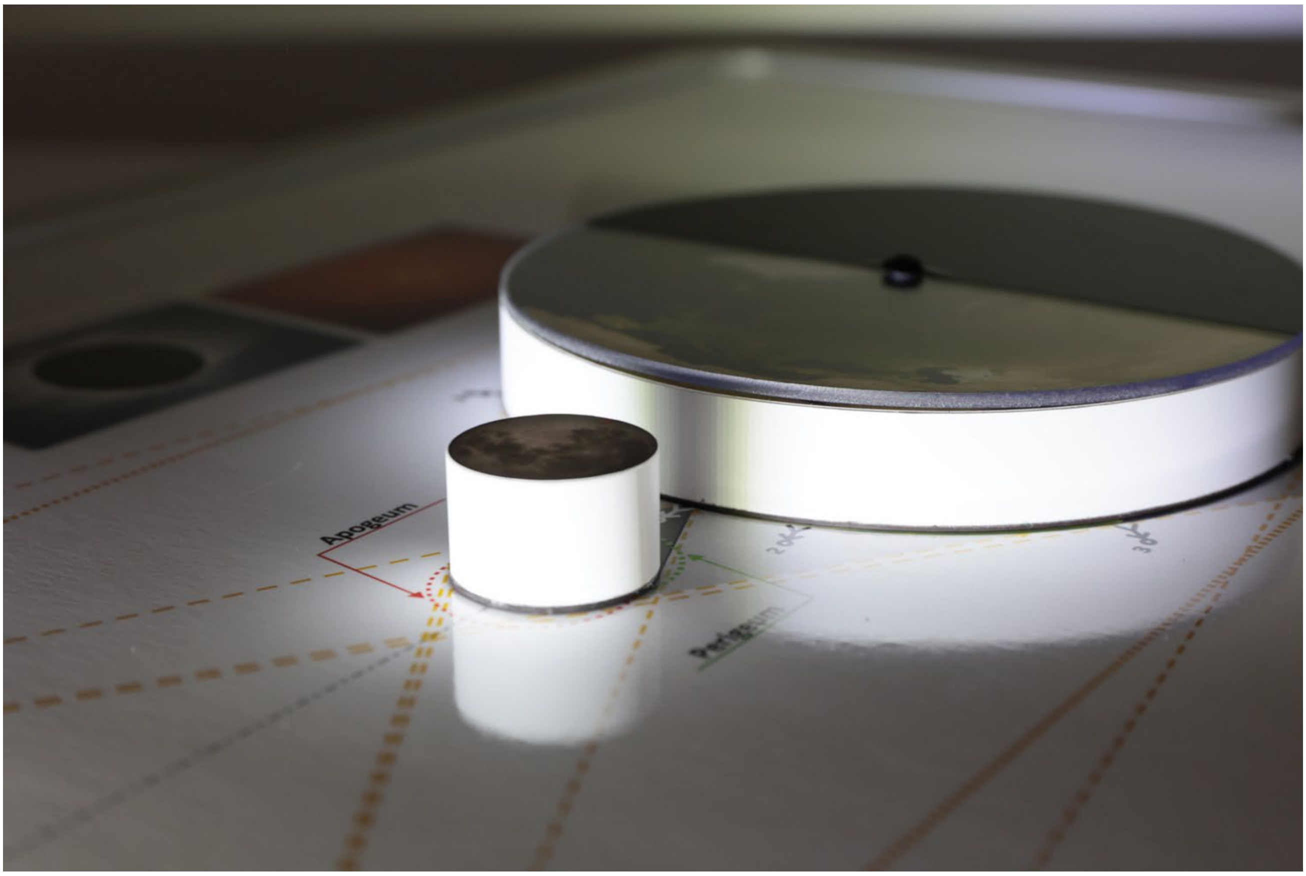
Place the Moon in the position of the image of the Moon - between the Sun and the Earth. Watch the Moon creates a shadow on Earth. Look at the Earth from the side of the Sun.

Summary:

A total solar eclipse occurs only in the new moon phase when the Sun, Moon and Earth are in the plane. If they are not in the plane, then a common new moon phase occurs.

The observer at position no. 1 on Earth is in “full shadow of the Moon” – lunar umbra and sees a total solar eclipse.
The observer at positions no. 2 on Earth is in “half shade of the Moon” – lunar penumbra and sees a partial solar eclipse (its course is shown in the upper left image of the sheet).
The observer at positions no. 3 on Earth is not in any shadow and eclipse, which presents a normal day.


04
Postupný priebeh úplného zatmenia Slnka
Slnečná koróna počas úplného zatmenia Slnka
Prstencové zatmenie Slnka
Postupný priebeh čiastočného zatmenia Mesiaca
Atmosféra
Slnko
Apogeum
Perigeum
Úplné zatmenie Mesiaca
Čiastočné zatmenie Mesiaca
Polotieňové zatmenie Mesiaca
Atmosféra
Apogeum - Mesiac najďalej od Zeme
Jeho úplný tieň je menší alebo žiadny
(podľa polohy Zeme voči Slnku)
Vtedy nastávajú najkratšie úplné
Perigeum - Mesiac najbližšie k Zemi
Jeho úplný tieň má väčší priemer
(podľa polohy Zeme voči Slnku)
Vtedy nastávajú najdlhšie
úplné zatmenia Slnka.
Umbra
Úplný tieň telesa (Zem alebo Mesiac)
Penumbra
Polotieň telesa (Zem alebo Mesiac)


Apogeum
Perigeum

Task 4b: Total lunar eclipse

Task number: 8

Equipment:

Sheet no. 4, LED light source, Moon, Earth

Preparation:

Attach the LED light source, representing the Sun, to the marked place on the sheet. Attach the Earth to the marked place.

Activity:

Place the Moon in the position of the image of the Moon behind the Earth. Observe how the whole Moon is in the shadow of the Earth.

Summary:

The observer at positions no. 4 on Earth observes a total lunar eclipse. The Moon is in “complete shadow of the Earth” - umbra. A total lunar eclipse occurs only in the full moon phase when the Sun, Earth, and Moon are in one plane.

Task 4c: Blood Moon

Task number: 9

Equipment:

Sheet no. 4, LED light source, Moon, Earth, Earth's atmosphere

Preparation:

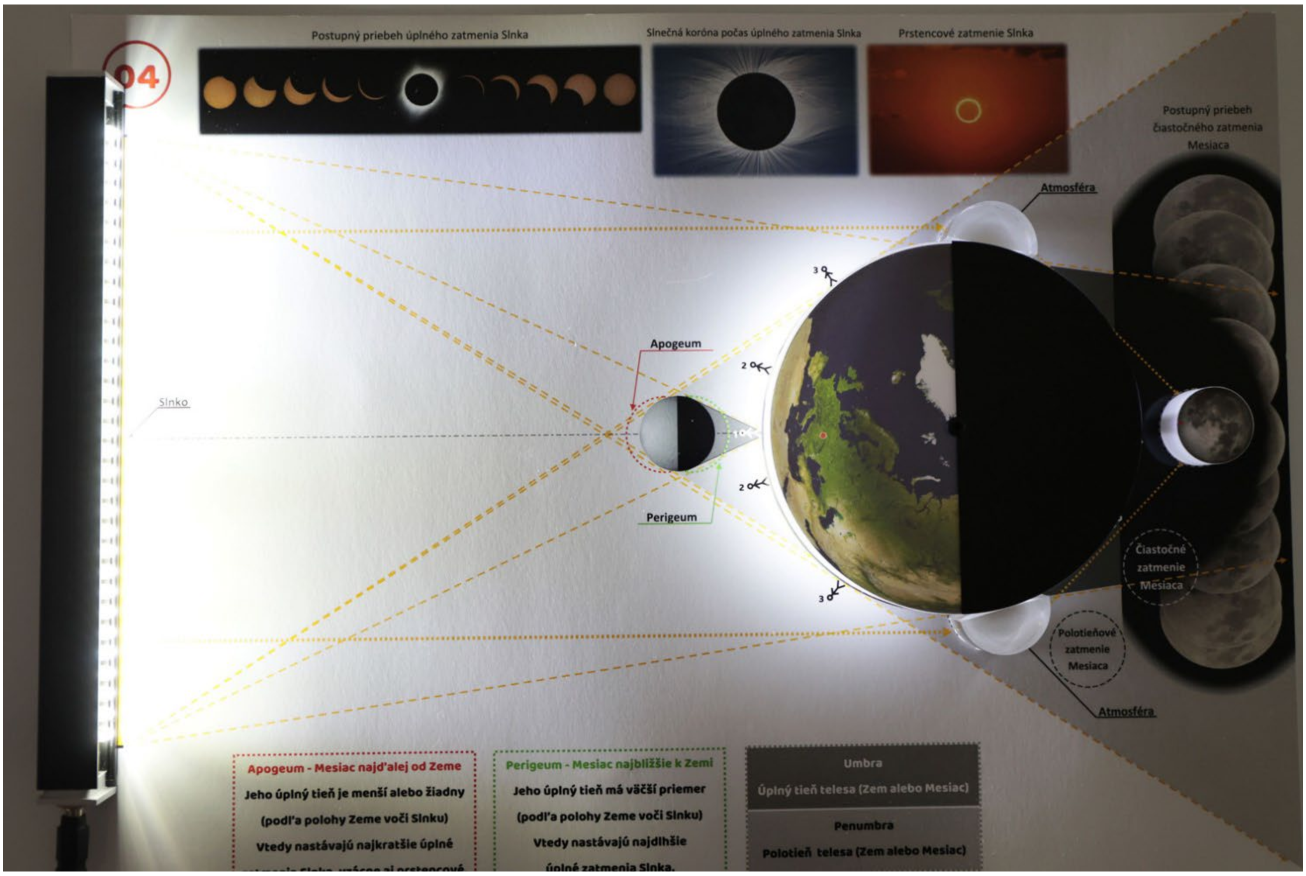
Attach the LED light source, representing the Sun, to the marked place on the sheet. Attach the Earth to the marked place. Attach the Moon to the picture with its orange colour behind the Earth.

Activity:

Attach the Atmosphere of the Earth, represented by two semicircles, to their marked positions opposite each other, behind the poles of the Earth. On the Moon, observe how it is partially illuminated. Remove one semicircle of the Earth's Atmosphere and watch the part of the Moon "go out".

Summary:

The red (or "bloody") Moon is a phenomenon that occurs during a total lunar eclipse when the Moon enters “the complete shadow of the Earth” - umbra. However, the atmosphere of the Earth causes the refraction of the Sun's rays and some of the light reaches the earth’s umbra. The red colour is caused by the scattering of blue light in the atmosphere - that's why the sky is blue and the red component of the light moves to the Moon, thus turning it red. In this case, it's seen only the illumination of the Moon, but not a colour change - the atmosphere is still a little thicker and more blue light is scattered in it.


Postupný priebeh úplného zatmenia Slnka
Slnečná koróna počas úplného zatmenia Slnka
Prstencové zatmenie Slnka
04
Postupný priebeh čiastočného zatmenia Mesiaca
Atmosféra
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Slnko
Perigeum
Čiastočné zatmenie Mesiaca
Polotieňové zatmenie Mesiaca
Atmosféra
Apogeum - Mesiac najďalej od Zeme
Jeho úplný tieň je menší alebo žiadny
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Perigeum - Mesiac najbližšie k Zemi
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Umbra
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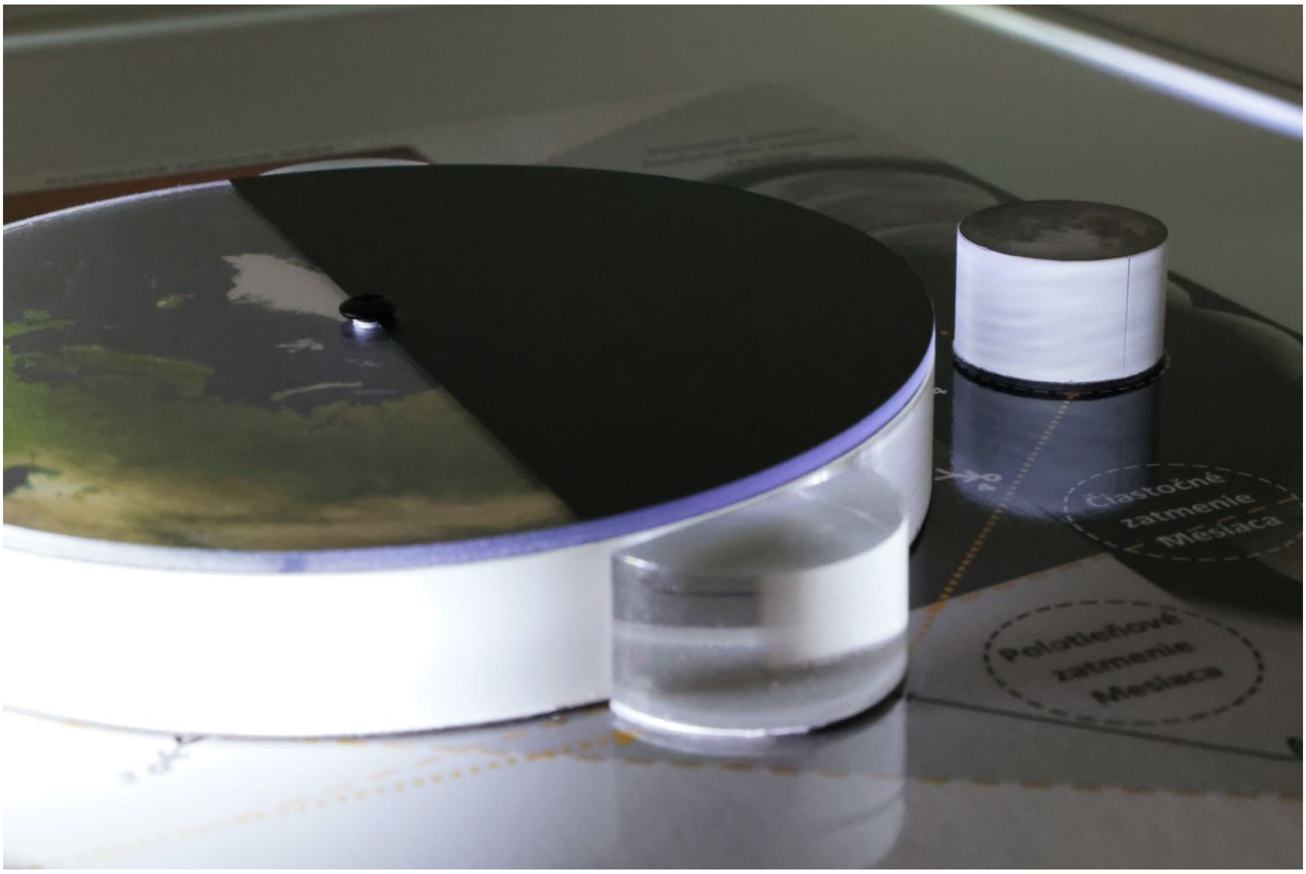
Penumbra
Polotieň telesa (Zem alebo Mesiac)


Čiastočné zatmenie Mesiaca
Polotieňové zatmenie Mesiaca

TASK 4D: PARTIAL AND PENUMBRAL LUNAR ECLIPSE

Task number: 10

Equipment:

Sheet no. 4, LED light source, Moon, Earth, thicker pad under the Moon, thinner pad under the Moon

Preparation:

Attach the LED light source, representing the Sun, to the marked place on the sheet. Attach the Earth to the marked place.

Activity 1:

First, place a thicker pad under the Moon in the total lunar eclipse position, then place a thinner pad under the Moon and finally place the Moon on them. Observe the full moon phase when the whole Moon is visible.

Summary 1:

The Moon has a plane of rotation inclined 5.2 degrees from the plane of rotation of the Earth around the Sun. If this inclination does not exist and all three bodies were orbiting in one plane, there would be a total lunar eclipse and total solar eclipse in each new moon phase. If they are not in one plane, then the usual full moon phase occurs.

Activity 2:

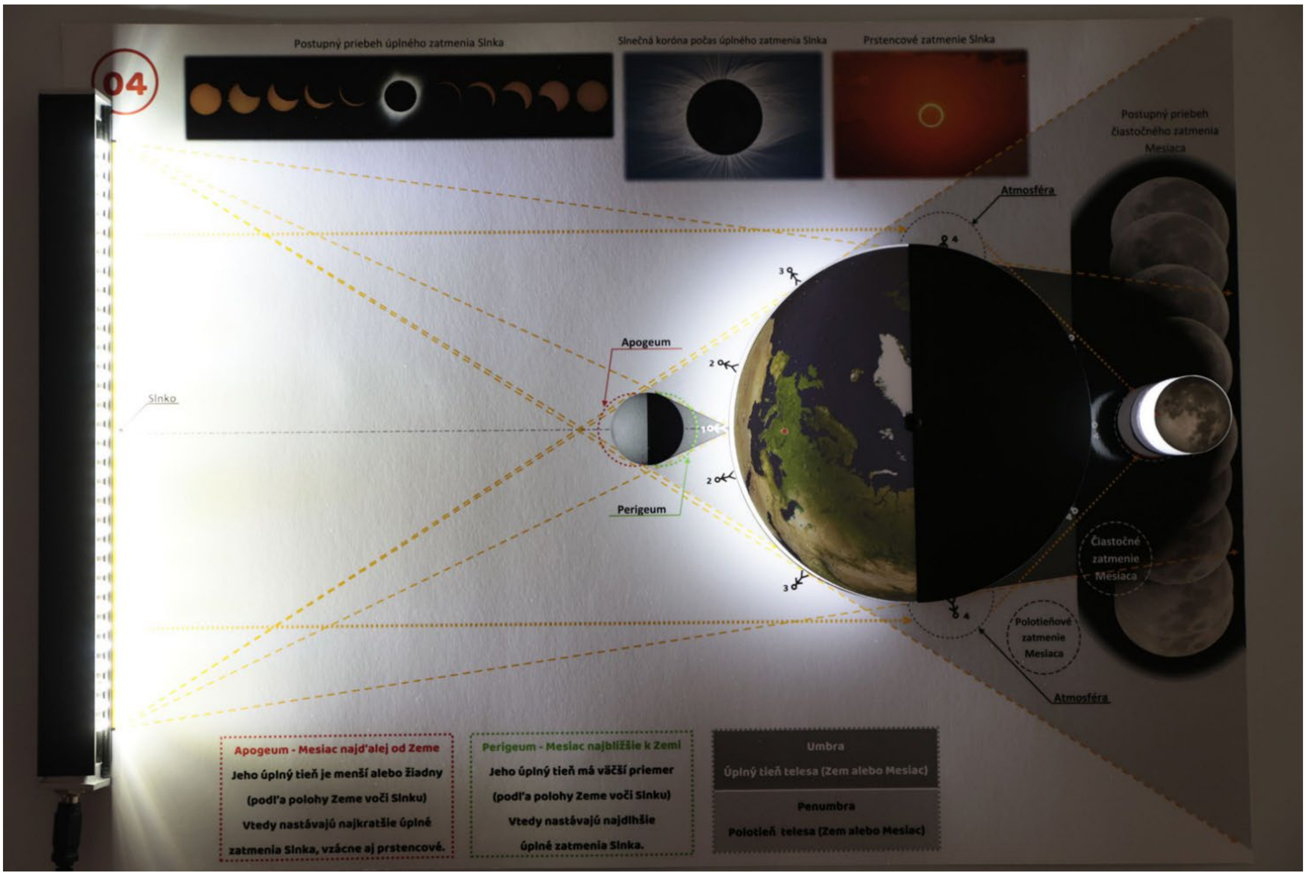
Place a thinner pad under the Moon in the position of a total or partial lunar eclipse and place the Moon on it. Observe that the Moon has partially entered the shadow of the Earth.

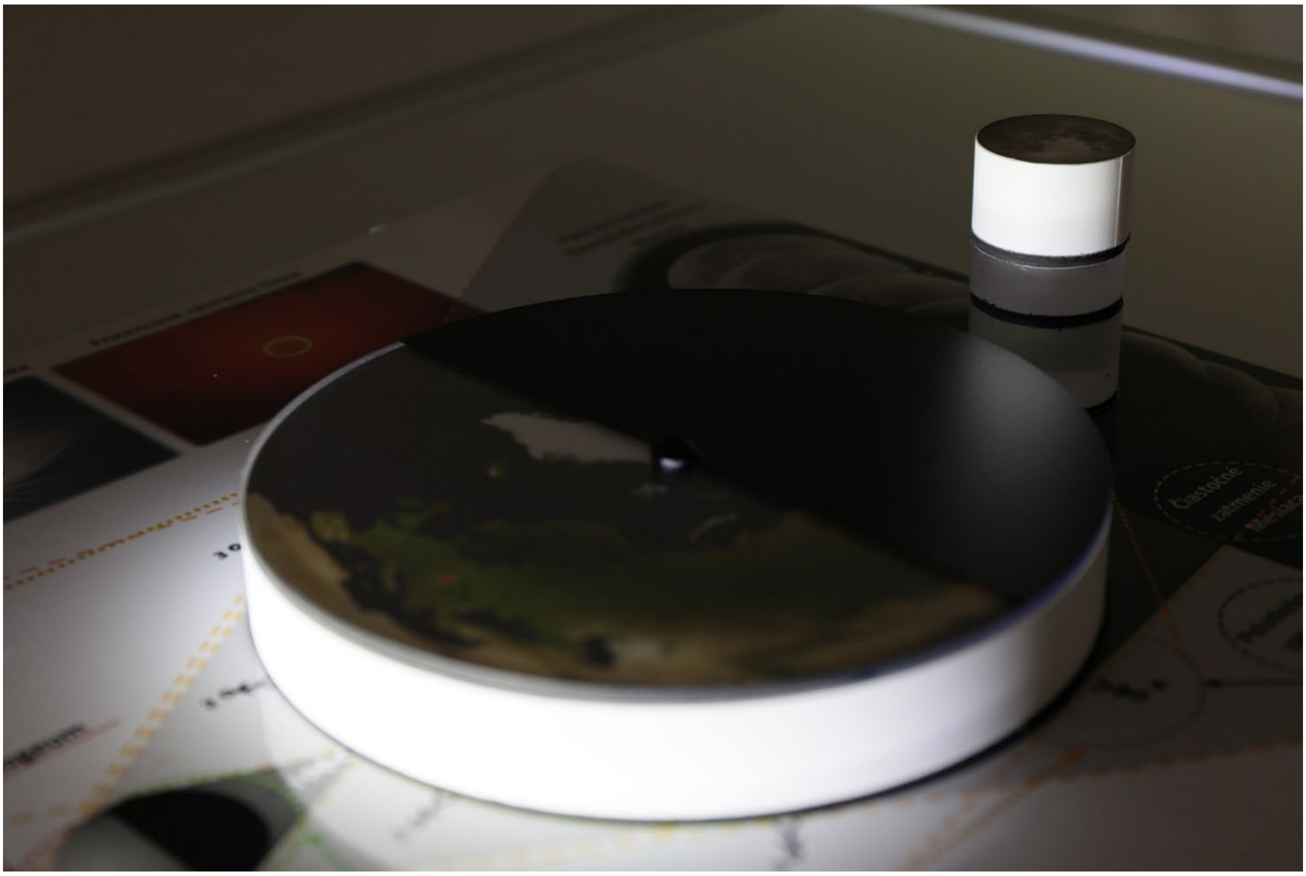
Summary 2:

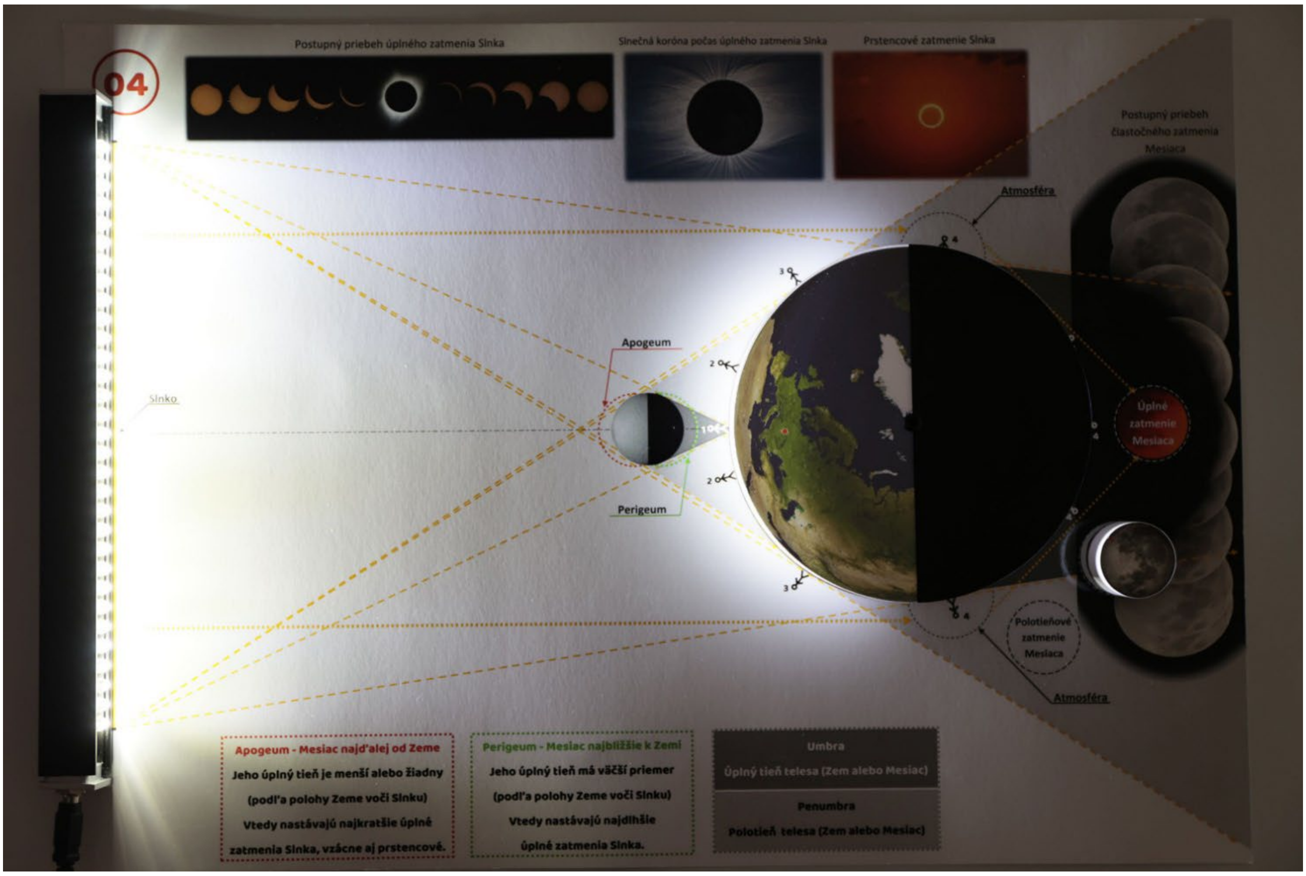
As the Moon approaches the plane of rotation of the Earth around the Sun, it enters the earth's umbra, but not in its entire volume. This is a partial lunar eclipse. With each total lunar eclipse, there is first a partial lunar eclipse.

Summary 3:

Before each total and partial lunar eclipse, the Moon first enters the earth's penumbra. Place the Moon at the position of the penumbral lunar eclipse. Its brightness decreases very slightly, which can be observed photometrically only and then the penumbral lunar eclipse occurs.
A penumbral lunar eclipse can occur even without a partial or total lunar eclipse if the Moon is far from the Sun-Earth-Moon plane.


04
Postupný priebeh úplného zatmenia Slnka
Slnečná koróna počas úplného zatmenia Slnka
Prstencové zatmenie Slnka
Postupný priebeh čiastočného zatmenia Mesiaca
Atmosféra
Slnko
Apogeum
Perigeum
Čiastočné zatmenie Mesiaca
Polotieňové zatmenie Mesiaca
Atmosféra
Apogeum - Mesiac najďalej od Zeme
Jeho úplný tieň je menší alebo žiadny
(podľa polohy Zeme voči Slnku)
Vtedy nastávajú najkratšie úplné
zatmenia Slnka, vzácne aj prstencové.
Perigeum - Mesiac najbližšie k Zemi
Jeho úplný tieň má väčší priemer
(podľa polohy Zeme voči Slnku)
Vtedy nastávajú najdlhšie
úplné zatmenia Slnka.
Umbra
Úplný tieň telesa (Zem alebo Mesiac)
Penumbra
Polotieň telesa (Zem alebo Mesiac)




04
Postupný priebeh úplného zatmenia Slnka
Slnečná koróna počas úplného zatmenia Slnka
Prstencové zatmenie Slnka
Postupný priebeh čiastočného zatmenia Mesiaca
Atmosféra
Slnko
Apogeum
Perigeum
Úplné zatmenie Mesiaca
Polotieňové zatmenie Mesiaca
Atmosféra
Apogeum - Mesiac najďalej od Zeme
Jeho úplný tieň je menší alebo žiadny
(podľa polohy Zeme voči Slnku)
Vtedy nastávajú najkratšie úplné
zatmenia Slnka, vzácne aj prstencové.
Perigeum - Mesiac najbližšie k Zemi
Jeho úplný tieň má väčší priemer
(podľa polohy Zeme voči Slnku)
Vtedy nastávajú najdlhšie
úplné zatmenia Slnka.
Umbra
Úplný tieň telesa (Zem alebo Mesiac)
Penumbra
Polotieň telesa (Zem alebo Mesiac)


Polotieňové zatmenie Mesiaca

Task 4e: Partial solar eclipse

Task number: 11

Equipment:

Sheet no. 4, LED light source, Moon, Earth, thinner pad under the Moon

Preparation:

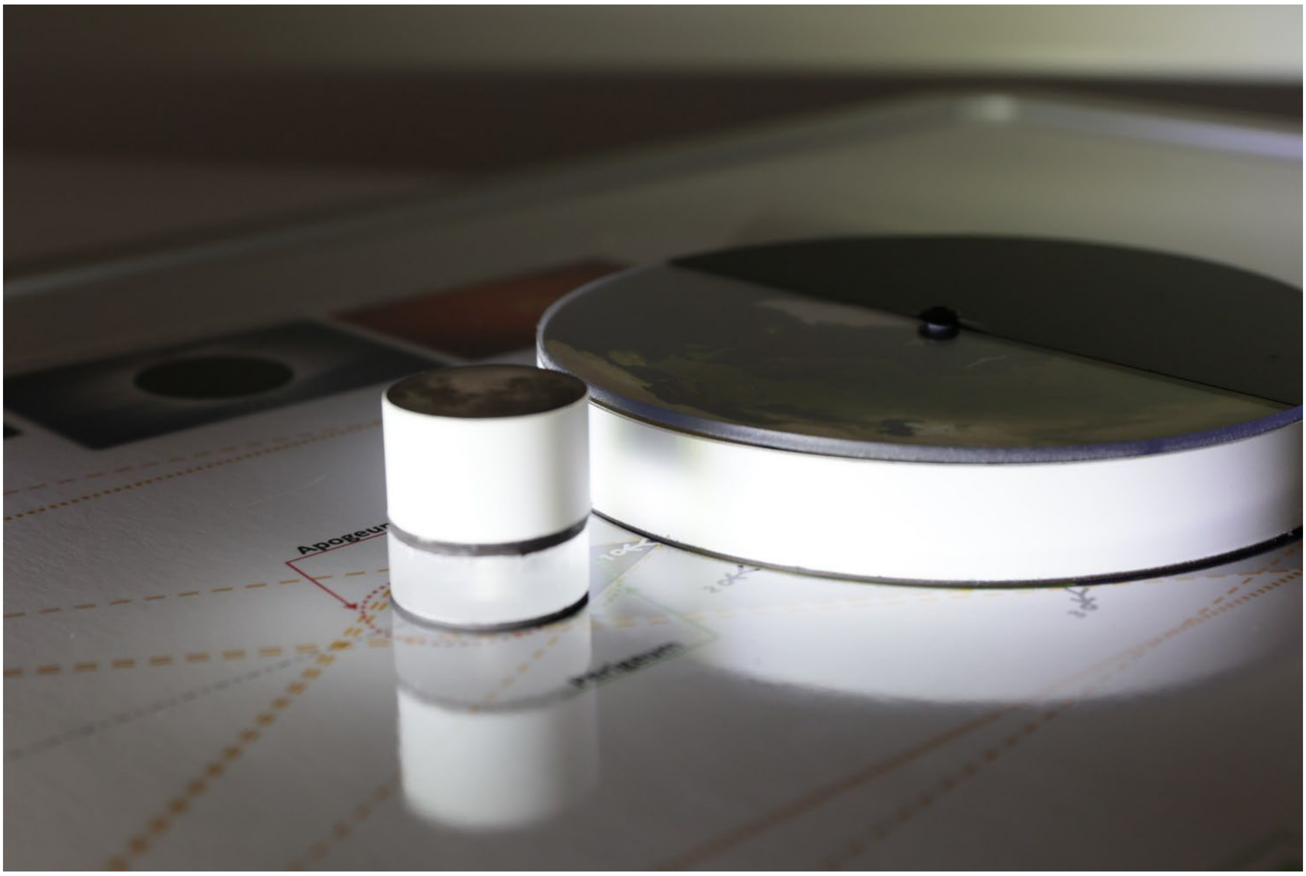
Attach the LED light source, representing the Sun, to the marked place on the sheet. Attach the Earth to the marked place.

Activity:

Place a thinner pad under the Moon in the position of the image of the Moon between the Earth and the Sun and place the Moon on it. Observe that a shadow similar to a total solar eclipse has formed on Earth, but not at the full height of the Earth's module.

Summary:

A partial solar eclipse occurs when the Moon gets between the Sun and the Earth, but is not completely in the plane with them.



TASK 4F: MOON IN APOGEUM AND PERIGEUM

Task number: 12

Equipment:

Sheet no. 4, LED light source, Moon, Earth

Preparation:

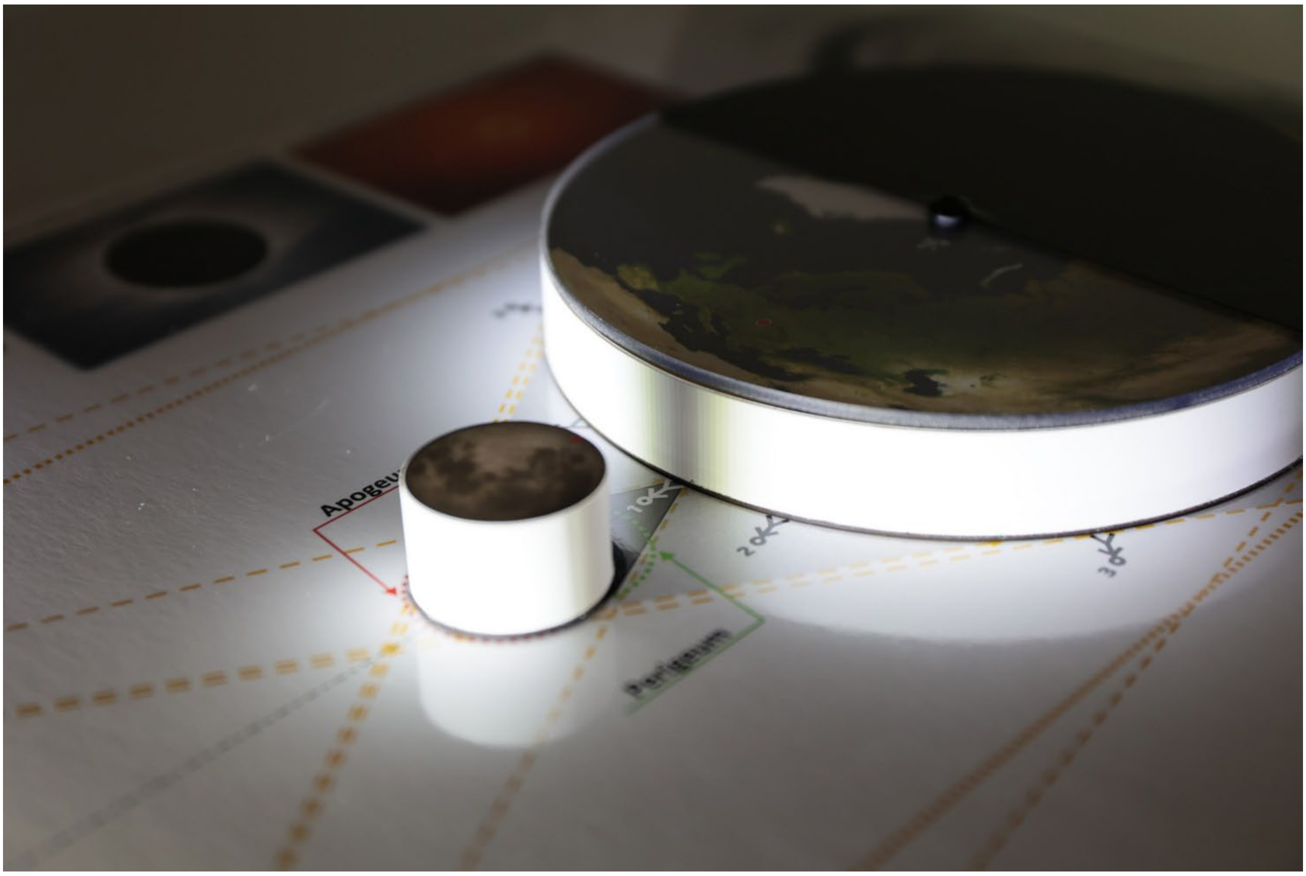
Attach the LED light source, representing the Sun, to the marked place on the sheet. Attach the Earth to the marked place. Attach the Moon first to the position of its image between the Sun and the Earth.

Activity:

Move the Moon to the point perigeum (green dashed line in the sheet) and back to the point apogeum (red dashed line in the sheet).

Summary:

The Moon rotates around the Earth in an ellipse. Once the Moon is closer to the Earth, other times further. The closest point of the Moon to the Earth is the perigeum (approx. 364,397 km) and the farthest point of the Moon from the Earth is the apogeum (approx. 406,731 km).
In the perigeum there is also a phase of the Moon, when it is very large, the so-called Supermoon.


Apogeum
Perigeum


Apogeum
Perigeum

TASK 4G: ANNULAR SOLAR ECLIPSE

Task number: 13

Equipment:

Sheet no. 4, LED light source, Moon, Earth

Preparation:

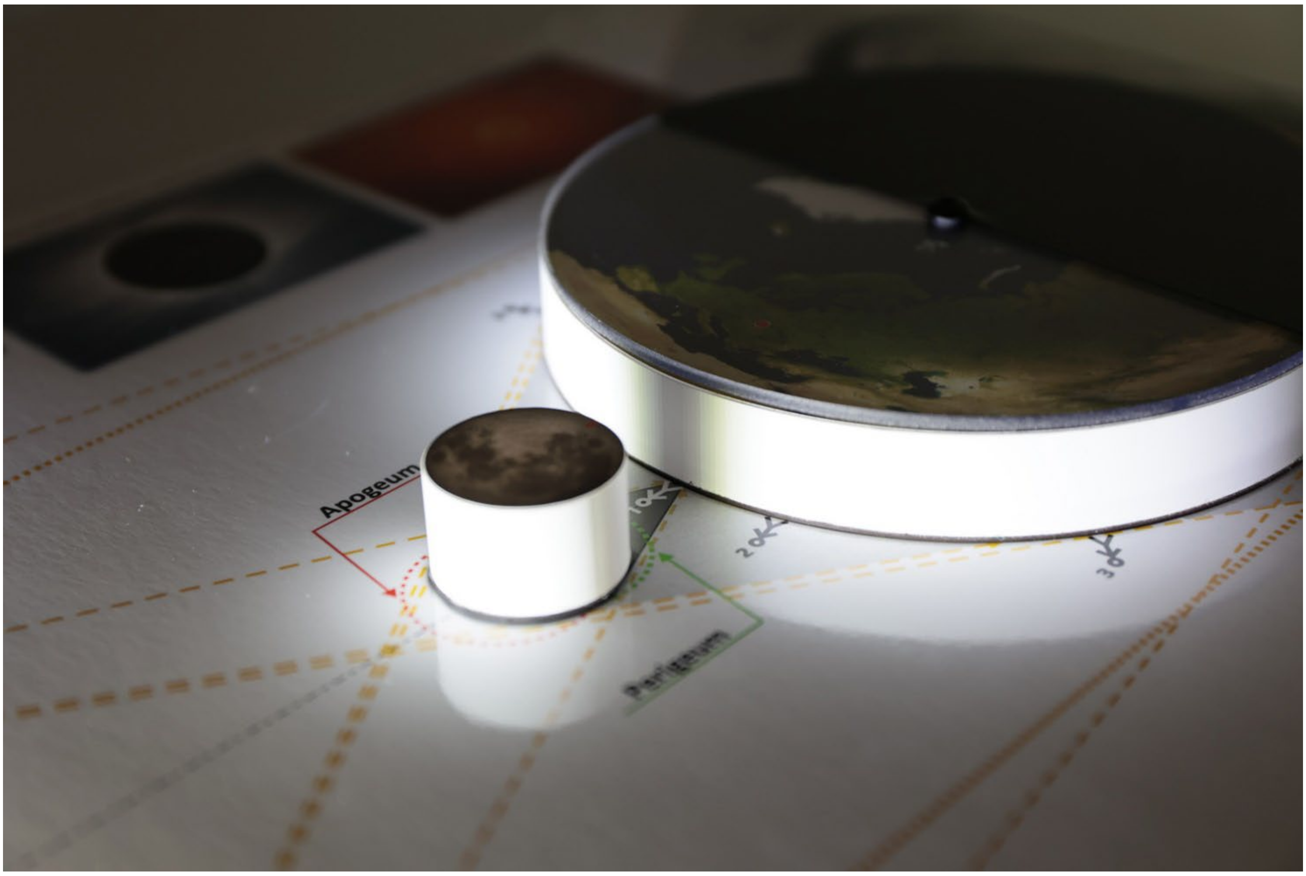
Attach the LED light source, representing the Sun, to the marked place on the sheet. Attach the Earth to the marked place. Attach the Moon first to the position of its image between the Sun and the Earth.

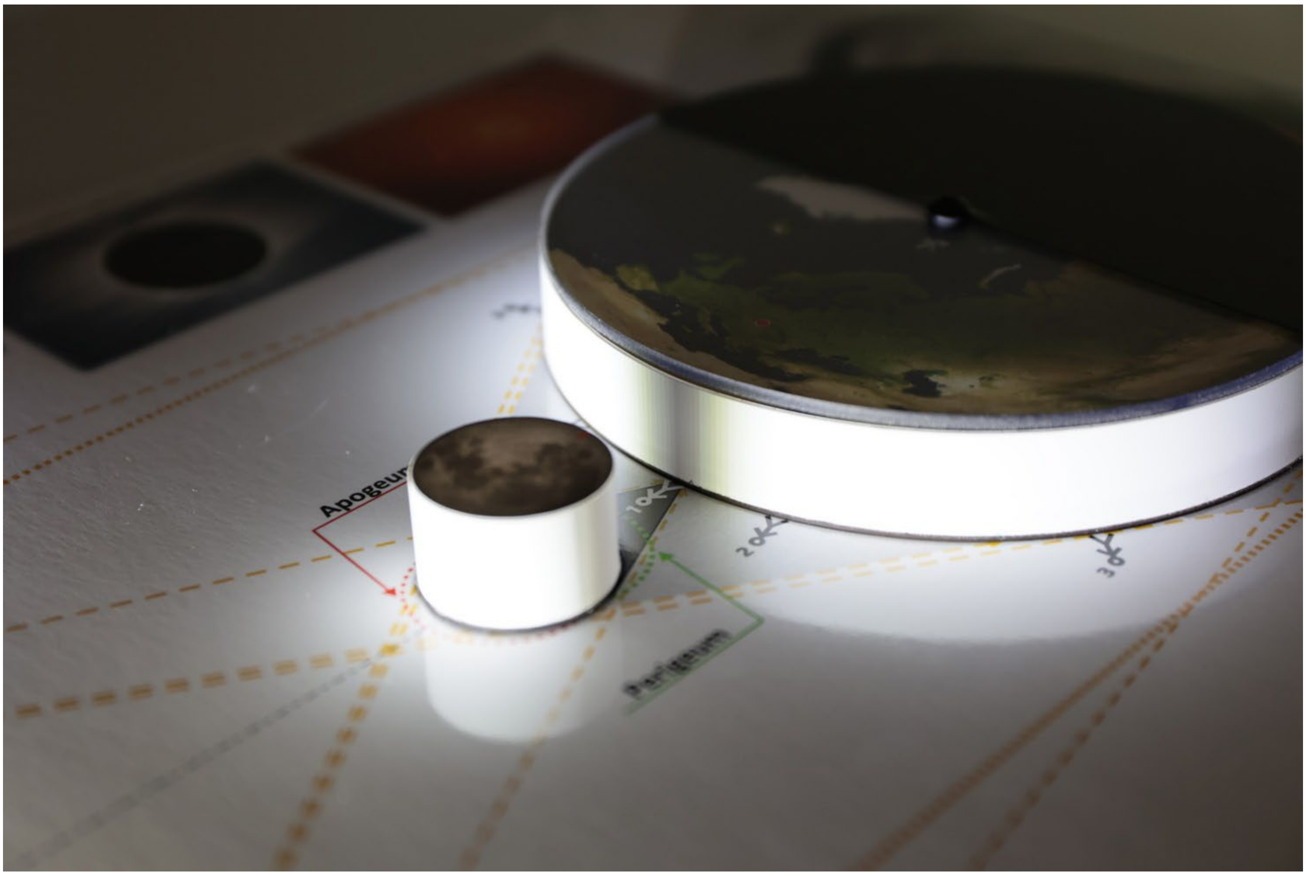
Activity:

First, observe the lunar umbra on Earth (the darkest part of the shadow). Move the Moon to the perigeum point (the green dashed line in the sheet) and observe on the Earth lunar umbra, which is larger than in the average position of the Moon. Move the Moon by attaching it to the top of your finger so that you don't create an unwanted shadow on Earth with your hand.
Move the Moon to the point of the apogeum (red dashed line in the sheet) and at the same time observe on Earth the lunar umbra, which gradually decreases. At one point, the lunar umbra is lost, and then an annular solar eclipse occurs.

Summary:

The annular solar eclipse occurs when the Sun, Moon, and Earth are in one plane, and at the same time, the Moon is so far from the Earth that its apparent disc is smaller than the apparent disc of the Sun. Therefore, on Earth, we observe the ring of the Sun around the Moon. Its illustration is in the upper right image of the sheet. This phenomenon is also influenced by the position of the Earth from the Sun, as the Earth's orbit around the Sun is also elliptical.


Apogeum
Perigeum
10
20
30


Apogeum
Perigeum
10
20
30

Task 5a: Earthshine of the Moon

Task number: 14

Equipment:

Sheet no. 5, LED light source, Moon, Earth

Preparation:

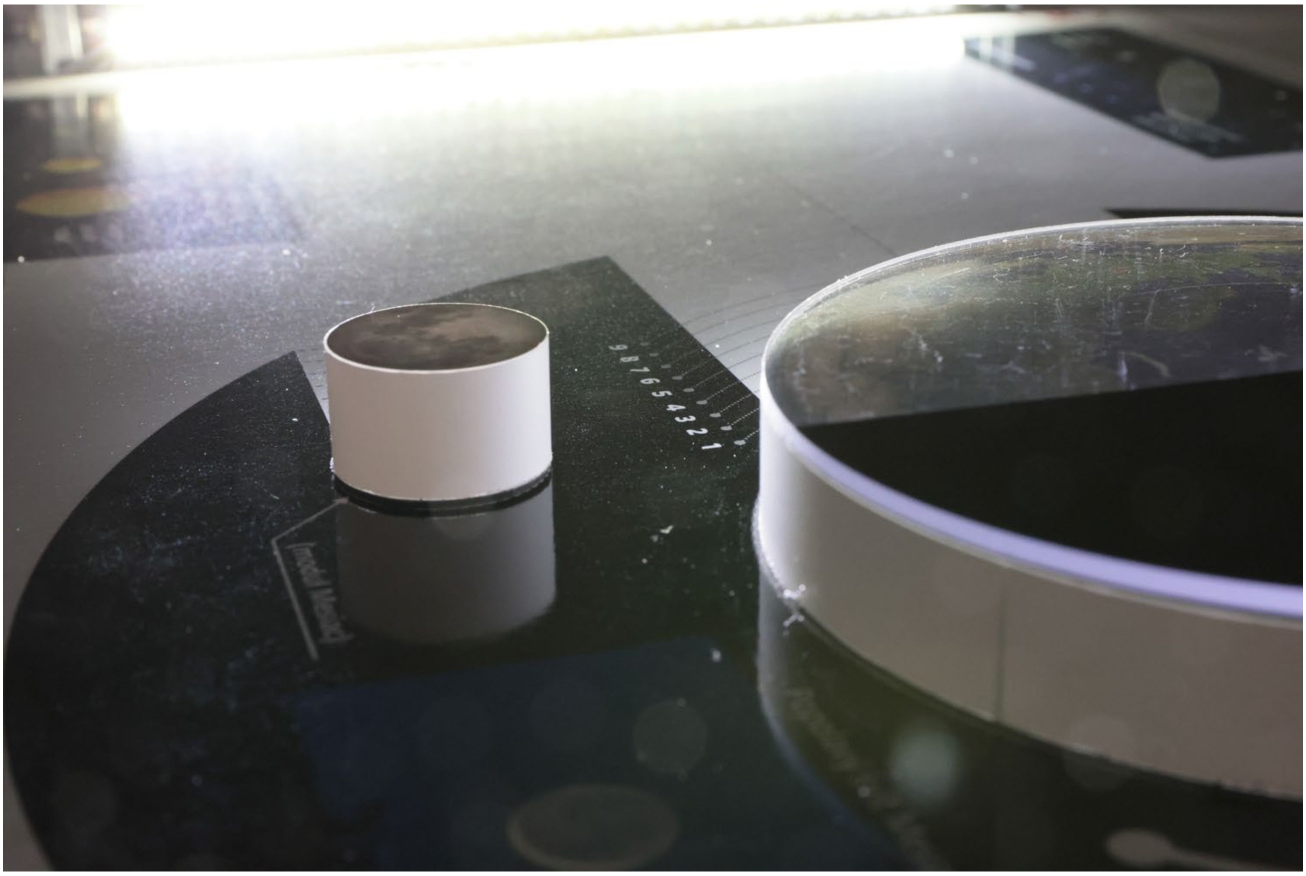
Attach the LED light source, representing the Sun, to the marked place on the sheet. Apply the Earth to the marked place as described in the sheet. Place the Moon on the marked position of the small bright body so that the red line on its surface faces the Earth. Observe the brightness of both the illuminated and unlit parts of the Moon from the center of the Earth. The observation procedure is the same as for the Individual phases of the Moon task.

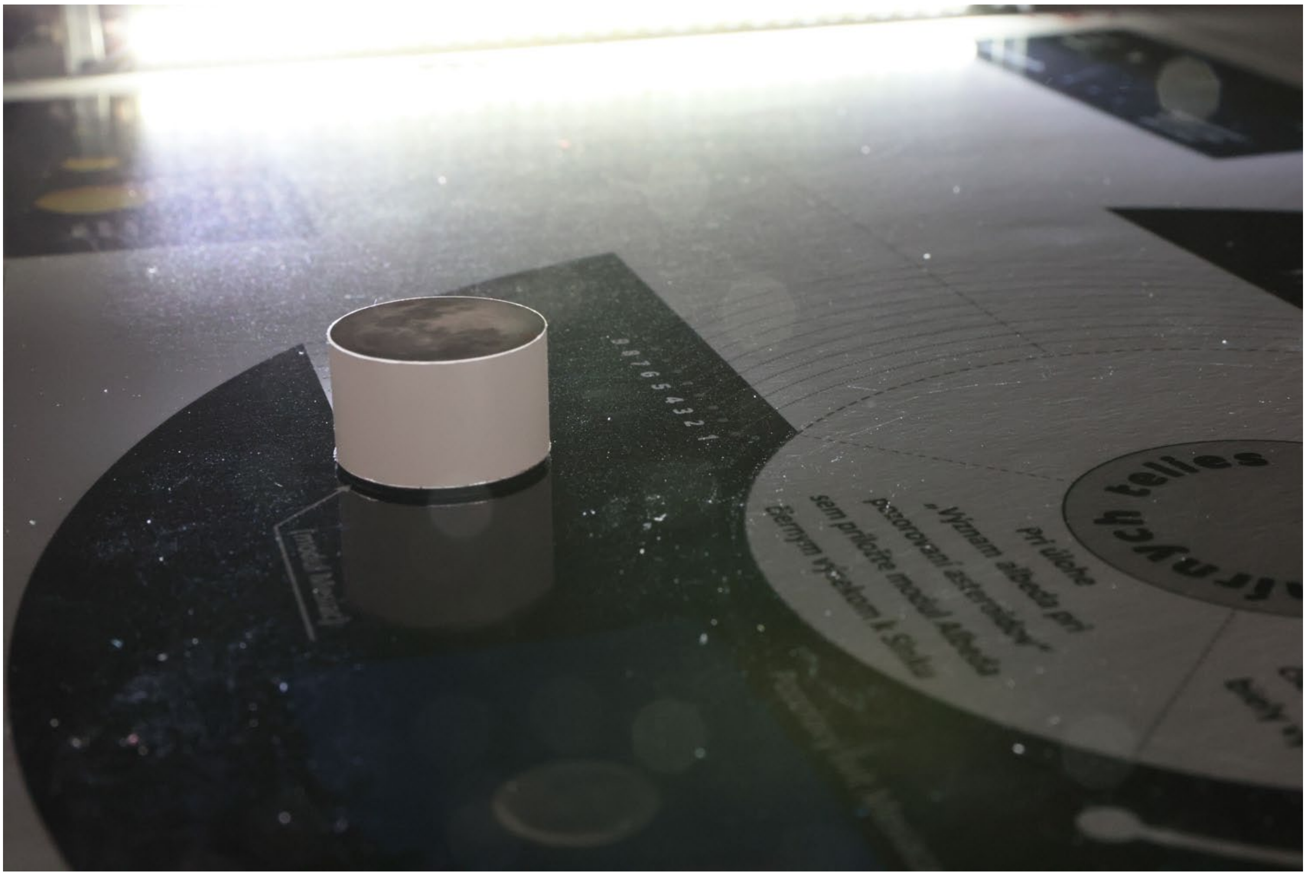
Activity:

Remove the Earth from the sheet and observe the loss of lighting on the unlit part of the Moon by the Sun. For a better illustration, try to add and remove the Earth repeatedly. In the phases of the Moon near the new moon phase, only a thin crescent of the Moon illuminated by the Sun should be visible. However, the reflected light from the Earth also illuminates the non-illuminated part of the Moon by the Sun, and therefore the whole Moon is visible as a dark circle against an even darker background.

Summary:

Leonardo da Vinci was the first to document a curiosity when the Moon was close to the new moon phase. He saw the sickle moon, but he also saw the unlit part of it. At this Moon phase, the Moon should be almost invisible. It is the Earthshine of the Moon (Da Vinci Glow) when the Moon is visible due to the reflected light from the Earth.


9 8 7 6 5 4 3 2 1


9 8 7 6 5 4 3 2 1

TASK 5B: ALBEDO OF CELESTIAL BODIES

Task number: 15

Equipment:

Sheet no. 5, LED light source, Albedo

Preparation:

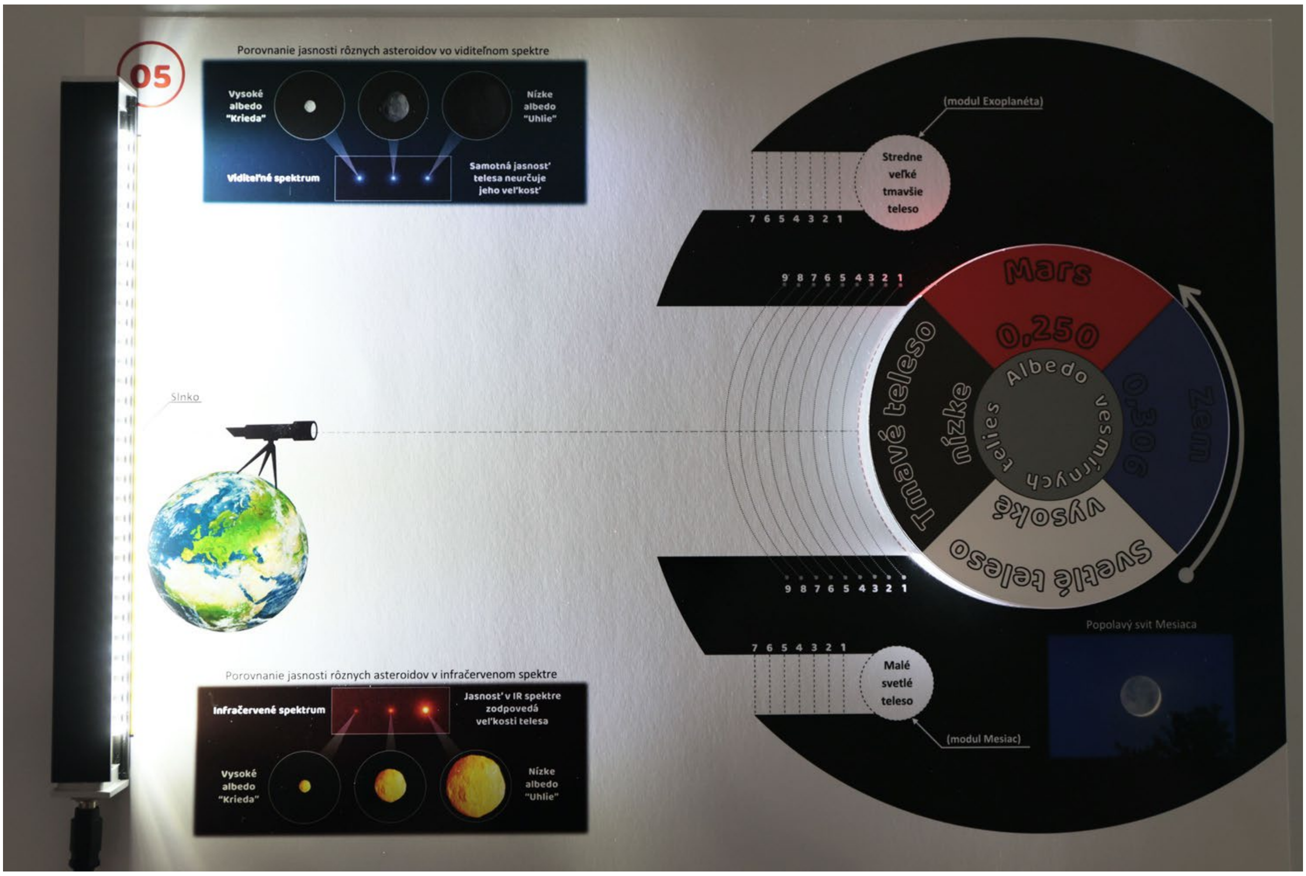
Attach the LED light source, representing the Sun, to the marked place on the sheet. Attach the Albedo module to the marked area as described in the sheet.

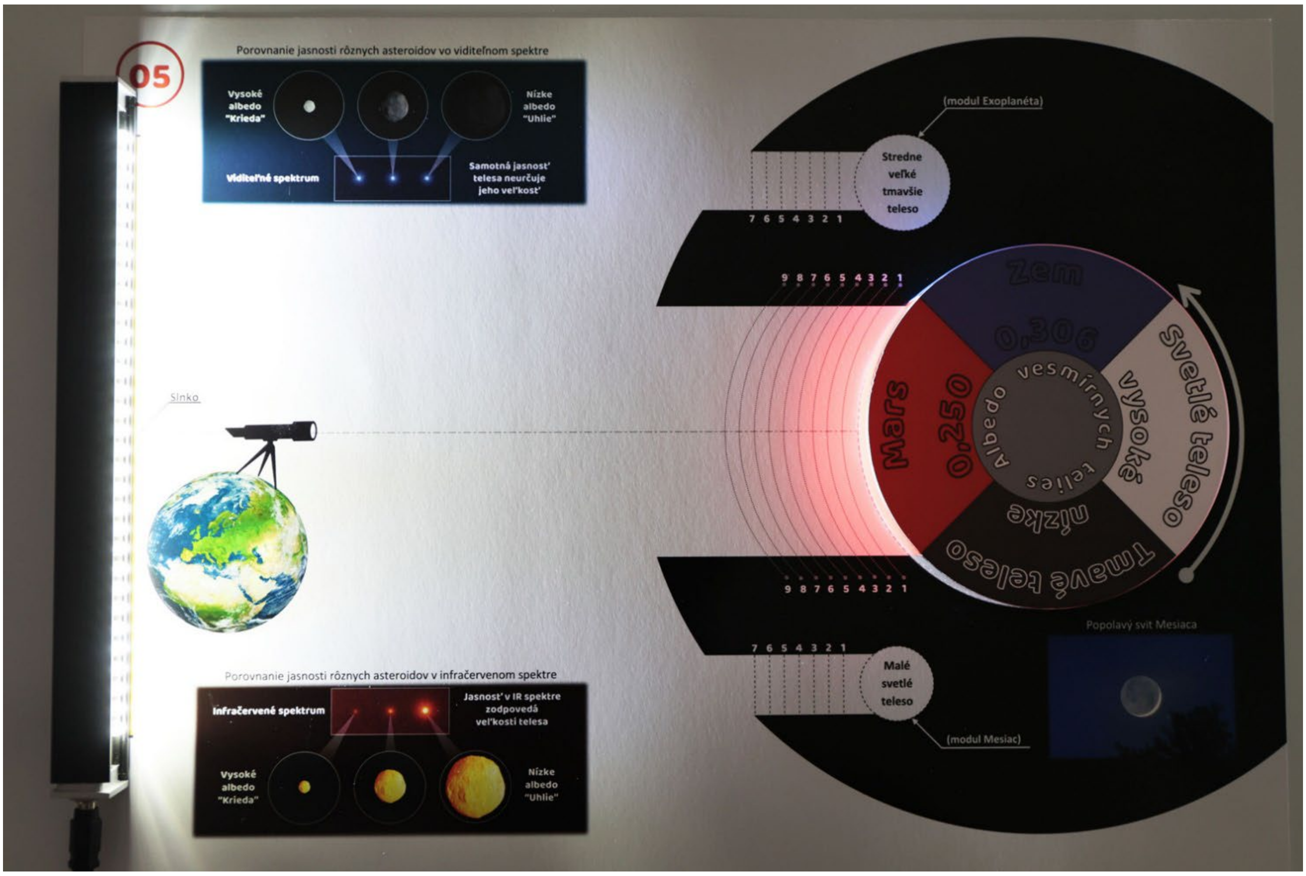
Activity:

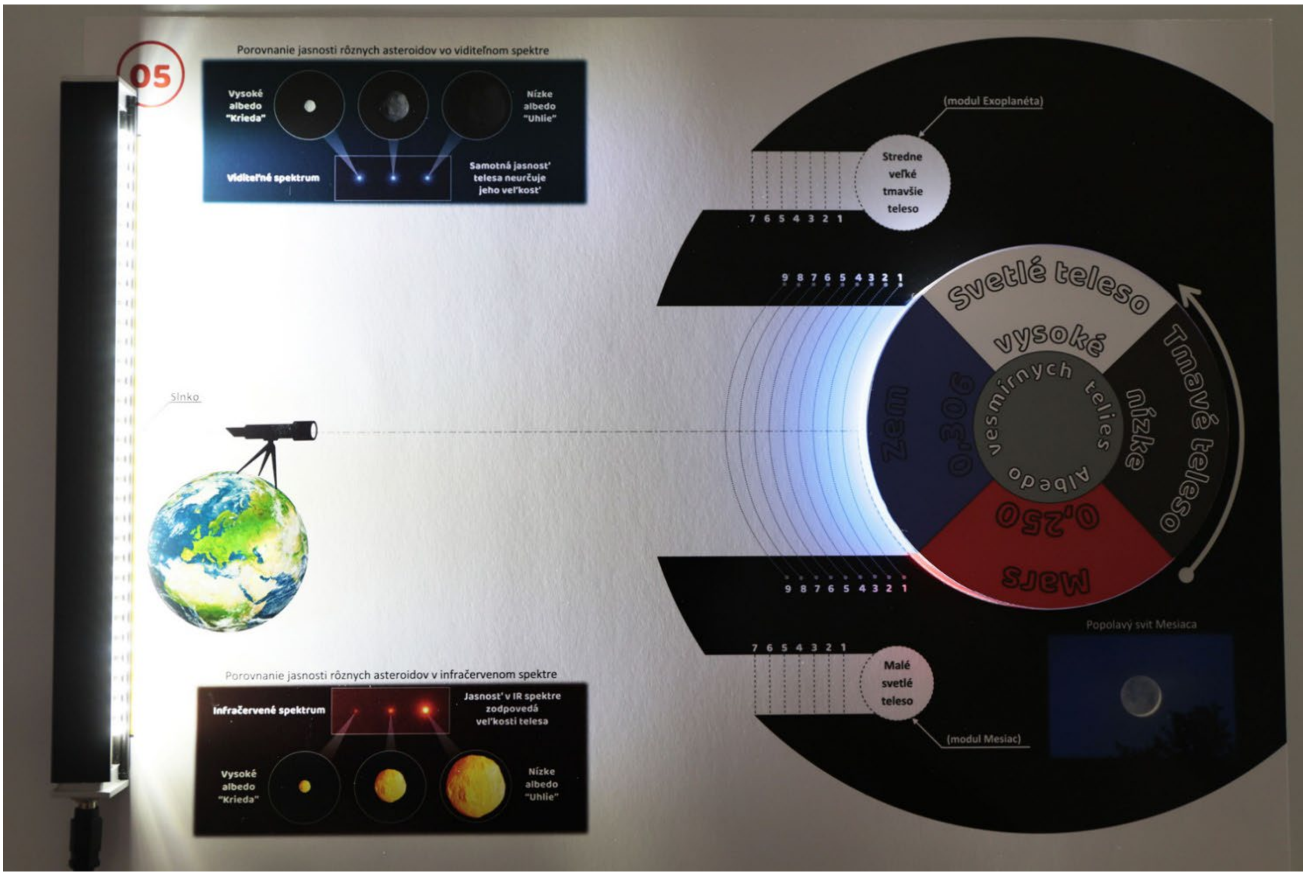
Gradually rotate the Albedo module from the black to the white section in the direction shown in the sheet. Observe the different levels of the reflection coefficient of the four celestial bodies (dark body, Mars, Earth and light body) and compare it on a scale from 1 to 9 in the sheet. For a more visible illustration, leave the Albedo module rotated in the position between the two types of bodies - on the optical axis.

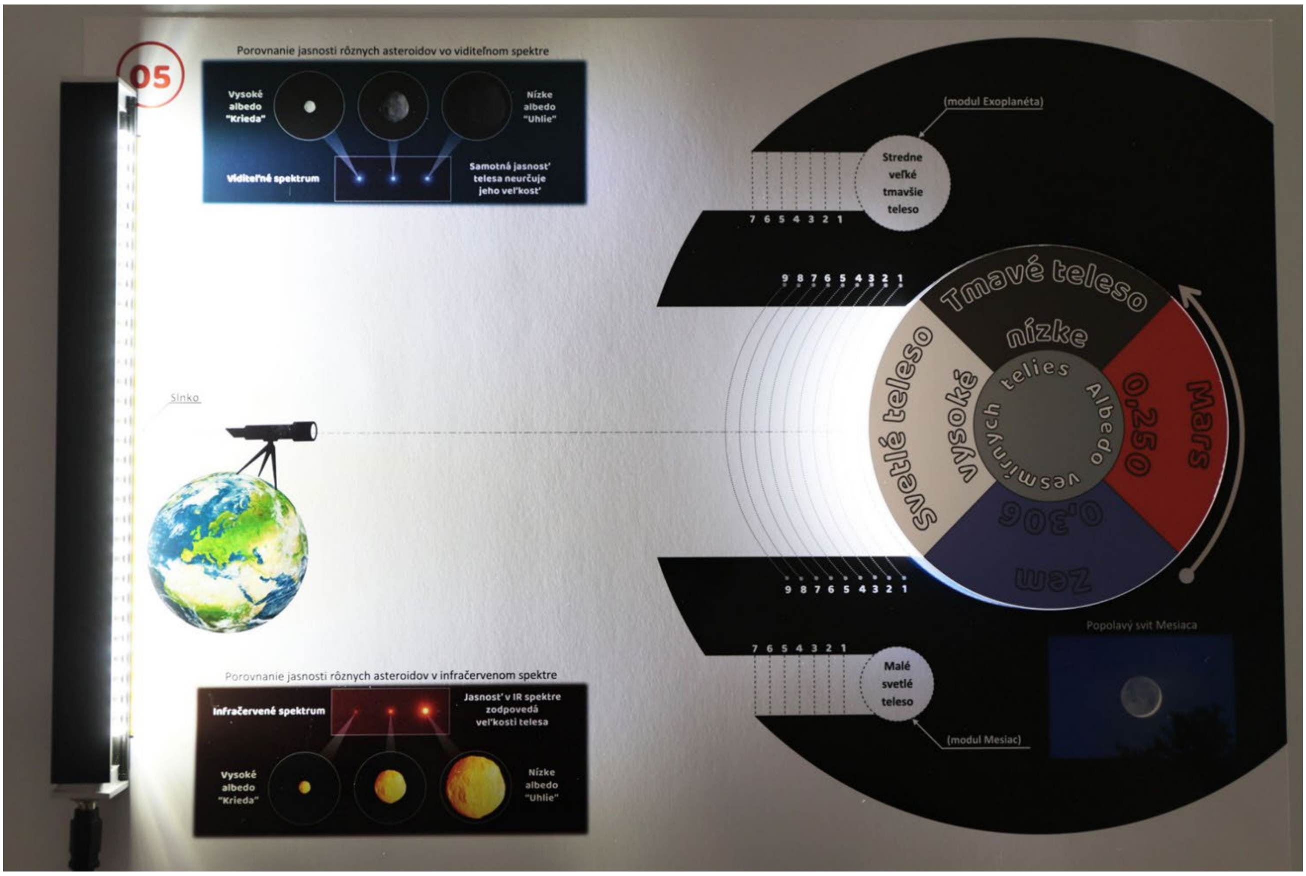
Summary:

Albedo is a measure of the reflectivity of a body or its surface. It is the ratio of the incident radiation to the body and the radiation reflected from the body. This ratio is expressed by a number from 0 to 1 (0 = no radiation was reflected and 1 all radiation was reflected). The black body reflects a minimum of light because it absorbs almost everything.


05
Porovnanie jasnosti rôznych asteroidov vo viditeľnom spektre
Vysoké albedo "Krieda"
Nízke albedo "Uhlie"
Viditeľné spektrum
Samotná jasnosť telesa neurčuje jeho veľkosť
(modul Exoplanéta)
Stredne veľké tmavšie teleso
Mars
0,250
Zem
0,306
Albedo vesmírnych telies
Tmavé teleso
nízke
Svetlé teleso
vysoké
Slnko
Porovnanie jasnosti rôznych asteroidov v infračervenom spektre
Infračervené spektrum
Jasnosť v IR spektre zodpovedá veľkosti telesa
Vysoké albedo "Krieda"
Nízke albedo "Uhlie"
Malé svetlé teleso
(modul Mesiac)
Popolavý svit Mesiaca


05
Porovnanie jasnosti rôznych asteroidov vo viditeľnom spektre
Vysoké albedo "Krieda"
Nízke albedo "Uhlie"
Viditeľné spektrum
Samotná jasnosť telesa neurčuje jeho veľkosť
(modul Exoplanéta)
Stredne veľké tmavšie teleso
Zem
0,306
Mars
0,250
Albedo vesmírnych telies
Svetlé teleso
vysoké
nízke
Tmavé teleso
Slnko
Porovnanie jasnosti rôznych asteroidov v infračervenom spektre
Infračervené spektrum
Jasnosť v IR spektre zodpovedá veľkosti telesa
Vysoké albedo "Krieda"
Nízke albedo "Uhlie"
Malé svetlé teleso
(modul Mesiac)
Popolavý svit Mesiaca


05
Porovnanie jasnosti rôznych asteroidov vo viditeľnom spektre
Vysoké albedo "Krieda"
Nízke albedo "Uhlie"
Viditeľné spektrum
Samotná jasnosť telesa neurčuje jeho veľkosť
(modul Exoplanéta)
Stredne veľké tmavšie teleso
Slnko
Svetlé teleso
vysoké
Tmavé teleso
nízke
Zem
0,306
vesmírnych telies
Albedo
0,250
Mars
Popolavý svit Mesiaca
Malé svetlé teleso
(modul Mesiac)
Porovnanie jasnosti rôznych asteroidov v infračervenom spektre
Infračervené spektrum
Jasnosť v IR spektre zodpovedá veľkosti telesa


05
Porovnanie jasnosti rôznych asteroidov vo viditeľnom spektre
Vysoké albedo "Krieda"
Nízke albedo "Uhlie"
Viditeľné spektrum
Samotná jasnosť telesa neurčuje jeho veľkosť
(modul Exoplanéta)
Stredne veľké tmavšie teleso
Slnko
Tmavé teleso
nízke
Svetlé teleso
vysoké
Mars
0,250
vesmírnych telies
Albedo
0,306
Zem
Popolavý svit Mesiaca
Malé svetlé teleso
(modul Mesiac)
Porovnanie jasnosti rôznych asteroidov v infračervenom spektre
Infračervené spektrum
Jasnosť v IR spektre zodpovedá veľkosti telesa

TASK 5C: THE SIGNIFICANCE OF ALBEDO AT ASTEROID OBSERVATION

Task number: 16

Equipment:

Sheet no. 5, LED light source, Albedo, Moon, Exoplanet

Preparation:

Attach the LED light source, which represents the Sun, to the marked place on the sheet. As described in the sheet, attach the Albedo module to the marked place - with a black cut to the Sun. Observe the reflection coefficient of a large black body on a scale from 1 to 9.

Activity:

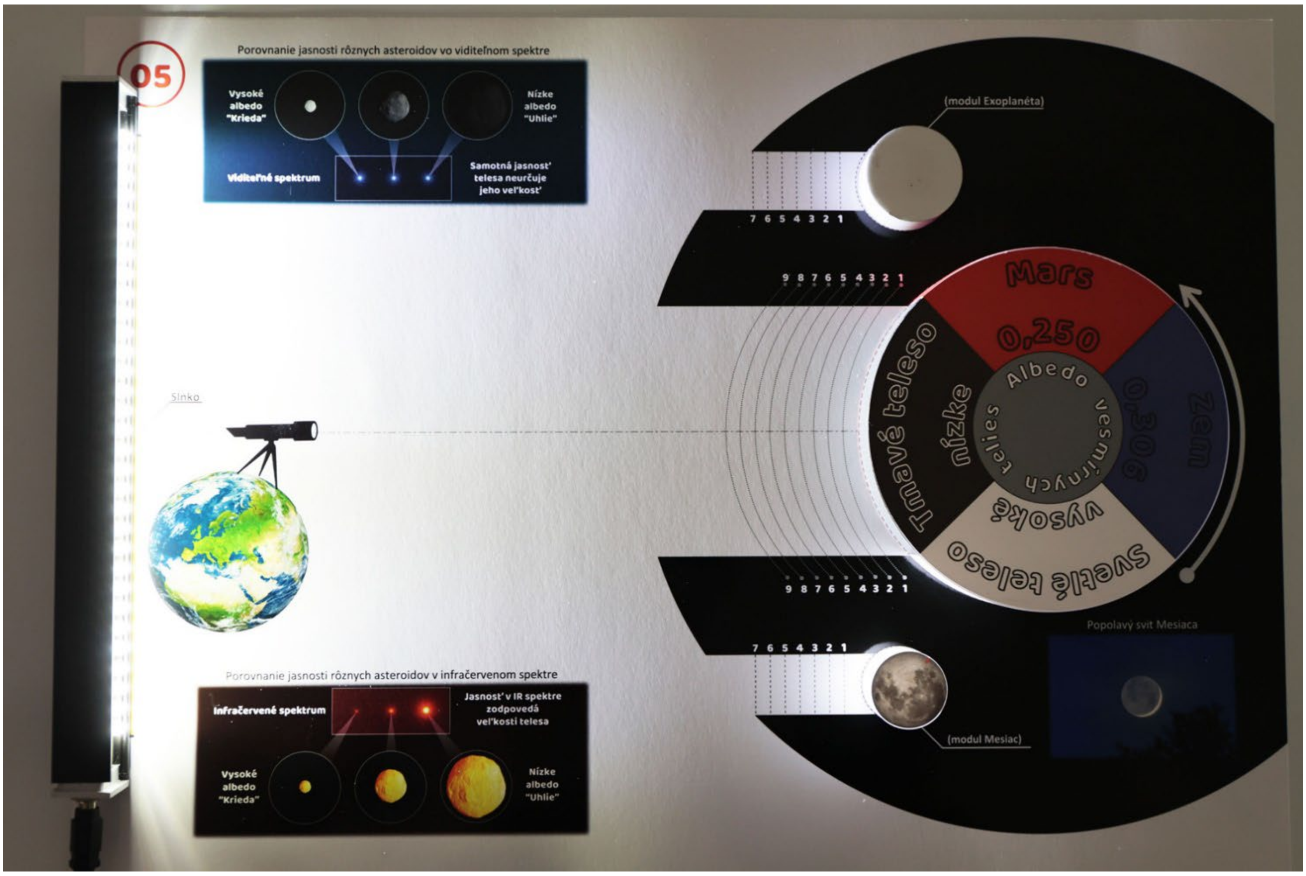
Place the Exoplanet auxiliary module on the marked position medium-sized darker body. Observe its reflection coefficient on a scale and compare it with a large black body. Place the Moon on the marked position of the small bright body. Observe its reflection coefficient as well on a scale and compare it with the other two bodies. Although the bodies are at the same distance from the Earth (shown in the sheet on the left), a small bright body may be brighter than larger bodies and may appear larger or the same size during photometric observation.

Summary:

In astronomy, albedo is an important concept because all the bodies that we observe and which are not stars, emit only reflected radiation. The brighter the body, the higher the albedo. We are intentionally talking about radiation and not light because if we observe an albedo of different bodies (e.g. asteroids), it also depends on the spectrum in which we observe them. Comparisons of the brightness of different asteroids in the visible and infrared radiation are shown in the sheet.

If we observe celestial bodies at the same distance as luminous points, then the brightness of these points without other measurements may lead to the determination of the size of the bodies on the assumption: a larger body reflects more light and is brighter. This way we can determine the size incorrectly.

In this task, we found that when observed in the visible spectrum, small bright asteroids can attract our attention, which may not be dangerous to Earth. However, much larger dark asteroids could escape our attention, which could pose a great danger in an encounter with Earth. Therefore, the search for potentially dangerous asteroids takes place in the infrared spectrum, where their albedo corresponds to the size of the body.


05
Porovnanie jasnosti rôznych asteroidov vo viditeľnom spektre
Vysoké albedo "Krieda"
Nízke albedo "Uhlie"
Viditeľné spektrum
Samotná jasnosť telesa neurčuje jeho veľkosť
(modul Exoplanéta)
Mars
0,250
Zem
0,306
Tmavé teleso
nízke
Albedo vesmírnych telies
vysoké
Svetlé teleso
Slnko
Porovnanie jasnosti rôznych asteroidov v infračervenom spektre
Infračervené spektrum
Jasnosť v IR spektre zodpovedá veľkosti telesa
Vysoké albedo "Krieda"
Nízke albedo "Uhlie"
Popolavý svit Mesiaca
(modul Mesiac)


Tmavé teleso
nízke
Mars
0,250
Albedo vesmírnych telies
vysoké
Svetlé teleso
0,306
(modul Mesiac)
(modul Exoplanéta)

TASK 6: GALILEI TELESCOPE

Task number: 17

Equipment:

Sheet no. 6, laser light source, lens no. 1, plano-concave lens

Preparation:

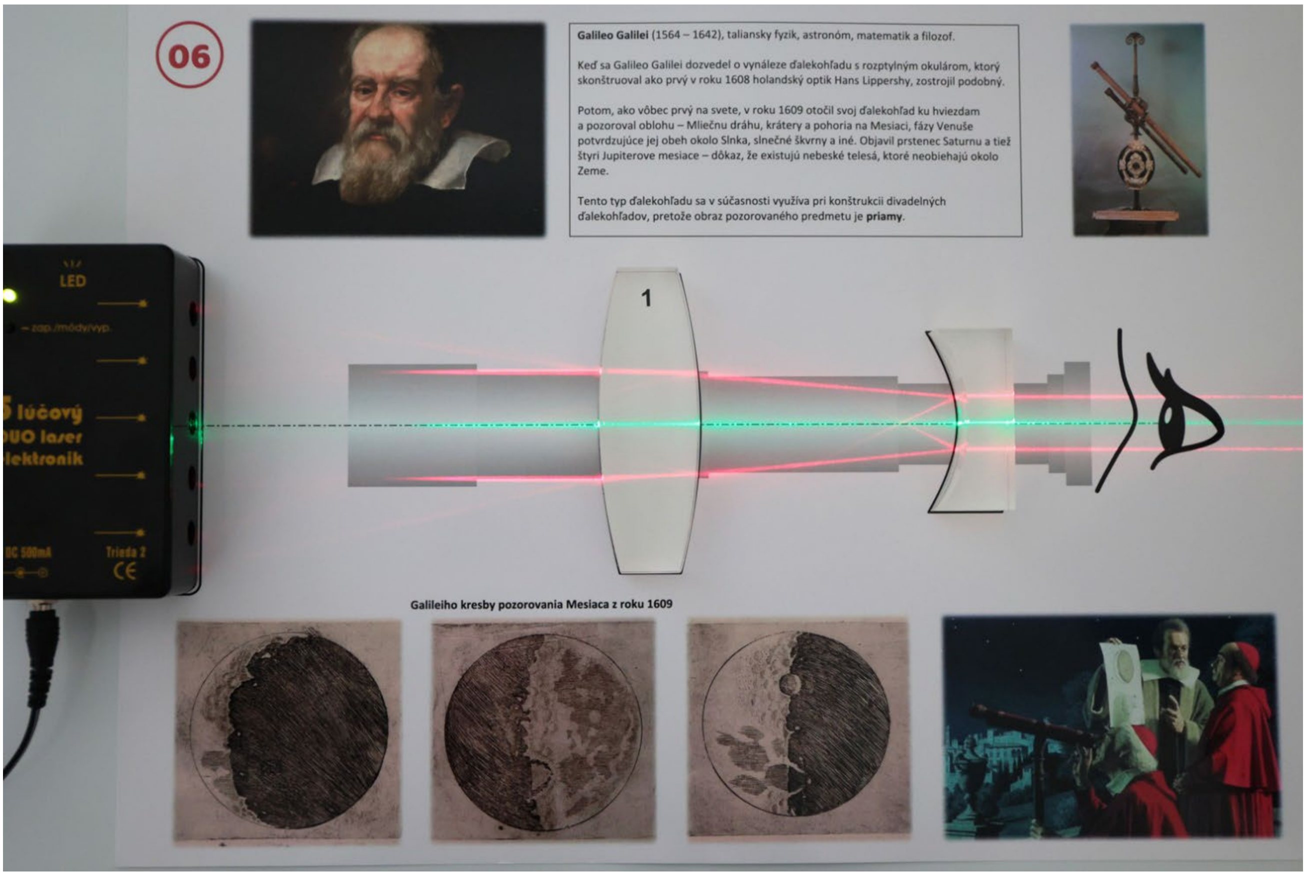
Attach lens no. 1 and plano-concave lens to the marked places on the sheet. Position the laser light source outside the sheet as close to its left edge as possible. Its exact position is determined by the optical axis in the sheet, which corresponds to the middle (green) beam.
The laser light source is a view into space. Use the light mode switch button to turn on 3 beams - second, third and fourth. Adjust the position of the laser light source so that the center (green) beam shines in the optical axis.

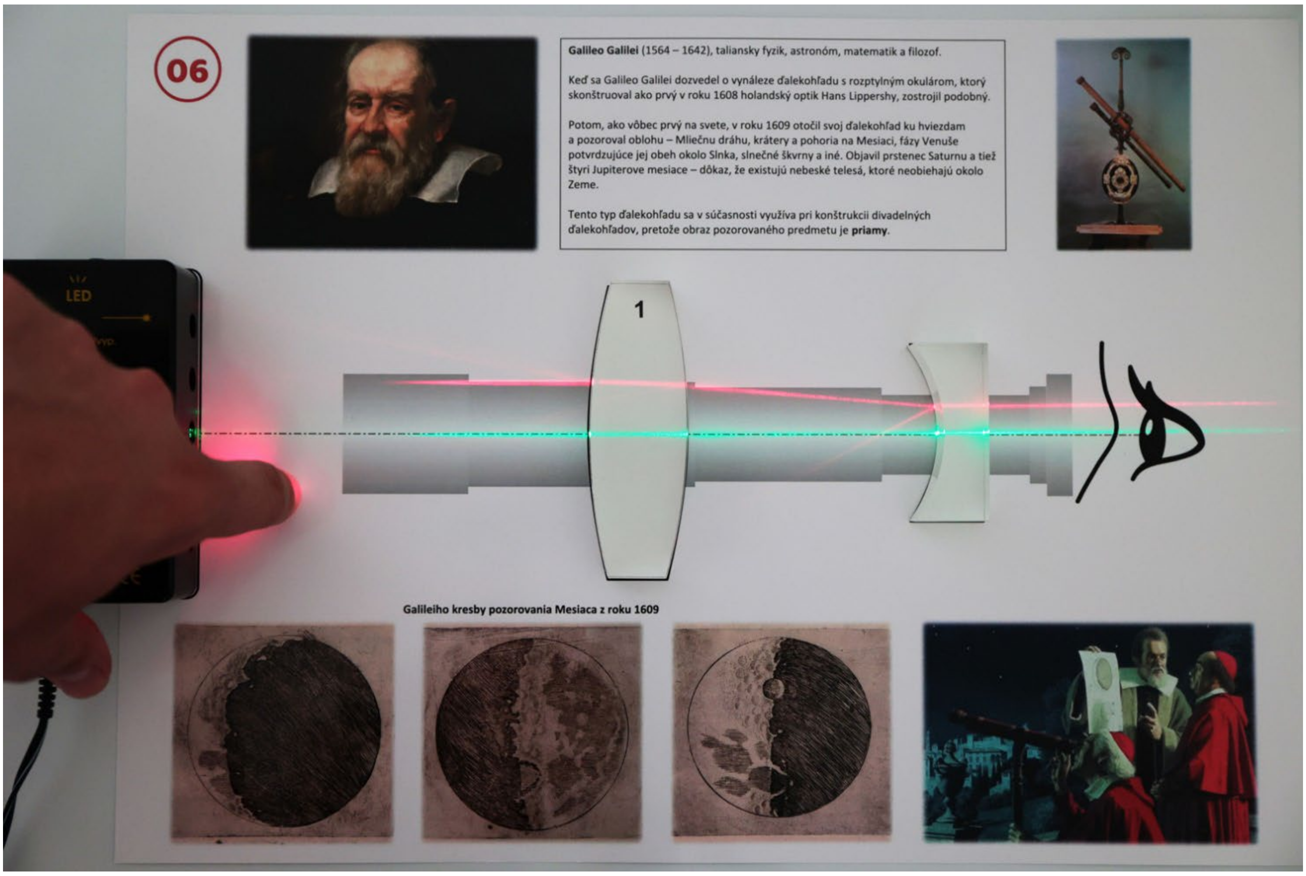
Activity:

Observe the reduced image of the laser beams behind the eyepiece. Gradually cover the laser beams with your finger in front of where they emit and observe which beams are behind the eyepiece. Hold your finger so that you only cover one beam at a time and no more. When you cover the lower beam from where it radiates, the lower beam is also covered behind the eyepiece. The image of the observed object is therefore straightforward.

Summary:

Galileo Galilei was the first to aim a telescope at the sky and was able to "zoom in" on celestial bodies. Thus, the first astronomical telescope was created. In 1609 he built a telescope with a magnification of about 20 times. Two lenses were used in his system - one converging lens and one plano-concave lens. This type was named the Galileo binocular and is currently no longer used for astronomical observations.


06
Galileo Galilei (1564 – 1642), taliansky fyzik, astronóm, matematik a filozof.
Keď sa Galileo Galilei dozvedel o vynáleze ďalekohľadu s rozptylným okulárom, ktorý skonštruoval ako prvý v roku 1608 holandský optik Hans Lippershy, zostrojil podobný.
Potom, ako vôbec prvý na svete, v roku 1609 otočil svoj ďalekohľad ku hviezdam a pozoroval oblohu – Mliečnu dráhu, krátery a pohoria na Mesiaci, fázy Venuše potvrdzujúce jej obeh okolo Slnka, slnečné škvrny a iné. Objavil prstenec Saturnu a tiež štyri Jupiterove mesiace – dôkaz, že existujú nebeské telesá, ktoré neobiehajú okolo Zeme.
Tento typ ďalekohľadu sa v súčasnosti využíva pri konštrukcii divadelných ďalekohľadov, pretože obraz pozorovaného predmetu je priamy.
LED
1
Galileiho kresby pozorovania Mesiaca z roku 1609


06
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Tento typ ďalekohľadu sa v súčasnosti využíva pri konštrukcii divadelných ďalekohľadov, pretože obraz pozorovaného predmetu je priamy.
LED
1
Galileiho kresby pozorovania Mesiaca z roku 1609

TASK 7: KEPLER TELESCOPE

Task number: 18

Equipment:

Sheet no. 7, laser light source, lens no. 1, semicircle (converging plano-convex lens)

Preparation:

Attach lens no. 1 and semicircle to the marked places on the sheet. Position the laser light source outside the sheet as close to its left edge as possible. Its exact position is determined by the optical axis in the sheet, which corresponds to the middle (green) beam.
The laser light source is a view into space. Use the light mode switch button to turn on 3 beams - second, third and fourth. Adjust the position of the laser light source so that the center (green) beam shines in the optical axis.

Activity:

Observe the reduced image of the laser beams behind the eyepiece. Gradually cover the laser beams with your finger in front of where they emit and observe which beams are behind the eyepiece. Hold your finger so that you only cover one beam at a time and no more. When you cover the lower beam from where it radiates, the upper beam is covered behind the eyepiece. The image of the observed object is thus inverted.

Summary:

Kepler's telescope consists of two converging lenses. Refraction of light is used to enlarge the image. Therefore, this type is called a refractor. The most commonly used amateur telescopes in astronomy are the Kepler type.


07
Johanes Kepler (1571 – 1630), nemecký astronóm, fyzik a matematik.
Princíp ďalekohľadu so spojným okulárom vysvetlil Kepler v roku 1611. Neskôr bol skonštruovaný jezuitom Schneinerom, pomenovanie však zostalo po Keplerovi.
Skladá sa z dvoch spojných šošoviek. Objektív vytvorí skutočný, zmenšený a prevrátený obraz predmetu. Predmet potom pozorujeme okulárom ako lupou. Čím väčší je priemer objektívu, tým viac svetla sa sústredí v ďalekohľade a tým menej jasné objekty môžeme pozorovať.
Najbežnejšie používané amatérske ďalekohľady sú Keplerovho typu.
LED
2
REFRAKTOR
Pre zväčšenie obrazu sa v tomto type ďalekohľadov používa lom svetla, odborne refrakcia. Preto šošovkový ďalekohľad nazývame „REFRAKTOR".


07
Johanes Kepler (1571 – 1630), nemecký astronóm, fyzik a matematik.
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Najbežnejšie používané amatérske ďalekohľady sú Keplerovho typu.
LED
2
REFRAKTOR
Pre zväčšenie obrazu sa v tomto type ďalekohľadov používa lom svetla, odborne refrakcia. Preto šošovkový ďalekohľad nazývame „REFRAKTOR".

TASK 8: SPHERICAL ABERRATION AND ITS CORRECTION

Task number: 19

Equipment:

Sheet no. 8, laser light source, semicircle (converging plano-convex lens), plano-concave lens

Preparation:

Attach semicircle to the marked places on the sheet. Position the laser light source outside the sheet as close to its left edge as possible. Its exact position is determined by the optical axis in the sheet, which corresponds to the middle (green) beam. The laser light source is a view of a point at infinity (star). Turn on all 5 beams. Adjust the position of the laser light source so that the center (green) beam shines in the optical axis.

Activity 1:

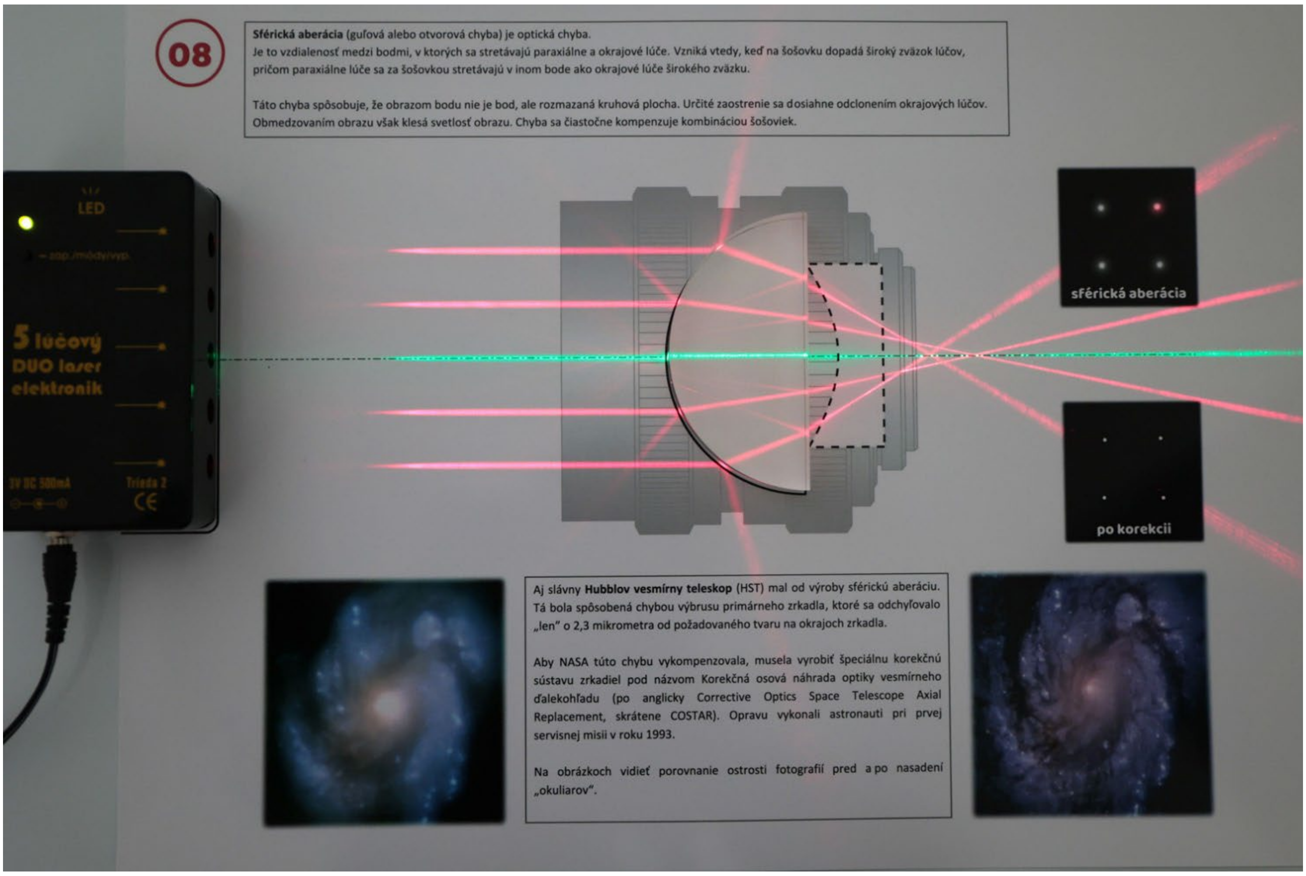
First, observe the spherical aberration behind the semicircle, which occurs when a wide beam of rays strikes the lens, with the paraxial rays meeting behind the lens at a different point than the edge rays of the wide beam. This aberration causes the dot image to be not a dot, but a blurred circular area. Use two fingers to cover the upper and lower rays away from where they radiate so that you do not obscure other rays (create a letter V inverted with your fingers). This will create a light screen. Observe how some focus is achieved by deflecting the edge beams. However, by limiting the light of the observed image, its brightness decreases. In this way, this optical defect could not be eliminated.

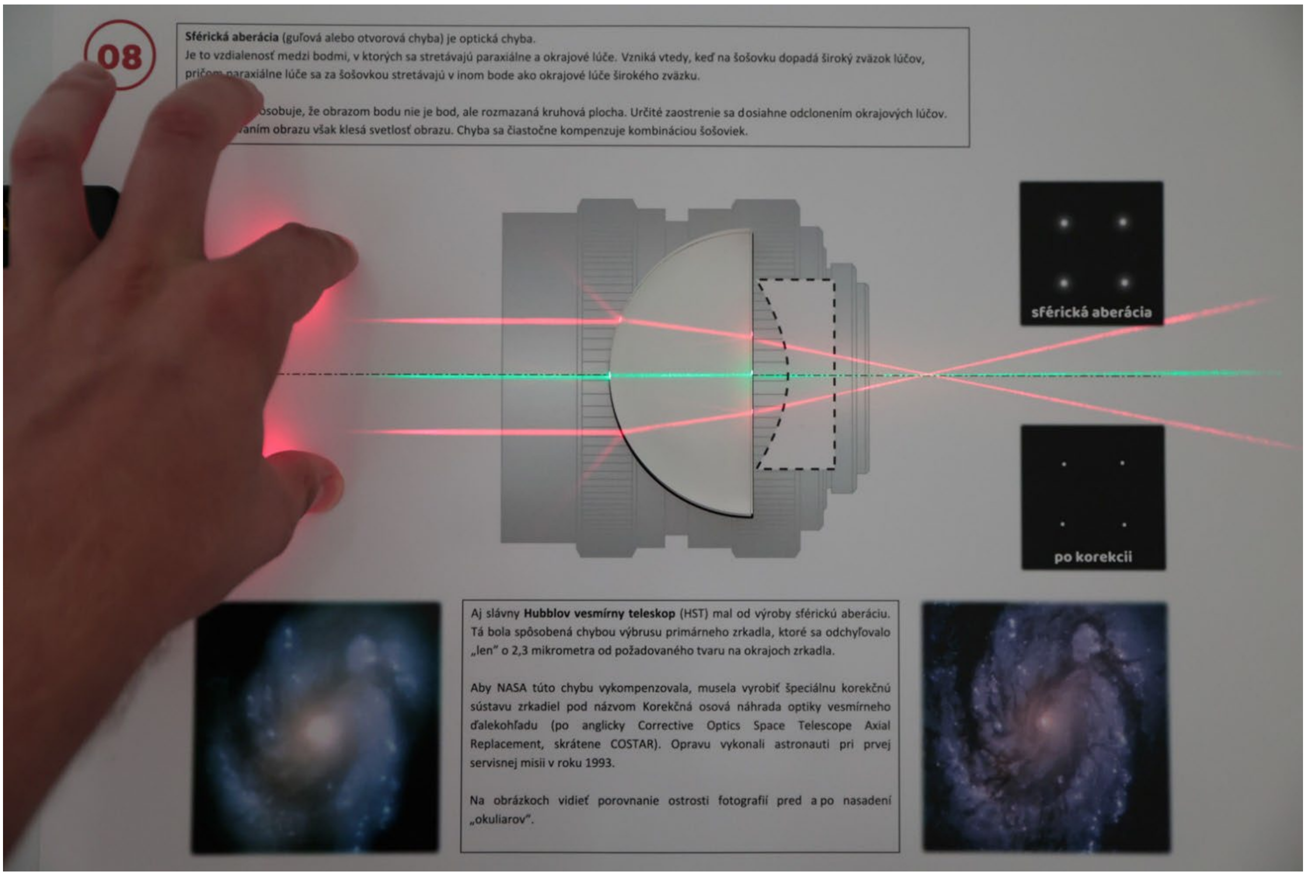
Activity 2:

Uncover the upper and lower beams and place the plano-concave lens on the sheet at the marked place. Observe how the defect was removed by a combination of lenses and the rays met in the corrected focus, but at the expense of its extension. By correctly recalculating the combination of lenses, we can achieve the same focal length.

Summary:

Lenses generally produce various defects, especially when light rays fall on their edges. Spherical aberration is a significant one. Optical elements defects in telescopes can be minimized.


08
Sférická aberácia (guľová alebo otvorová chyba) je optická chyba.
Je to vzdialenosť medzi bodmi, v ktorých sa stretávajú paraxiálne a okrajové lúče. Vzniká vtedy, keď na šošovku dopadá široký zväzok lúčov, pričom paraxiálne lúče sa za šošovkou stretávajú v inom bode ako okrajové lúče širokého zväzku.
Táto chyba spôsobuje, že obrazom bodu nie je bod, ale rozmazaná kruhová plocha. Určité zaostrenie sa dosiahne odclonením okrajových lúčov. Obmedzovaním obrazu však klesá svetlosť obrazu. Chyba sa čiastočne kompenzuje kombináciou šošoviek.
LED
5 lúčový
DUO laser
elektronik
Trieda 2
sférická aberácia
po korekcii
Aj slávny Hubblov vesmírny teleskop (HST) mal od výroby sférickú aberáciu. Tá bola spôsobená chybou výbrusu primárneho zrkadla, ktoré sa odchyľovalo „len" o 2,3 mikrometra od požadovaného tvaru na okrajoch zrkadla.
Aby NASA túto chybu vykompenzovala, musela vyrobiť špeciálnu korekčnú sústavu zrkadiel pod názvom Korekčná osová náhrada optiky vesmírneho ďalekohľadu (po anglicky Corrective Optics Space Telescope Axial Replacement, skrátene COSTAR). Opravu vykonali astronauti pri prvej servisnej misii v roku 1993.
Na obrázkoch vidieť porovnanie ostrosti fotografií pred a po nasadení „okuliarov".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sobuje, že obrazom bodu nie je bod, ale rozmazaná kruhová plocha. Určité zaostrenie sa dosiahne odclonením okrajových lúčov.
aním obrazu však klesá svetlosť obrazu. Chyba sa čiastočne kompenzuje kombináciou šošoviek.
sférická aberácia
po korekcii
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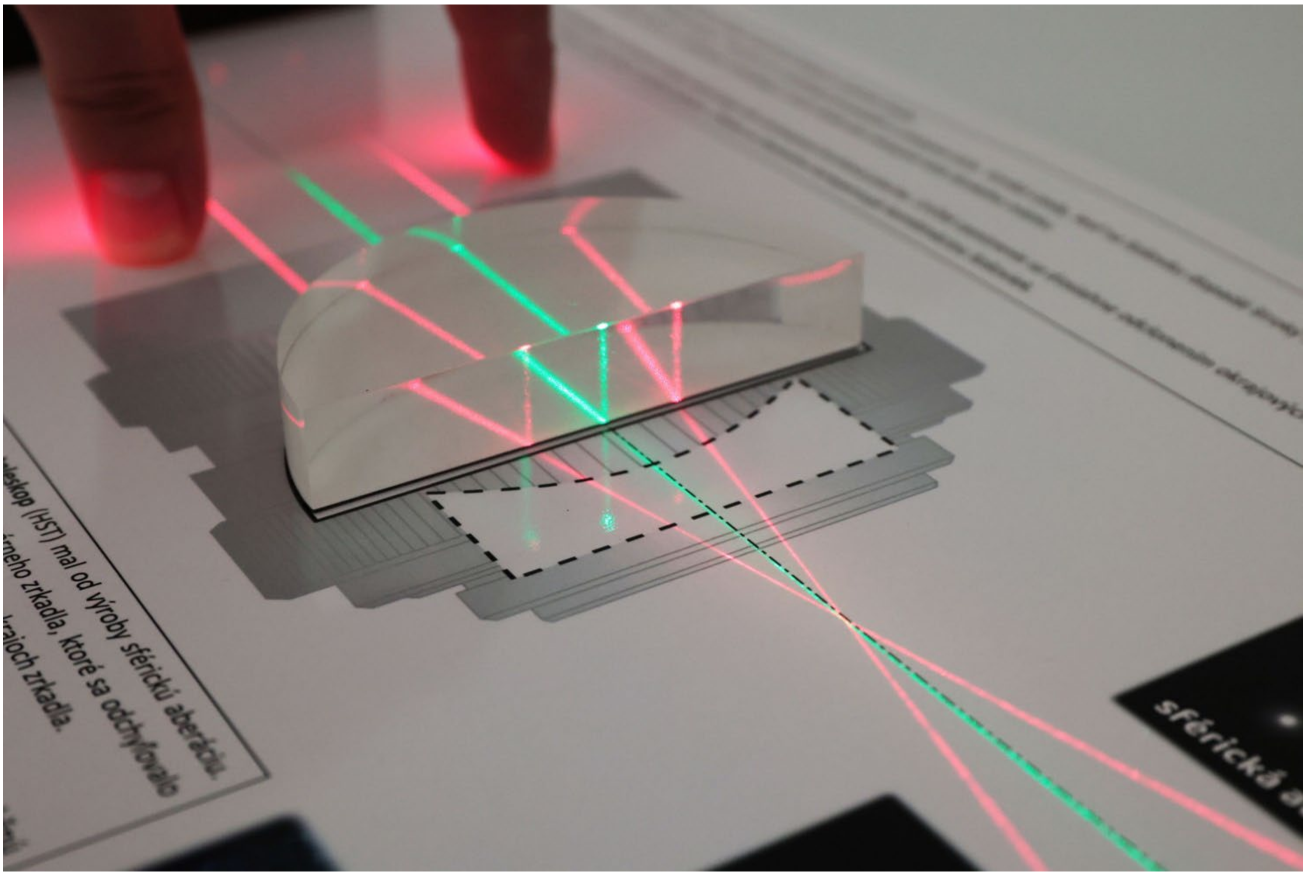
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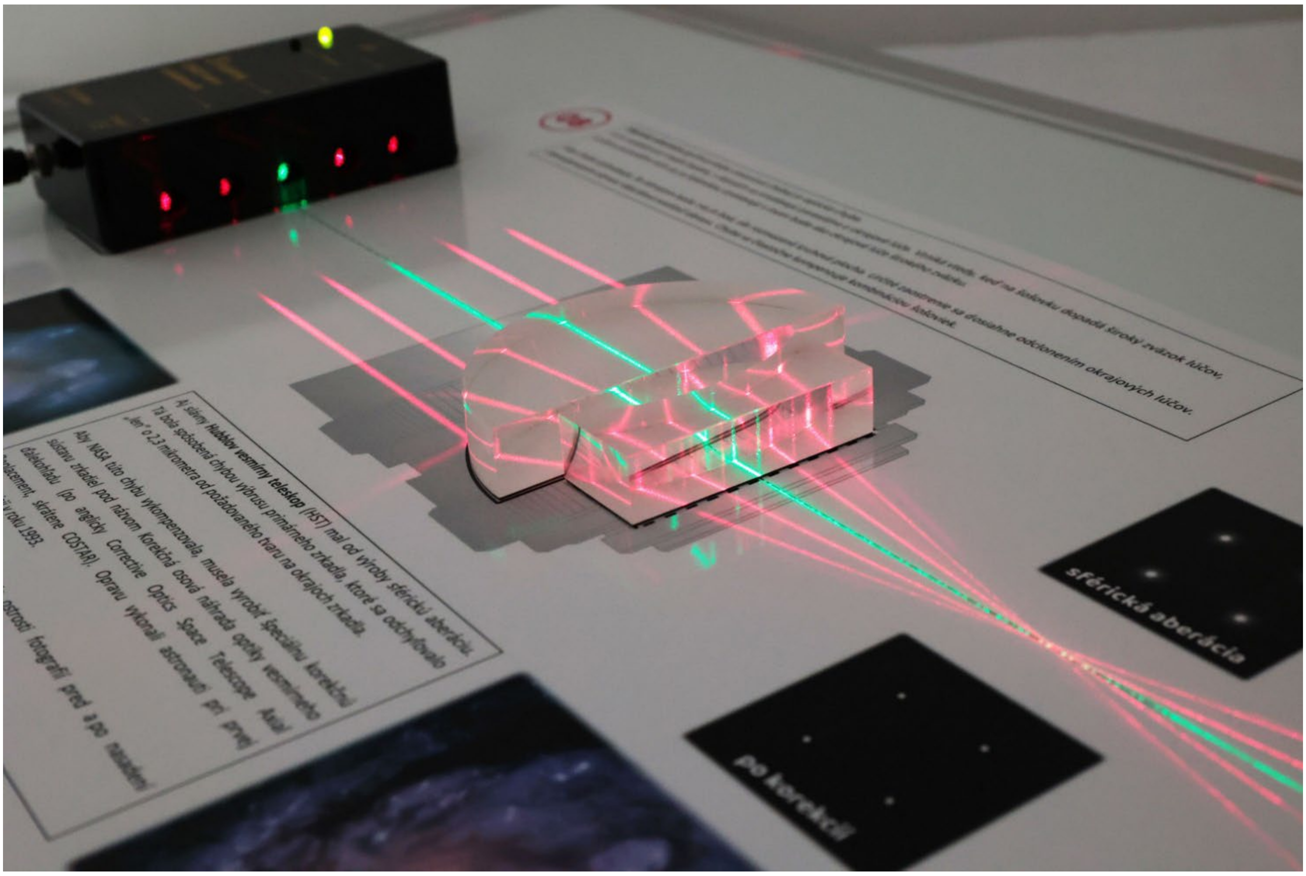
zrkadla, ktoré sa odchyľovalo
krajoch zrkadla.


sférická aberácia
po korekcii

TASK 9: NEWTON TELESCOPE

Task number: 20

Equipment:

Sheet no. 9, laser light source, Newton primary mirror, small mirror

Preparation:

Attach Newton primary mirror and small (secondary) mirror to the marked places on the sheet. Position the laser light source outside the sheet as close to its left edge as possible. Its exact position is determined by the optical axis in the sheet, which corresponds to the middle (green) beam. The laser light source is a view into space. Use the light mode switch button to turn on 3 beams - first, third and fifth. Adjust the position of the laser light source so that the center (green) beam shines in the optical axis.

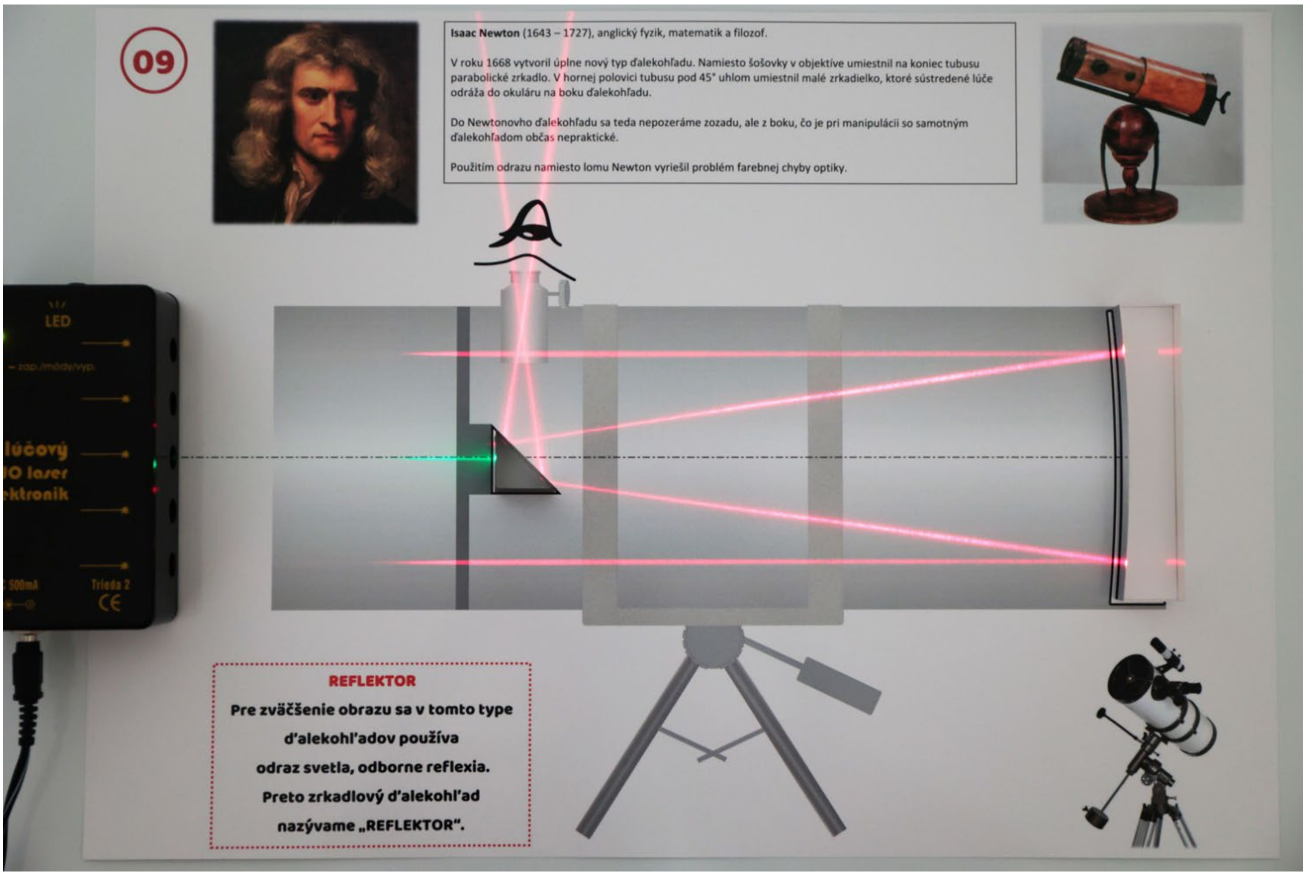
Activity:

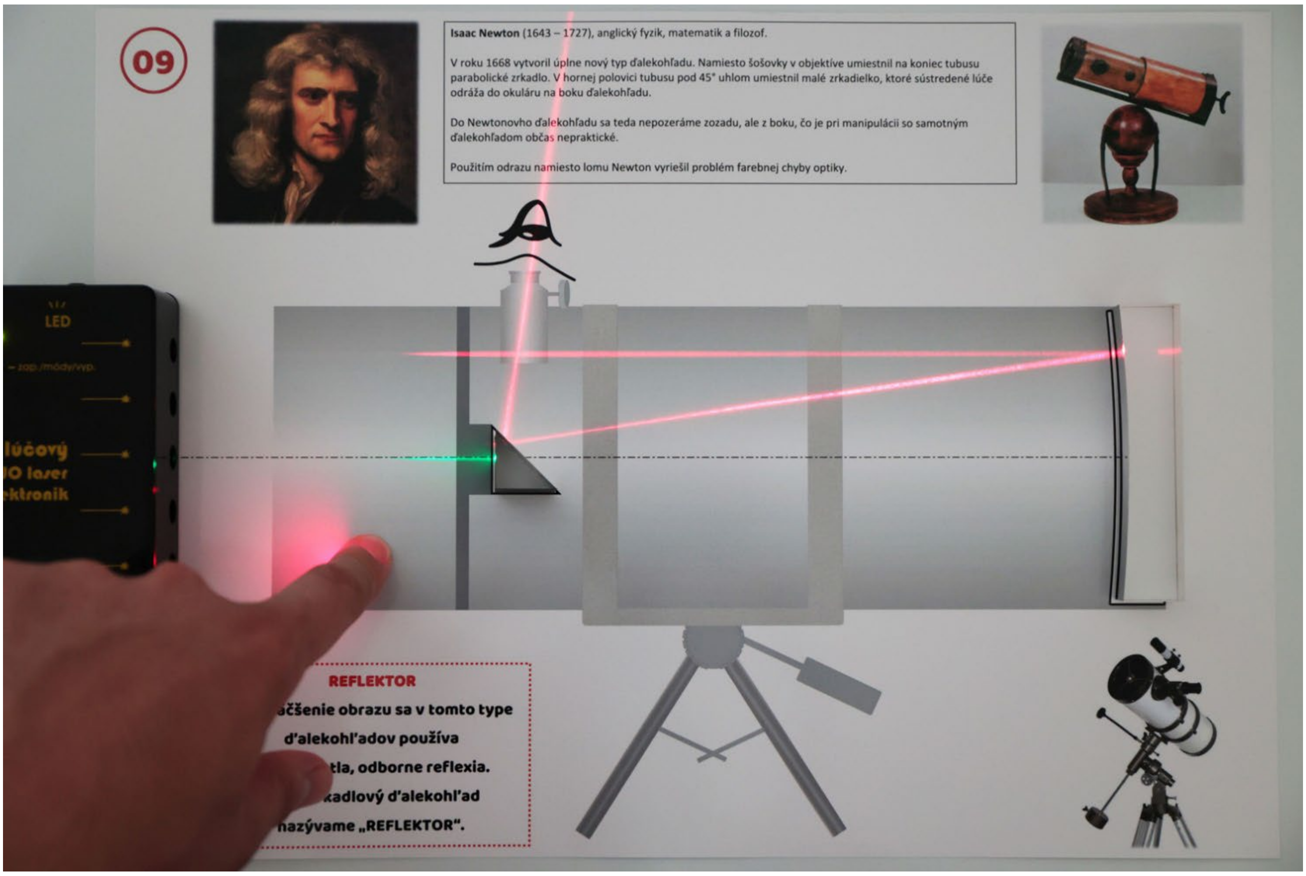
If necessary, gently adjust the positions of both mirrors and observe the reduced image of the laser beams behind the eyepiece so that the focus is directed at the eyepiece. Gradually cover the laser beams with your finger in front of where they emit and observe which beams are behind the eyepiece. Hold your finger so that you only cover one beam at a time and no more. When you cover the lower beam, the left beam is covered behind the eyepiece, and when you cover the upper beam, the right beam is covered behind the eyepiece.

Summary:

Newton telescope consists of two mirrors. The primary - parabolic mirror is at the end of the tube and the secondary is a small mirror, which is at a 45° angle in the front. From there, the focused rays reflect into the eyepiece on the side of the telescope. So, you don't look into this telescope from behind but from the side. Light reflection is used to enlarge the image. Therefore, this type is called a reflector.

By using reflection instead of refraction, Newton also solved the problem of chromatic aberration - colour defect. When he was the first to fragmented white light to the spectrum using a prism, he found that the individual colours of electromagnetic radiation refract at different angles, and the chromatic defect of the telescopes was actually due to the glass of the refractor lenses. The correction of chromatic aberration consists in the use of a mirror in which the light rays do not pass through the glass, resp. they do not break but are reflected - each at the same angle.


09
Isaac Newton (1643 – 1727), anglický fyzik, matematik a filozof.
V roku 1668 vytvoril úplne nový typ ďalekohľadu. Namiesto šošovky v objektíve umiestnil na koniec tubusu parabolické zrkadlo. V hornej polovici tubusu pod 45° uhlom umiestnil malé zrkadielko, ktoré sústredené lúče odráža do okuláru na boku ďalekohľadu.
Do Newtonovho ďalekohľadu sa teda nepozeráme zozadu, ale z boku, čo je pri manipulácii so samotným ďalekohľadom občas nepraktické.
Použitím odrazu namiesto lomu Newton vyriešil problém farebnej chyby optiky.
LED
Trieda 2
REFLEKTOR
Pre zväčšenie obrazu sa v tomto type ďalekohľadov používa odraz svetla, odborne reflexia. Preto zrkadlový ďalekohľad nazývame „REFLEKTOR".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Použitím odrazu namiesto lomu Newton vyriešil problém farebnej chyby optiky.
LED
REFLEKTOR
ďalekohľadov používa
nazývame „REFLEKTOR".

TASK 10: CASSEGRAIN TELESCOPE

Task number: 21

Equipment:

Sheet no. 10, laser light source, Cassegrain primary mirror, Cassegrain secondary mirror, screen (white surface of Newton primary mirror)

Preparation:

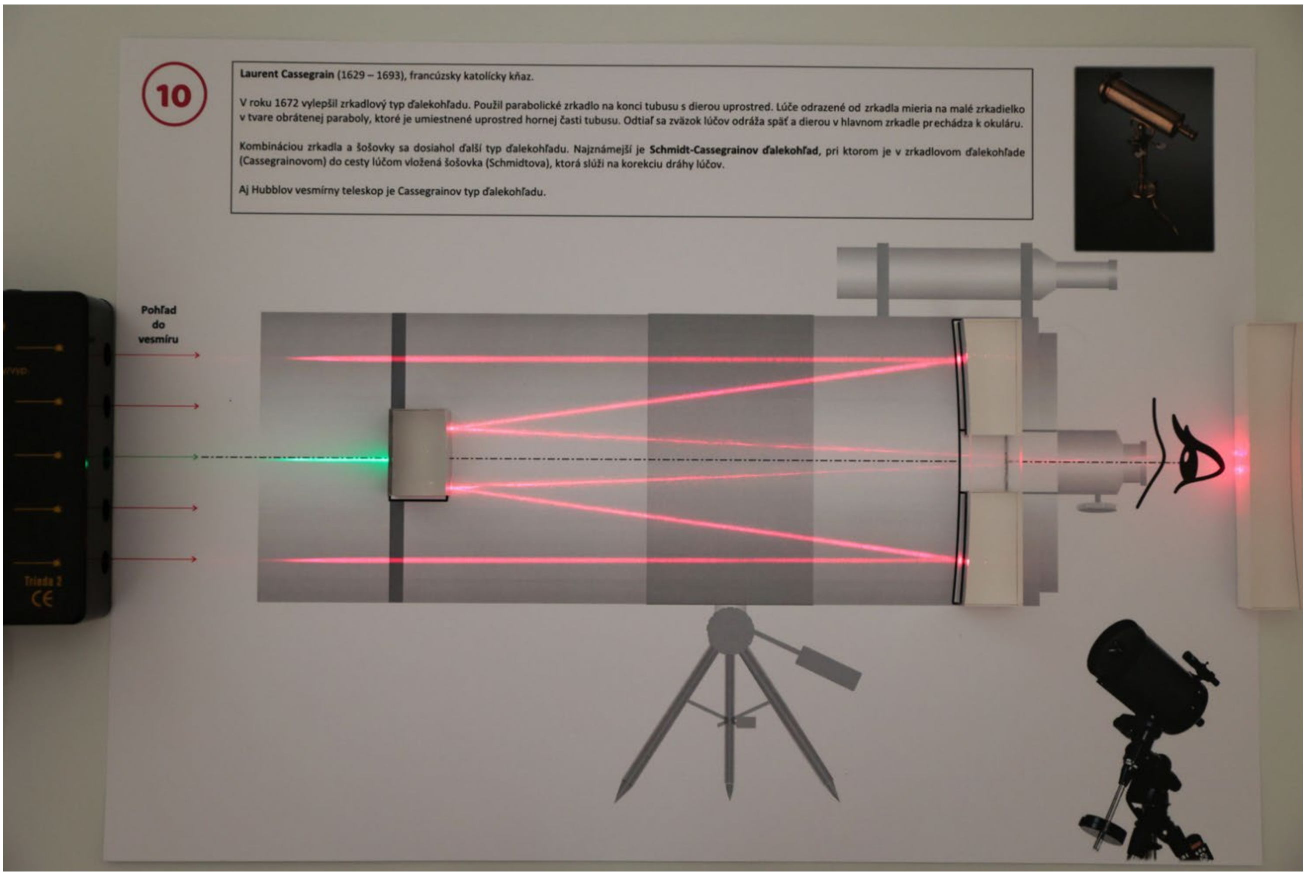
Attach Cassegrain primary mirror and Cassegrain secondary mirror to the marked places on the sheet. Position the laser light source outside the sheet as close to its left edge as possible. Its exact position is determined by the optical axis in the sheet, which corresponds to the middle (green) beam. The laser light source is a view into space. Use the light mode switch button to turn on 3 beams - first, third and fifth. Adjust the position of the laser light source so that the center (green) beam shines in the optical axis.

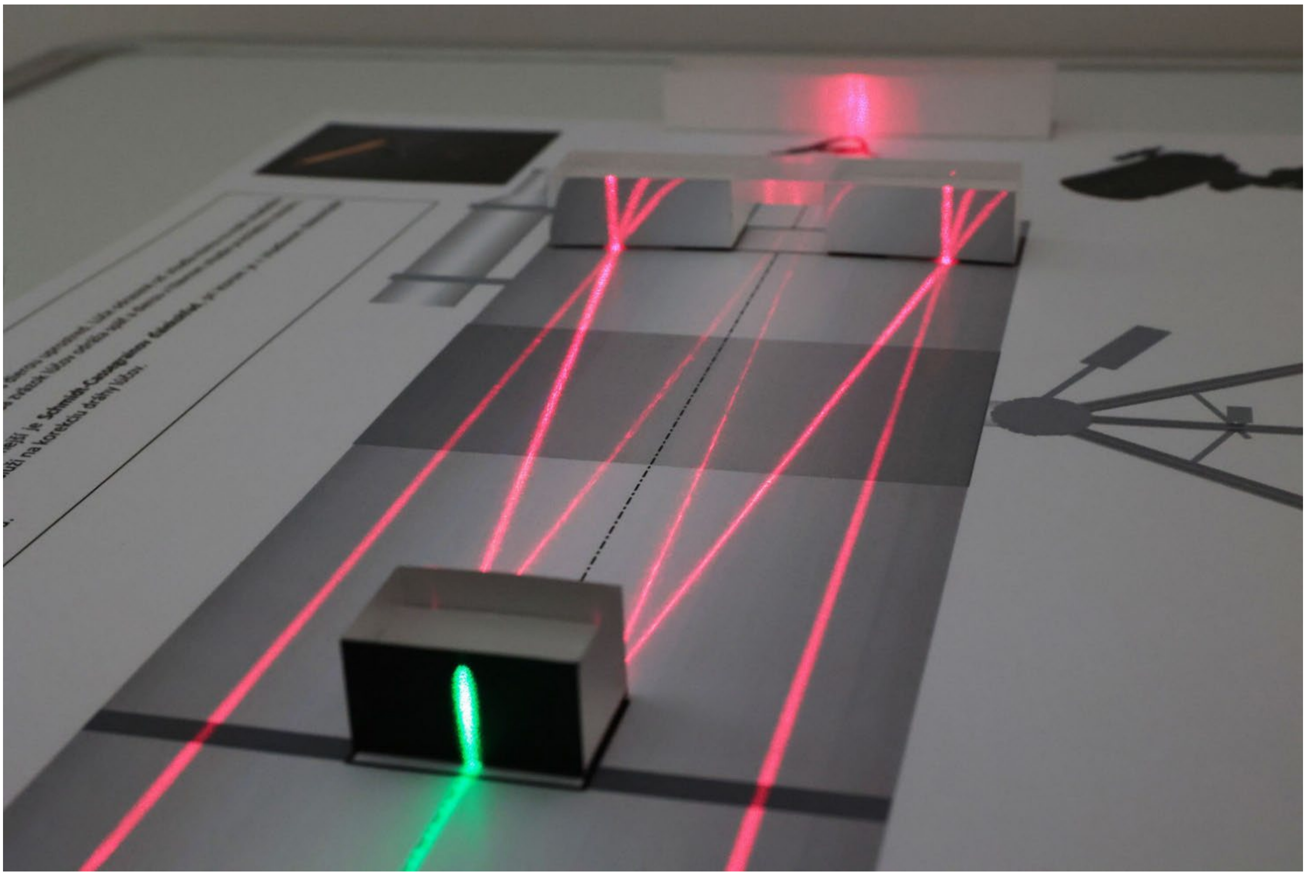
Activity:

If necessary, gently adjust the positions of both mirrors and observe the reduced image of the laser beams behind the eyepiece so that the focus is directed at the eyepiece. For this task, it is advisable to use a screen (white surface of the Newton primary mirror module) to facilitate the visibility of the adjustment and direction of the reflected laser beams from the Cassegrain secondary mirror.
Gradually cover the laser beams with your finger in front of where they emit and observe which beams are behind the eyepiece. Hold your finger so that you only cover one beam at a time and no more.
When you cover the lower beam from where it radiates, the upper beam is covered behind the eyepiece.

Summary:

Cassegrain telescope consists of the primary - parabolic mirror, which is at the end of the tube but has an aperture in the middle of it and a secondary small mirror in the shape of an inverted parabola, which is in front of the tube. From there, the focused rays reflect back and pass through the aperture in the main mirror into the eyepiece. Using the secondary mirror, which focuses the focus behind the primary mirror, the view is therefore directed in the same direction as the telescope is pointing. Most modern telescopes, as well as the Hubble Space Telescope, are of the Cassegrain type.


10
Laurent Cassegrain (1629 – 1693), francúzsky katolícky kňaz.
V roku 1672 vylepšil zrkadlový typ ďalekohľadu. Použil parabolické zrkadlo na konci tubusu s dierou uprostred. Lúče odrazené od zrkadla mieria na malé zrkadielko v tvare obrátenej paraboly, ktoré je umiestnené uprostred hornej časti tubusu. Odtiaľ sa zväzok lúčov odráža späť a dierou v hlavnom zrkadle prechádza k okuláru.
Kombináciou zrkadla a šošovky sa dosiahol ďalší typ ďalekohľadu. Najznámejší je Schmidt-Cassegrainov ďalekohľad, pri ktorom je v zrkadlovom ďalekohľade (Cassegrainovom) do cesty lúčom vložená šošovka (Schmidtova), ktorá slúži na korekciu dráhy lúčov.
Aj Hubblov vesmírny teleskop je Cassegrainov typ ďalekohľadu.
Pohľad
do
vesmíru



Task 11a: Monolithic primary mirror of the space telescope – Hubble space telescope

Task number: 22

Equipment:

Sheet no. 11, laser light source, Cassegrain primary mirror

Preparation:

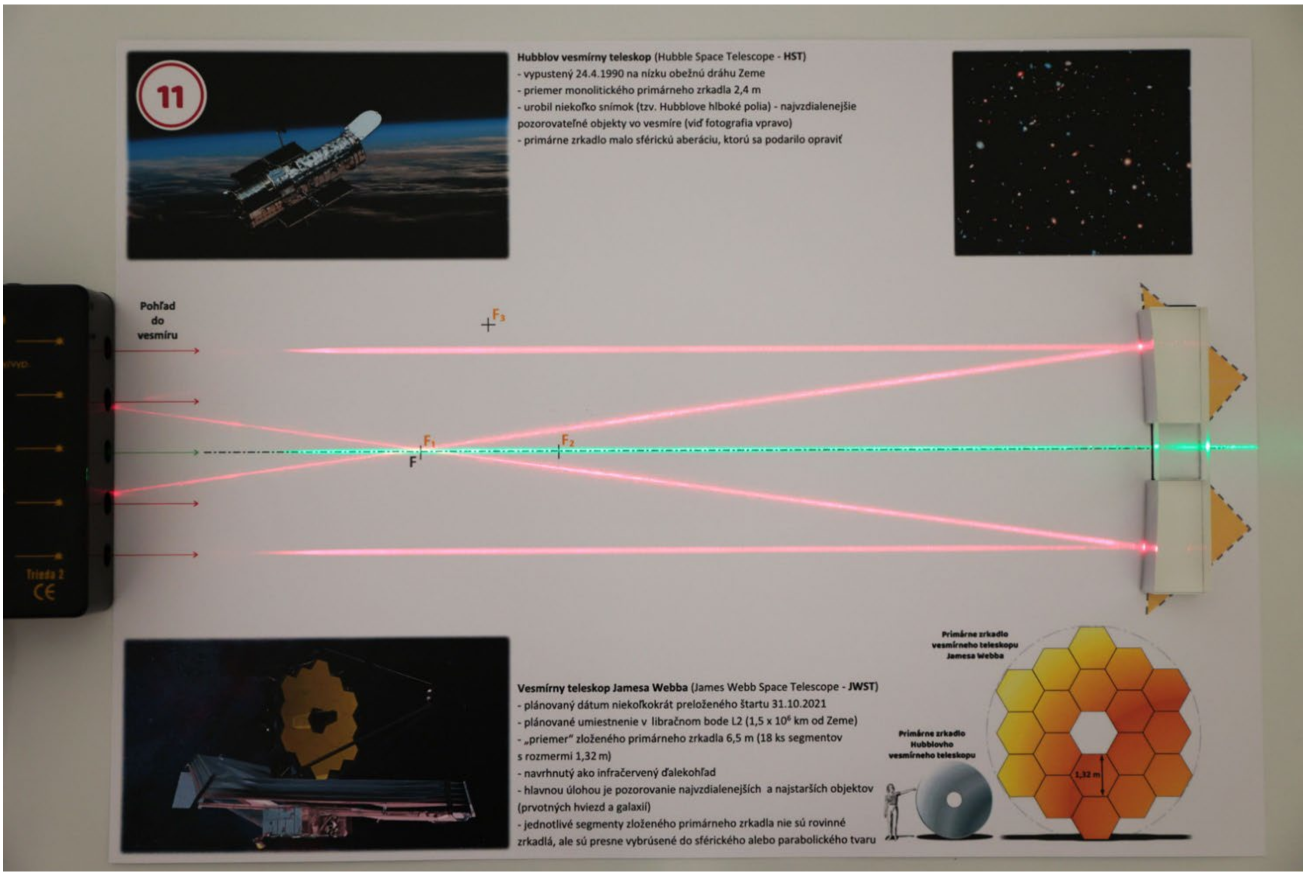
Attach the Cassegrain primary mirror to the marked place on the sheet. Position the laser light source outside the sheet as close to its left edge as possible. Its exact position is determined by the optical axis in the sheet, which corresponds to the middle (green) beam.
The laser light source is a view into space. Turn on all 5 beams. Adjust the position of the laser light source so that the center (green) beam shines in the optical axis.

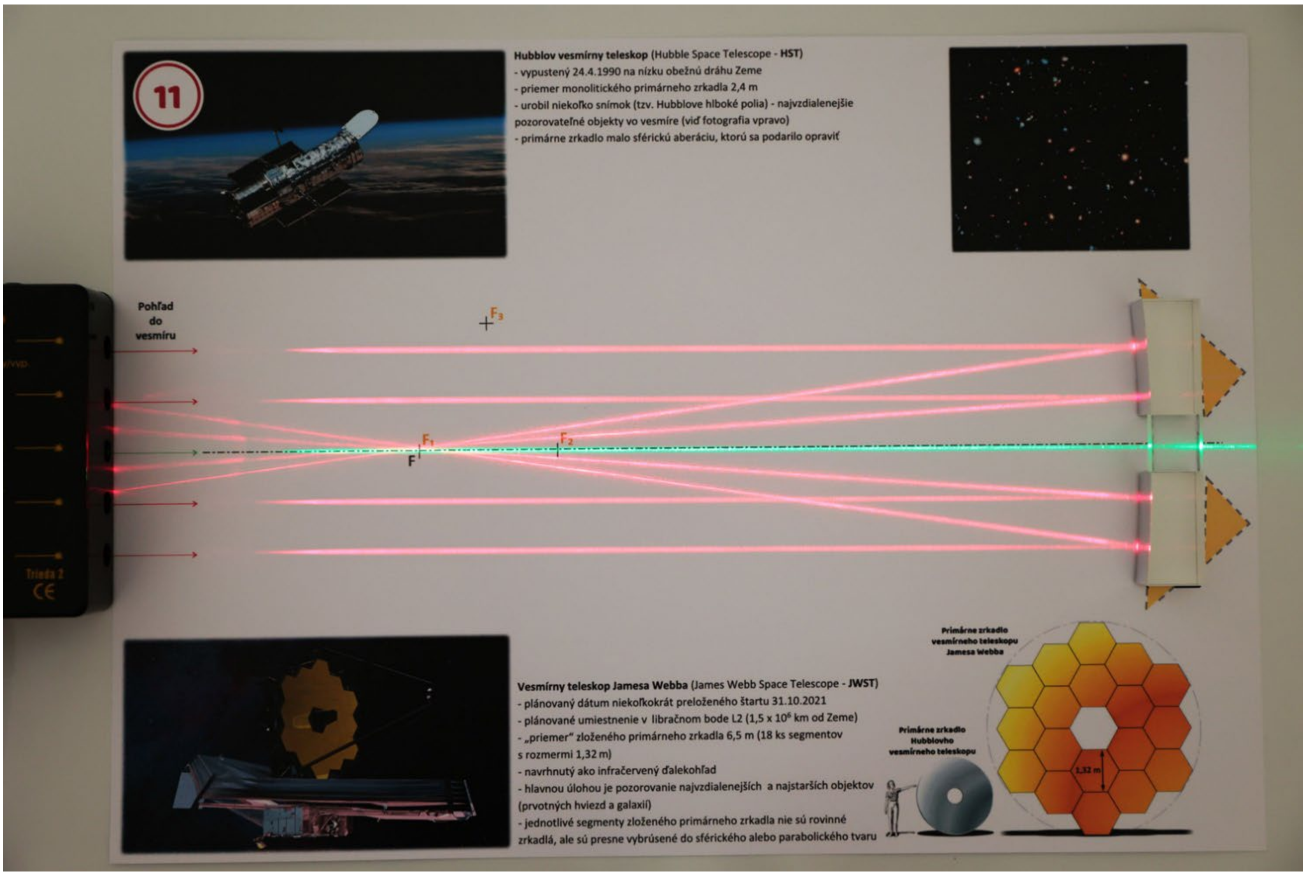
Activity:

If necessary, gently adjust the position of the mirror and observe that the reflected laser beams meet in a focus (F) that is fixed. Try tilting the mirror to target other focus positions in the sheet. Note that this is not possible.

Summary:

The monolithic primary mirror consists of only one piece and has only one focus. Telescopes are placed on plateaus in places where there are good observation conditions. However, it is increasingly difficult to find such places on Earth, because the problem of the quality of observation is also the atmosphere, which constantly refracts incoming rays. Scientists have agreed that it is ideal to place the telescope outside the atmosphere, i.e. in space.
An example is the Hubble Space Telescope, which has a mirror diameter of 2.4 m, which at the time of its launch was the largest possible diameter for transport by a space shuttle. This telescope is the Cassegrain type. The main aspect of improving the observation conditions is the increase in the diameter of the primary mirror. The largest current telescopes on Earth have a primary mirror diameter of about 10 m.


11
Hubblov vesmírny teleskop (Hubble Space Telescope - HST)
- vypustený 24.4.1990 na nízku obežnú dráhu Zeme
- priemer monolitického primárneho zrkadla 2,4 m
- urobil niekoľko snímok (tzv. Hubblove hlboké polia) - najvzdialenejšie pozorovateľné objekty vo vesmíre (viď fotografia vpravo)
- primárne zrkadlo malo sférickú aberáciu, ktorú sa podarilo opraviť
Pohľad do vesmíru
F
F1
F2
F3
Vesmírny teleskop Jamesa Webba (James Webb Space Telescope - JWST)
- plánovaný dátum niekoľkokrát preloženého štartu 31.10.2021
- plánované umiestnenie v libračnom bode L2 (1,5 x 10^6 km od Zeme)
- „priemer" zloženého primárneho zrkadla 6,5 m (18 ks segmentov s rozmermi 1,32 m)
- navrhnutý ako infračervený ďalekohľad
- hlavnou úlohou je pozorovanie najvzdialenejších a najstarších objektov (prvotných hviezd a galaxií)
- jednotlivé segmenty zloženého primárneho zrkadla nie sú rovinné zrkadlá, ale sú presne vybrúsené do sférického alebo parabolického tvaru
Primárne zrkadlo vesmírneho teleskopu Jamesa Webba
Primárne zrkadlo Hubblovho vesmírneho teleskopu
1,32 m


11
Hubblov vesmírny teleskop (Hubble Space Telescope - HST)
- vypustený 24.4.1990 na nízku obežnú dráhu Zeme
- priemer monolitického primárneho zrkadla 2,4 m
- urobil niekoľko snímok (tzv. Hubblove hlboké polia) - najvzdialenejšie pozorovateľné objekty vo vesmíre (viď fotografia vpravo)
- primárne zrkadlo malo sférickú aberáciu, ktorú sa podarilo opraviť
Pohľad do vesmíru
F
F1
F2
F3
Vesmírny teleskop Jamesa Webba (James Webb Space Telescope - JWST)
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- hlavnou úlohou je pozorovanie najvzdialenejších a najstarších objektov (prvotných hviezd a galaxií)
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Primárne zrkadlo vesmírneho teleskopu Jamesa Webba
Primárne zrkadlo Hubblovho vesmírneho teleskopu
1,32 m

TASK 11B: COMPOSITE PRIMARY MIRROR OF THE SPACE TELESCOPE – JAMES WEBB SPACE TELESCOPE

Task number: 23

Equipment:

Sheet no. 11, laser light source, small mirrors (4 pcs)

Preparation:

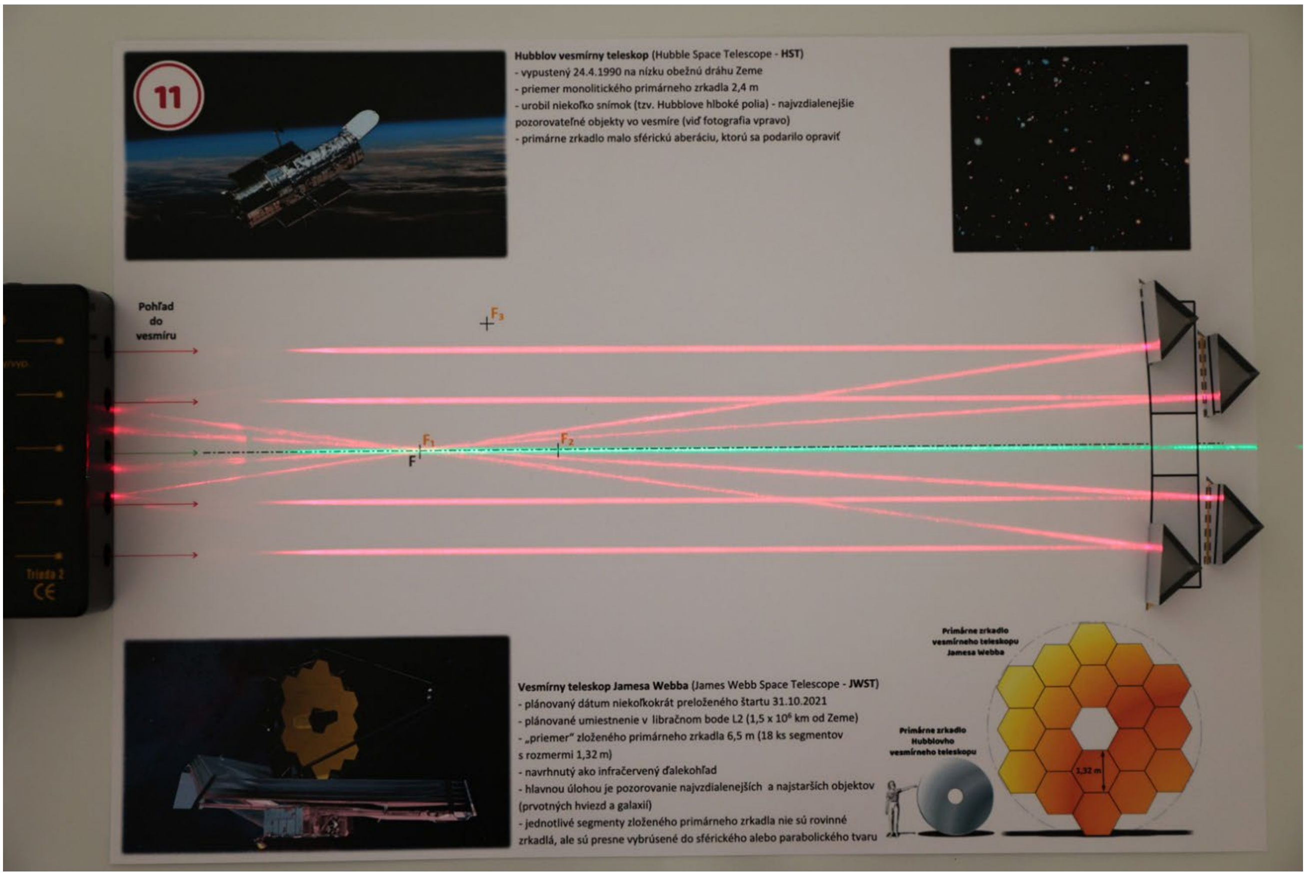
Attach the small mirrors to the marked places on the sheet. Position the laser light source outside the sheet as close to its left edge as possible. Its exact position is determined by the optical axis in the sheet, which corresponds to the middle (green) beam.
The laser light source is a view into space. Turn on all 5 beams. Adjust the position of the laser light source so that the center (green) beam shines in the optical axis.

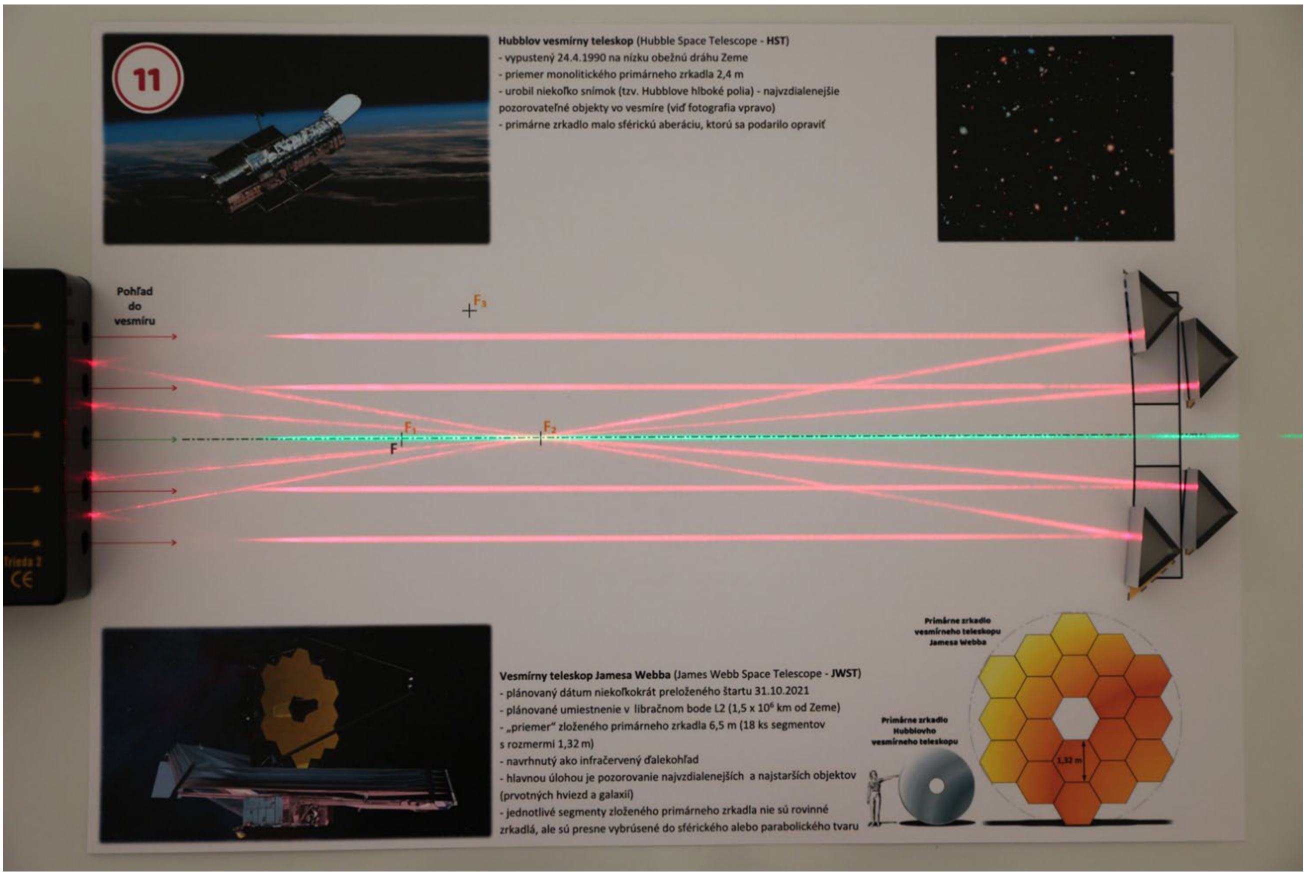
Activity:

Use gentle movements to adjust the positions of the mirrors and direct the laser beams into focus F_1 first. Observe that the rays meet in the same focus as in the task before, where only one mirror was used. Try setting up the mirrors and aiming the beams at other focuses as well (F_2 a F_3). Observe that by pointing with all the mirrors, you also hit a focus that is off the optical axis (F_3).

Summary:

The composite primary mirror consists of several pieces of smaller mirrors, which can be focused by gentle micro-movements and thus change the total focal length of the system of mirrors. Making larger and larger mirrors is more complicated and expensive, so scientists have come up with the idea of dividing one mirror into smaller segments that fold into the entire primary mirror. An example is the James Webb Space Telescope, which has a "diameter" of a compound primary mirror of up to 6.5 m and contains a total of 18 hexagons with dimensions of 1.32 m. Each of them will be individually adjustable. However, all hexagons are ground into a parabolic shape and are not planar. In this set, the principle is simplified.
This new telescope is going to be located at the libra point L2 (1.5×10^6 km from Earth) and is designed as an infrared telescope. The main task will be observing the farthest and oldest objects (primordial stars and galaxies).


11
Hubblov vesmírny teleskop (Hubble Space Telescope - HST)
- vypustený 24.4.1990 na nízku obežnú dráhu Zeme
- priemer monolitického primárneho zrkadla 2,4 m
- urobil niekoľko snímok (tzv. Hubblove hlboké polia) - najvzdialenejšie pozorovateľné objekty vo vesmíre (viď fotografia vpravo)
- primárne zrkadlo malo sférickú aberáciu, ktorú sa podarilo opraviť
Pohľad do vesmíru
Vesmírny teleskop Jamesa Webba (James Webb Space Telescope - JWST)
- plánovaný dátum niekoľkokrát preloženého štartu 31.10.2021
- plánované umiestnenie v libračnom bode L2 (1,5 x 10⁶ km od Zeme)
- „priemer" zloženého primárneho zrkadla 6,5 m (18 ks segmentov s rozmermi 1,32 m)
- navrhnutý ako infračervený ďalekohľad
- hlavnou úlohou je pozorovanie najvzdialenejších a najstarších objektov (prvotných hviezd a galaxií)
- jednotlivé segmenty zloženého primárneho zrkadla nie sú rovinné zrkadlá, ale sú presne vybrúsené do sférického alebo parabolického tvaru
Primárne zrkadlo vesmírneho teleskopu Jamesa Webba
Primárne zrkadlo Hubblovho vesmírneho teleskopu
1,32 m


11
Hubblov vesmírny teleskop (Hubble Space Telescope - HST)
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- urobil niekoľko snímok (tzv. Hubblove hlboké polia) - najvzdialenejšie pozorovateľné objekty vo vesmíre (viď fotografia vpravo)
- primárne zrkadlo malo sférickú aberáciu, ktorú sa podarilo opraviť
Pohľad do vesmíru
Vesmírny teleskop Jamesa Webba (James Webb Space Telescope - JWST)
- plánovaný dátum niekoľkokrát preloženého štartu 31.10.2021
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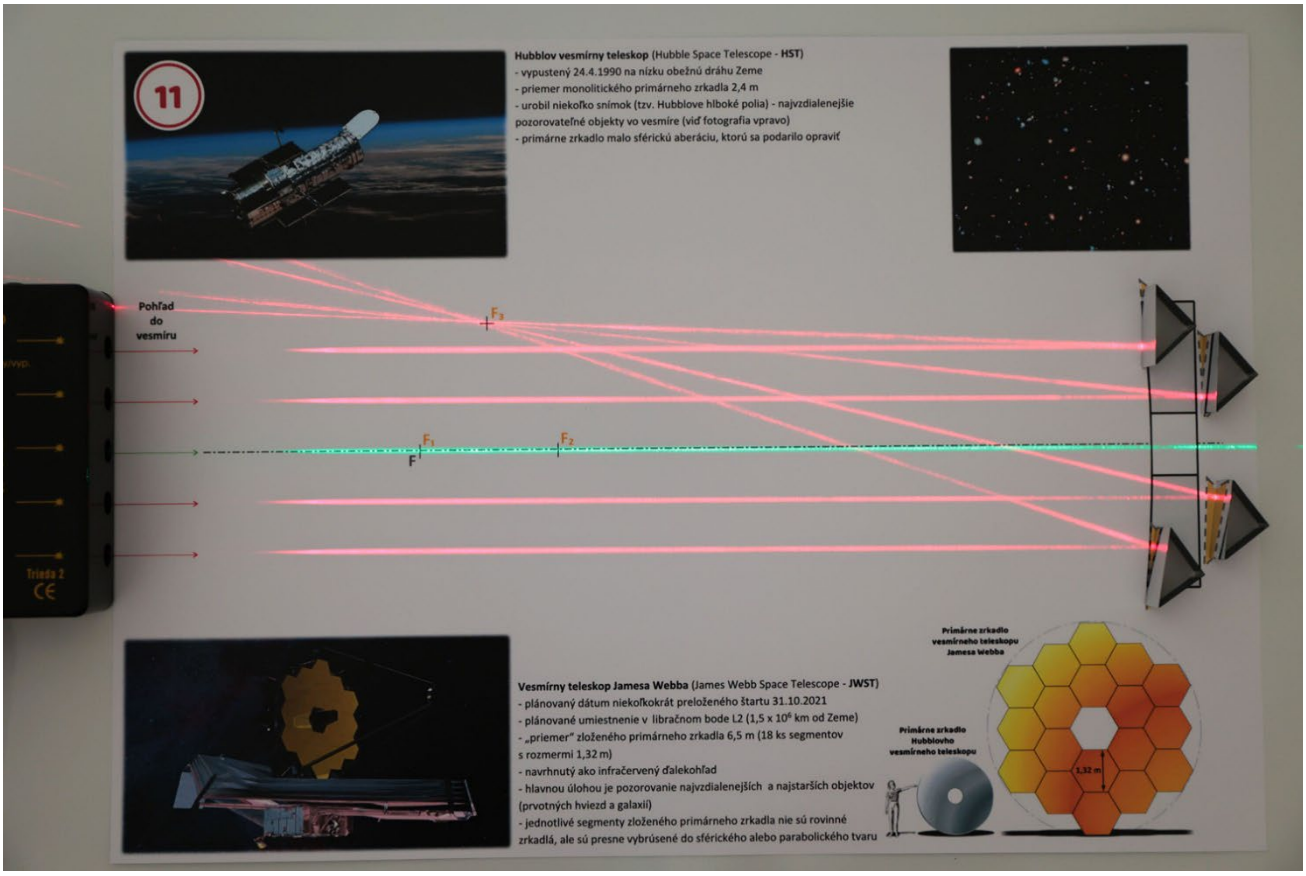
- jednotlivé segmenty zloženého primárneho zrkadla nie sú rovinné zrkadlá, ale sú presne vybrúsené do sférického alebo parabolického tvaru
Primárne zrkadlo vesmírneho teleskopu Jamesa Webba
Primárne zrkadlo Hubblovho vesmírneho teleskopu
1,32 m


11
Hubblov vesmírny teleskop (Hubble Space Telescope - HST)
- vypustený 24.4.1990 na nízku obežnú dráhu Zeme
- priemer monolitického primárneho zrkadla 2,4 m
- urobil niekoľko snímok (tzv. Hubblove hlboké polia) - najvzdialenejšie pozorovateľné objekty vo vesmíre (viď fotografia vpravo)
- primárne zrkadlo malo sférickú aberáciu, ktorú sa podarilo opraviť
Pohľad do vesmíru
Trieda 2
Vesmírny teleskop Jamesa Webba (James Webb Space Telescope - JWST)
- plánovaný dátum niekoľkokrát preloženého štartu 31.10.2021
- plánované umiestnenie v libračnom bode L2 (1,5 x 10⁶ km od Zeme)
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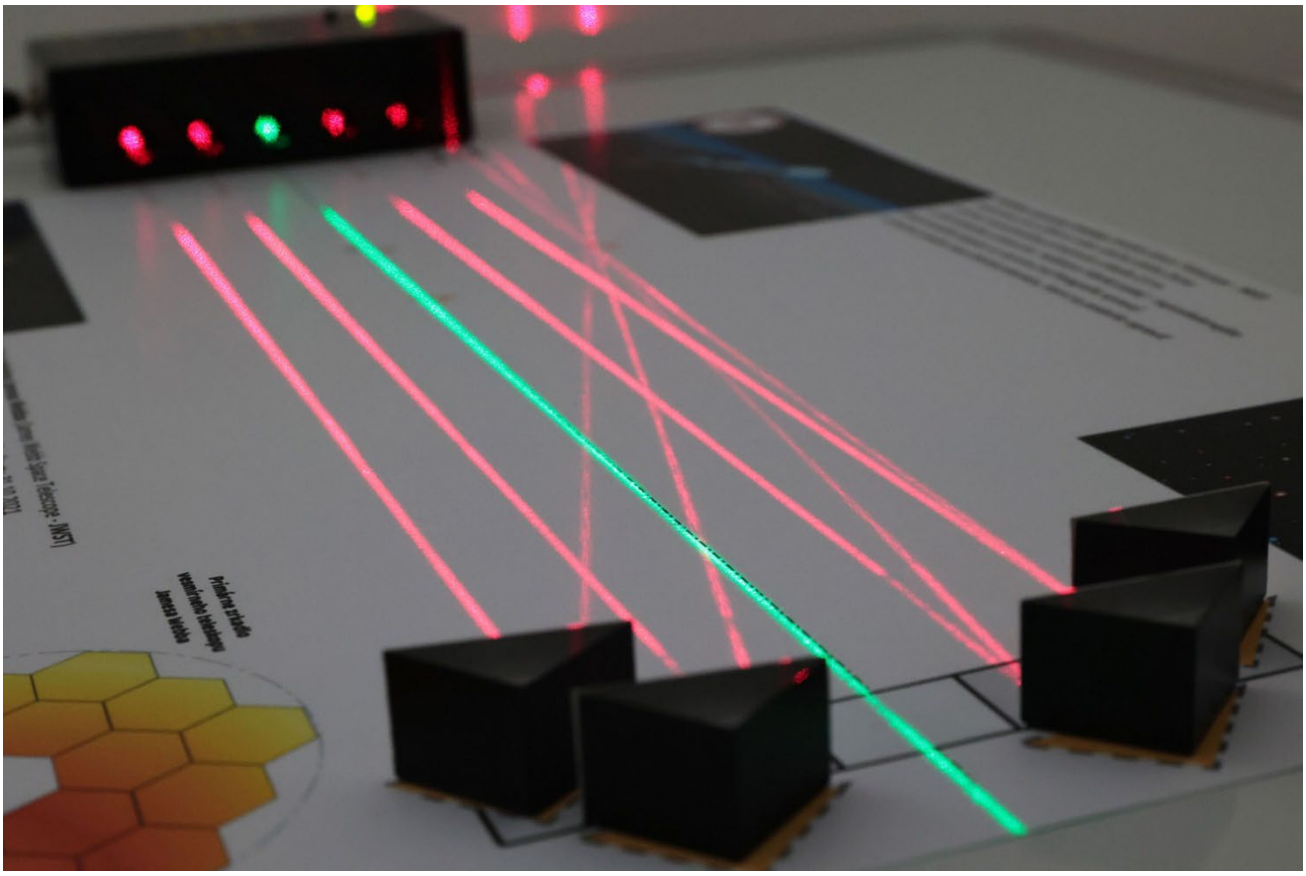
Primárne zrkadlo vesmírneho teleskopu Jamesa Webba
Primárne zrkadlo Hubblovho vesmírneho teleskopu
1,32 m



TASK 12A: CLASSIC RADIO TELESCOPE AND COMMUNICATION IN SPACE

Task number: 24

Equipment:

Sheet no. 12, laser light source, Newton primary mirror, Exoplanet

Preparation:

Attach the Newton primary mirror to the marked place on the sheet, which in this case is part of the parabolic antenna. Place the laser light source in the marked place, which represents a view into space. Turn on all 5 beams. Adjust the position of the laser light source so that the center (green) beam shines in the optical axis. Observe how the laser beams reflect from the primary mirror and point back at the light source.

Activity:

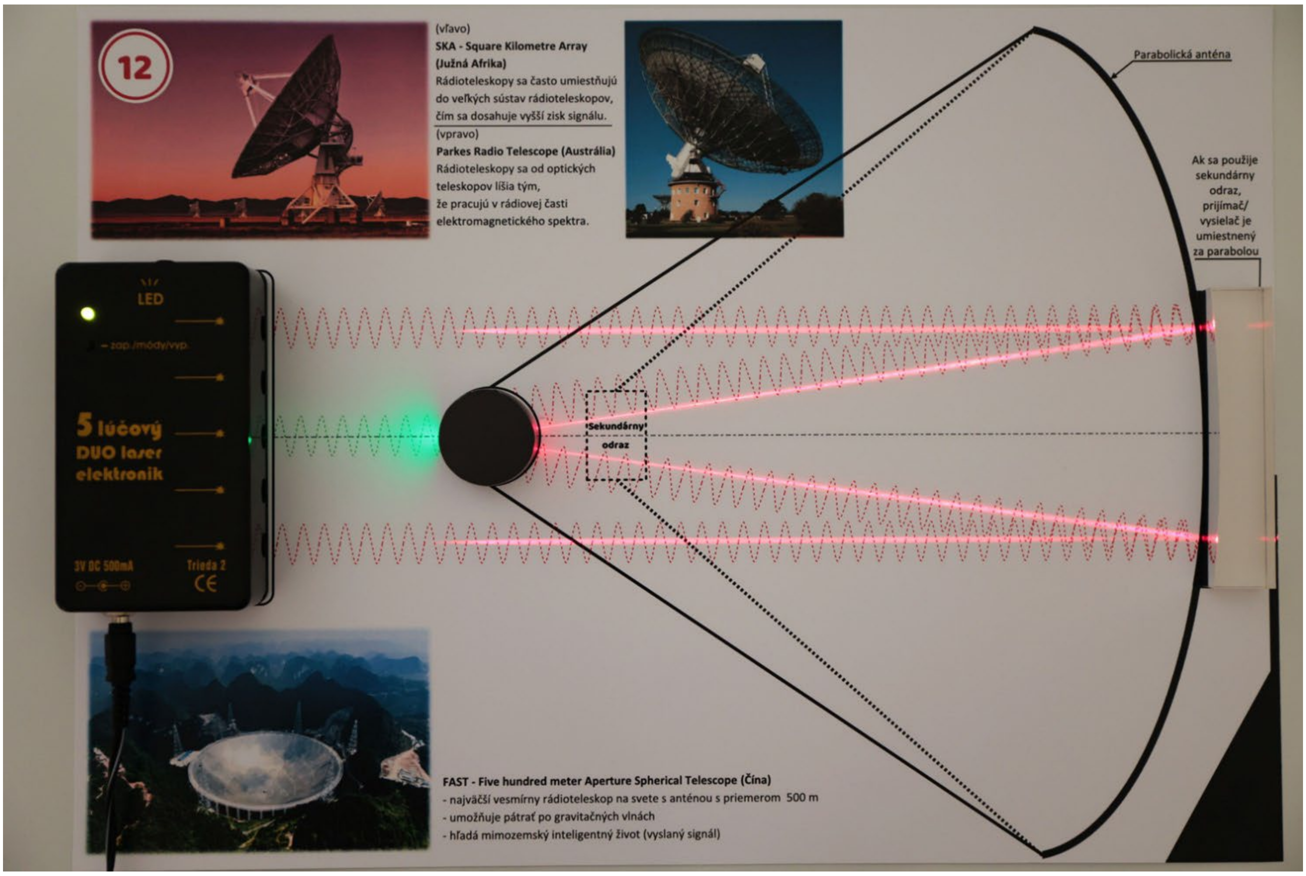
Place the Exoplanet auxiliary module on the marked position of the receiver/transmitter. Observe how the laser beams stop in the focus where the imaginary radio telescope receiver or transmitter is. The laser beams in this case show waves of radio radiation.

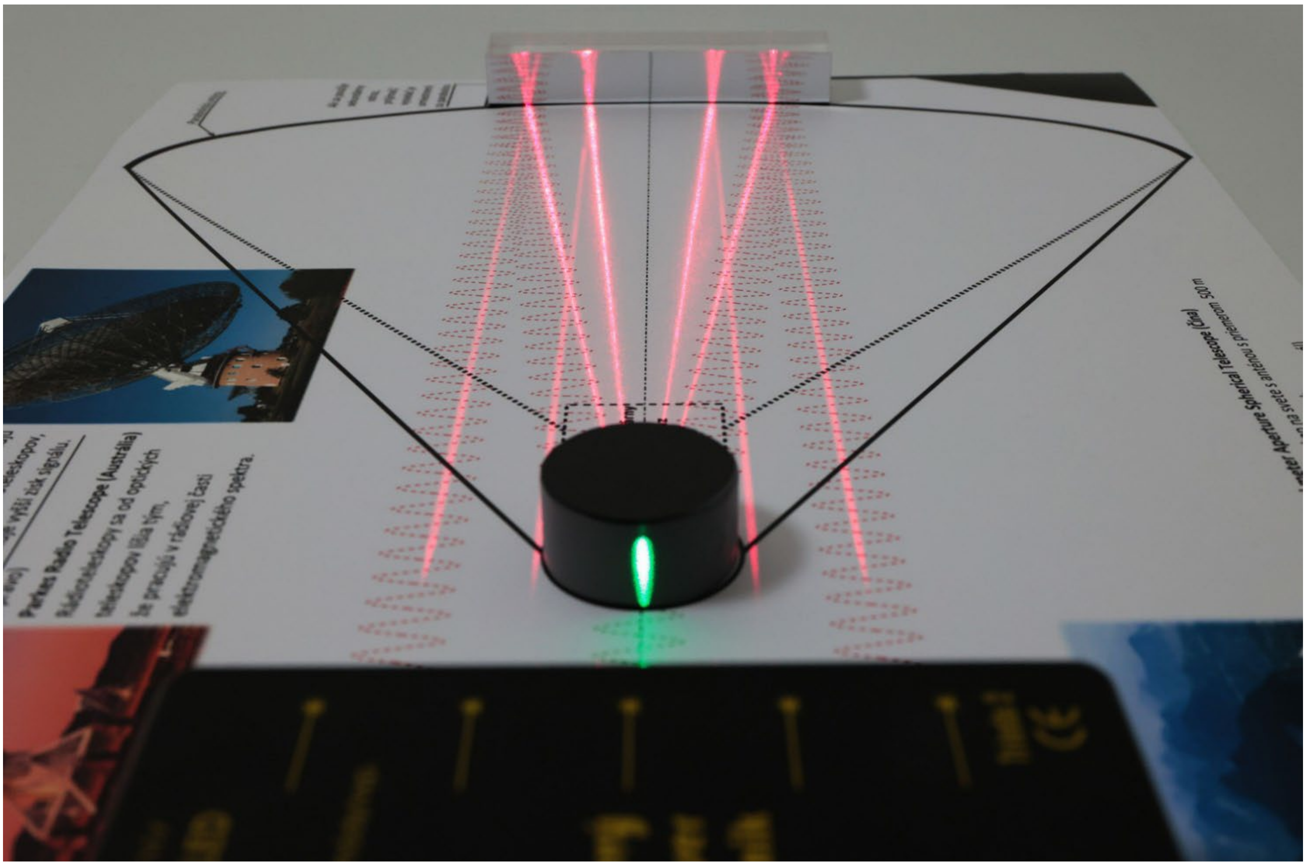
Summary:

Radio telescopes differ from optical telescopes in that they work in the radio part of electromagnetic radiation. They work on the principle of transmitting or receiving amplified airwaves from the Earth into space and vice versa. We can also call them the "ears of astronomers", through which they listen to signals in various parts of microwave and radio radiation.

In their case, everything works the same as with optical telescopes, but instead of a primary mirror, a parabola made of a material is used that reflects the part of the spectrum that we need in the same way as with the visible spectrum. Receivers and amplifiers of this signal are located in place of the secondary mirror.

Some areas of the night sky are opaque to the visible spectrum (e.g. interstellar dust), but they are completely transparent to the radio spectrum - that is why radio astronomy deals with it. Radio telescopes also represent the principle of radio communication in space. A classic radio telescope is also a parabola for receiving (downlink) or transmitting (uplink) a TV signal - satellite.


12
(vľavo)
SKA - Square Kilometre Array (Južná Afrika)
Rádioteleskopy sa často umiestňujú do veľkých sústav rádioteleskopov, čím sa dosahuje vyšší zisk signálu.
(vpravo)
Parkes Radio Telescope (Austrália)
Rádioteleskopy sa od optických teleskopov líšia tým, že pracujú v rádiovej časti elektromagnetického spektra.
Parabolická anténa
Ak sa použije sekundárny odraz, prijímač/ vysielač je umiestnený za parabolou
LED
zap./módy/vyp.
5 lúčový DUO laser elektronik
3V DC 500mA
Trieda 2
CE
Sekundárny odraz
FAST - Five hundred meter Aperture Spherical Telescope (Čína)
- najväčší vesmírny rádioteleskop na svete s anténou s priemerom 500 m
- umožňuje pátrať po gravitačných vlnách
- hľadá mimozemský inteligentný život (vyslaný signál)



TASK 12B: ADVANCED RADIO TELESCOPE

Task number: 25

Equipment:

Sheet no. 12, laser light source, Cassegrain primary mirror, Cassegrain secondary mirror, screen (white surface of Newton primary mirror)

Preparation:

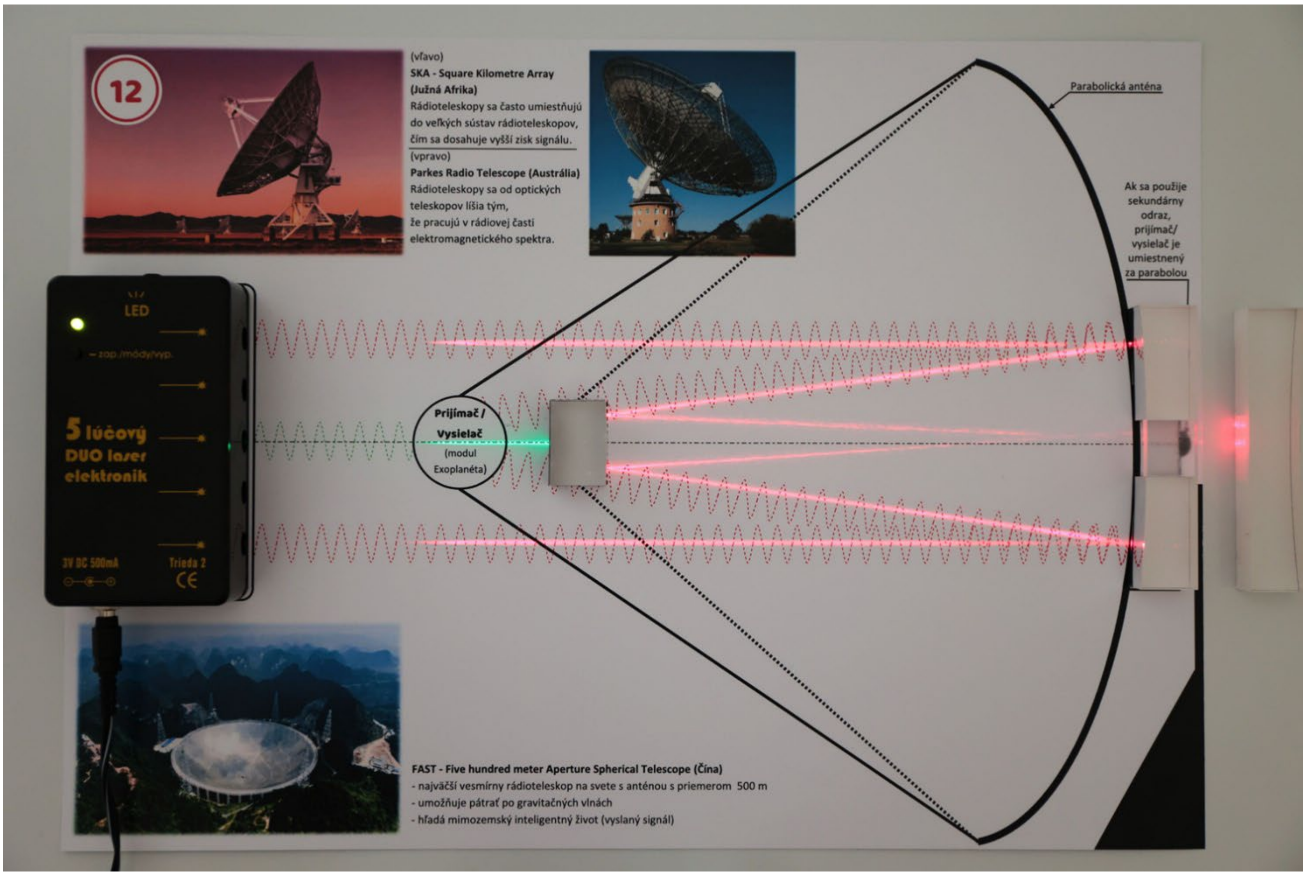
Attach the Cassegrain primary mirror, which in this case is part of the parabolic antenna, to the marked place on the sheet. Place the laser light source in the marked place, which represents a view into space. Turn on all 5 beams. Adjust the position of the laser light source so that the center (green) beam shines in the optical axis. Observe how the red laser beams reflect from the primary mirror and point back to the light source, and as the green laser beam passes through the aperture in the mirror along the optical axis.

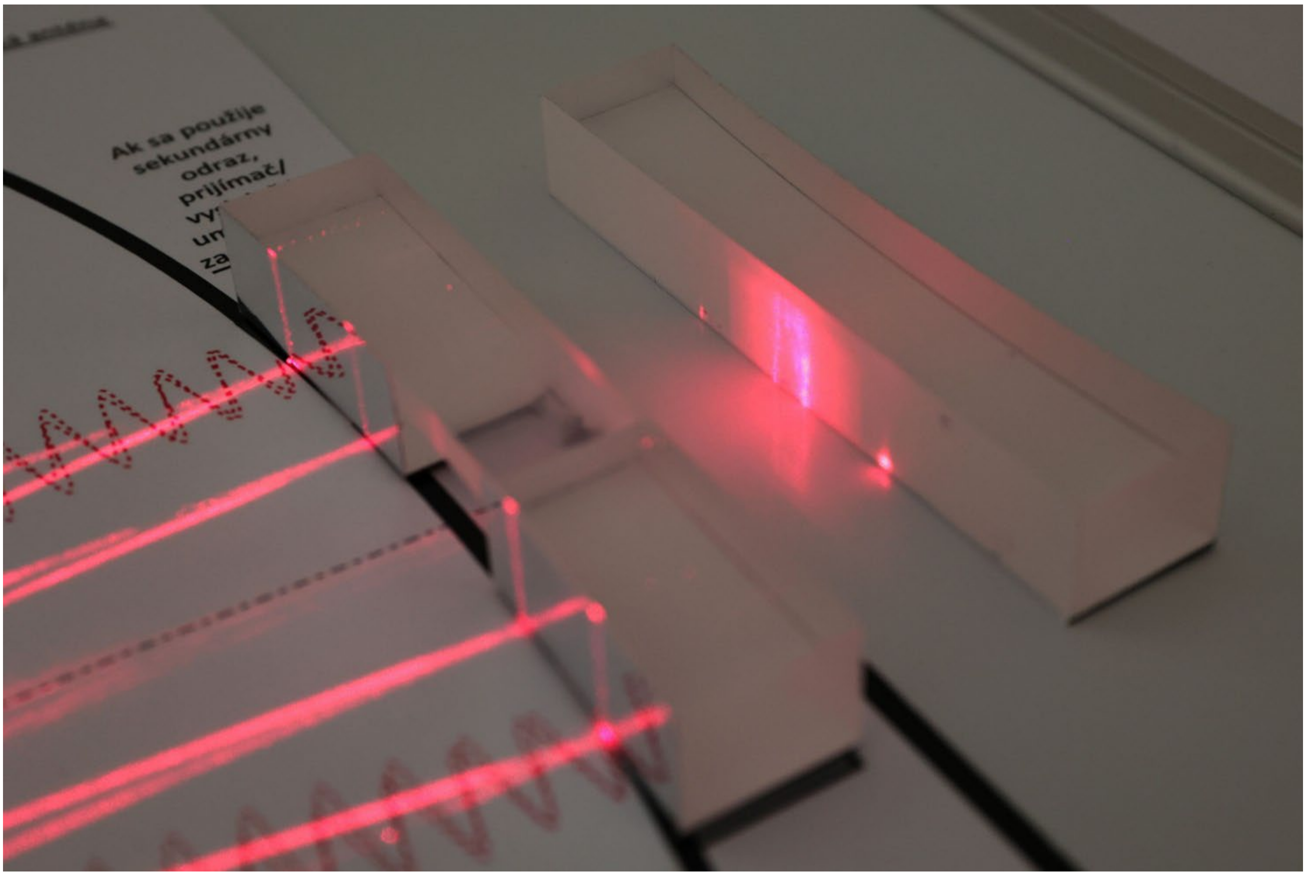
Activity:

Place the Cassegrain secondary mirror at the marked secondary reflection position. For this task, it is advisable to use a screen (white surface of the Newton primary mirror module) to facilitate the visibility of the adjustment and direction of the reflected laser beams from the Cassegrain secondary mirror.
Observe how the red laser beams reflect, pass through an aperture in the mirror and meet in the focus where the imaginary radio telescope receiver or transmitter is located - behind its satellite dish. Even in this case, the laser beams show waves of radio radiation.

Summary:

This model represents the operation's principle of advanced radio telescopes of the Cassegrain type, in which the whole technique is incorporated behind the primary mirror (parabolic antenna). This simplifies access to the technique in case of repair or replacement of components.


12
(vľavo)
SKA - Square Kilometre Array (Južná Afrika)
Rádioteleskopy sa často umiestňujú do veľkých sústav rádioteleskopov, čím sa dosahuje vyšší zisk signálu.
(vpravo)
Parkes Radio Telescope (Austrália)
Rádioteleskopy sa od optických teleskopov líšia tým, že pracujú v rádiovej časti elektromagnetického spektra.
Parabolická anténa
Ak sa použije sekundárny odraz, prijímač/ vysielač je umiestnený za parabolou
LED
5 lúčový DUO laser elektronik
3V DC 500mA
Trieda 2
CE
Prijímač / Vysielač (modul Exoplanéta)
FAST - Five hundred meter Aperture Spherical Telescope (Čína)
- najväčší vesmírny rádioteleskop na svete s anténou s priemerom 500 m
- umožňuje pátrať po gravitačných vlnách
- hľadá mimozemský inteligentný život (vyslaný signál)



Task 13: Light curve of exoplanet

Task number: 26

Equipment:

Sheet no. 13, laser light source, Exoplanet

Preparation:

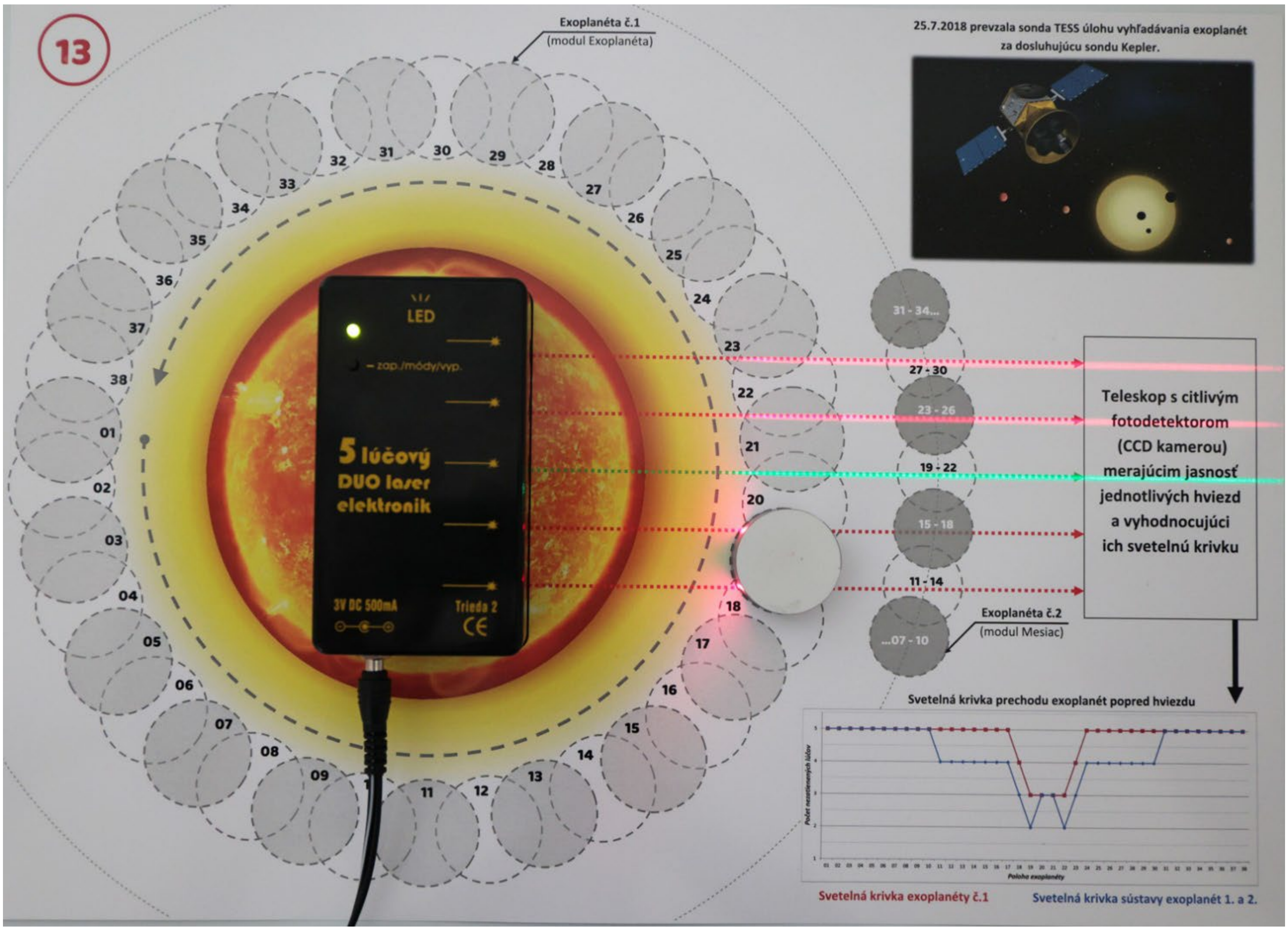
Place the laser light source representing a star in the marked area on the sheet. Turn on all 5 beams. Adjust the position of the laser light source so that the center (green) beam shines in the optical axis. On the right side of the sheet, where the laser beams shine, the telescope is shown as an observation point in which unshaded beams will be count off.

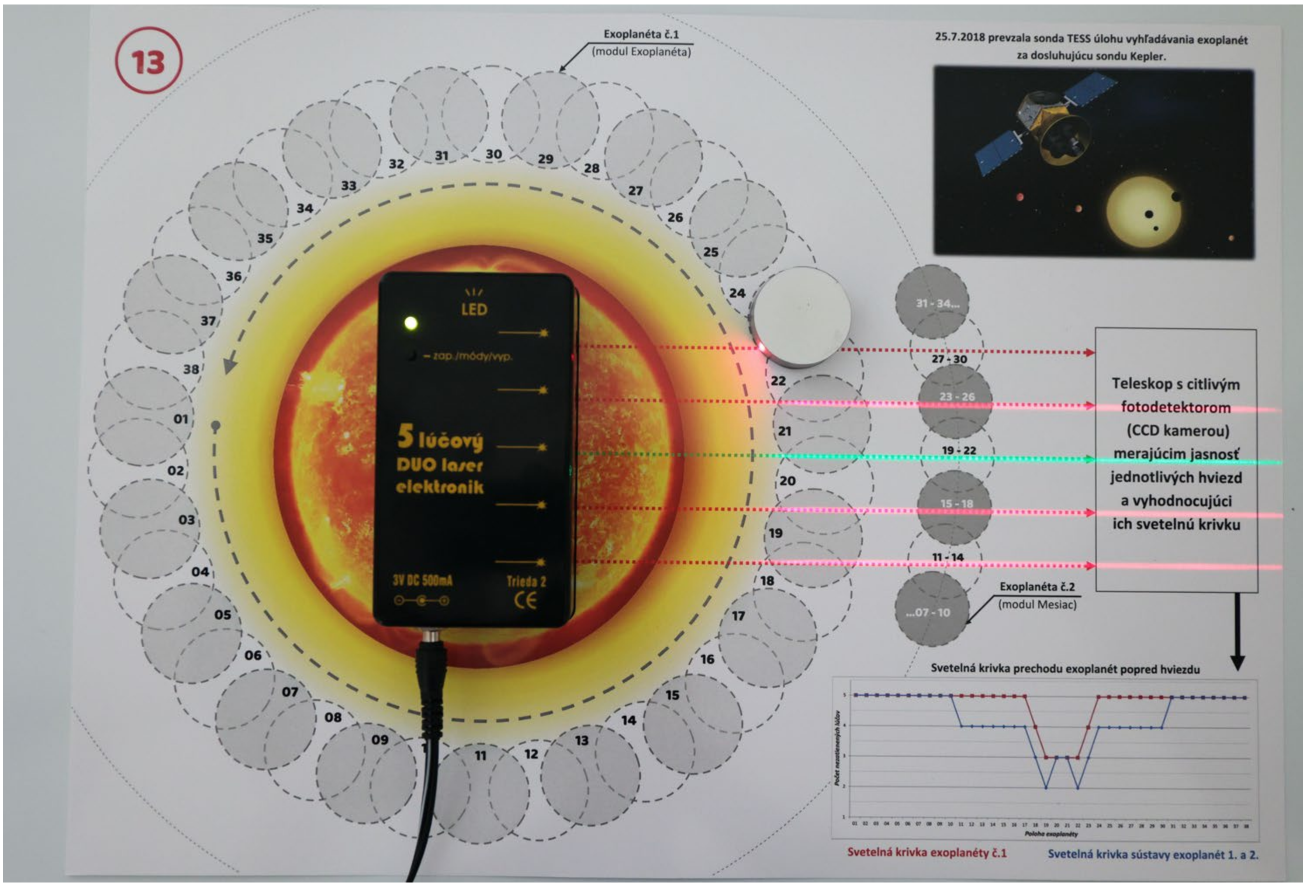
Activity:

The task is to observe and record the light (transition) curve of the exoplanet in front of the star. Attach Exoplanet module no. 1 to the marked position on the sheet. Exoplanet no. 1 revolves around a star in the direction of the arrow in the drawing from position 1 to 38.
The task is intended for 3 people. The first moves the Exoplanet module every 2 seconds, the second monitors the rays and the third writes the number of unshaded rays in each position in a table. After completing the exoplanet cycle, create a graph from the measured data (x-axis = position number, y-axis = number of unshaded rays). The result of the task is a graph - a light curve of the passageway of an exoplanet in front of the star.

Summary:

By measuring the brightness of the star using the eclipsing method with a sensitive CCD detector, regular deviations are detected. According to the shape of the transition curve, we can determine whether it is a transition - the transit of an exoplanet or a variable star. At the same time, we can determine the time of orbit of the exoplanet and its size. The problem with this method of observation is that the exoplanet must have an orbital plane with Earth and a star, otherwise, we will not see it. Exoplanets are especially sought after by stars similar to our Sun.


13
Exoplanéta č.1
(modul Exoplanéta)
25.7.2018 prevzala sonda TESS úlohu vyhľadávania exoplanét
za dosluhujúcu sondu Kepler.
LED
zap./módy/vyp.
5 lúčový
DUO laser
elektronik
3V DC 500mA
Trieda 2
Teleskop s citlivým
fotodetektorom
(CCD kamerou)
merajúcim jasnosť
jednotlivých hviezd
a vyhodnocujúci
ich svetelnú krivku
Exoplanéta č.2
(modul Mesiac)
Svetelná krivka prechodu exoplanét popred hviezdu
Svetelná krivka exoplanéty č.1
Svetelná krivka sústavy exoplanét 1. a 2.


13
Exoplanéta č.1
(modul Exoplanéta)
25.7.2018 prevzala sonda TESS úlohu vyhľadávania exoplanét
za dosluhujúcu sondu Kepler.
LED
zap./módy/vyp.
5 lúčový
DUO laser
elektronik
3V DC 500mA
Trieda 2
Teleskop s citlivým
fotodetektorom
(CCD kamerou)
merajúcim jasnosť
jednotlivých hviezd
a vyhodnocujúci
ich svetelnú krivku
Exoplanéta č.2
(modul Mesiac)
Svetelná krivka prechodu exoplanét popred hviezdu
Svetelná krivka exoplanéty č.1
Svetelná krivka sústavy exoplanét 1. a 2.

TASK 13B: LIGHT CURVE OF THE PLANETARY SYSTEM

Task number: 27

Equipment:

Sheet no. 13, laser light source, Exoplanet, Moon

Preparation:

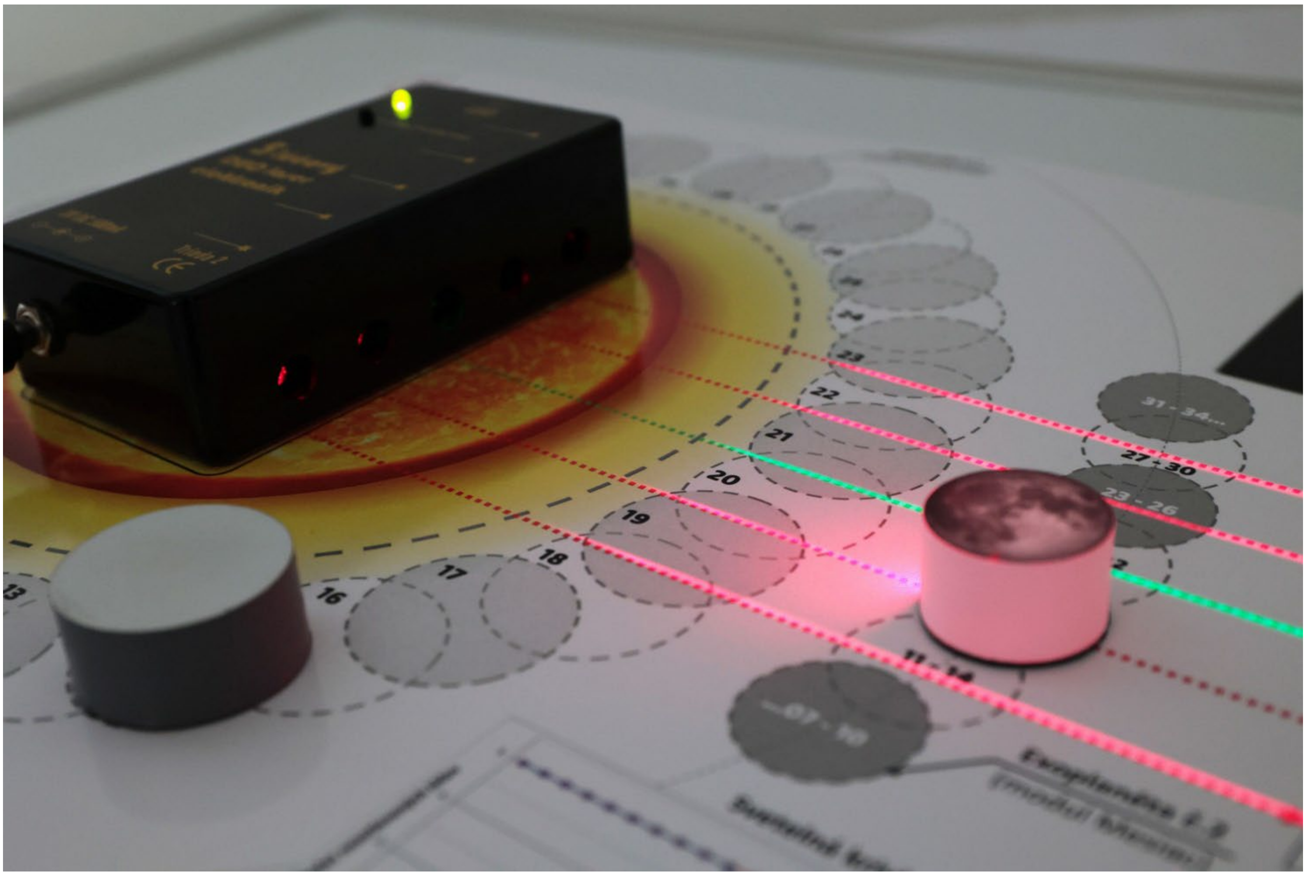
Place the laser light source representing a star in the marked area on the sheet. Turn on all 5 beams. Adjust the position of the laser light source so that the center (green) beam shines in the optical axis. On the right side of the sheet, where the laser beams shine, the telescope is shown as an observation point in which unshaded beams will be count off.

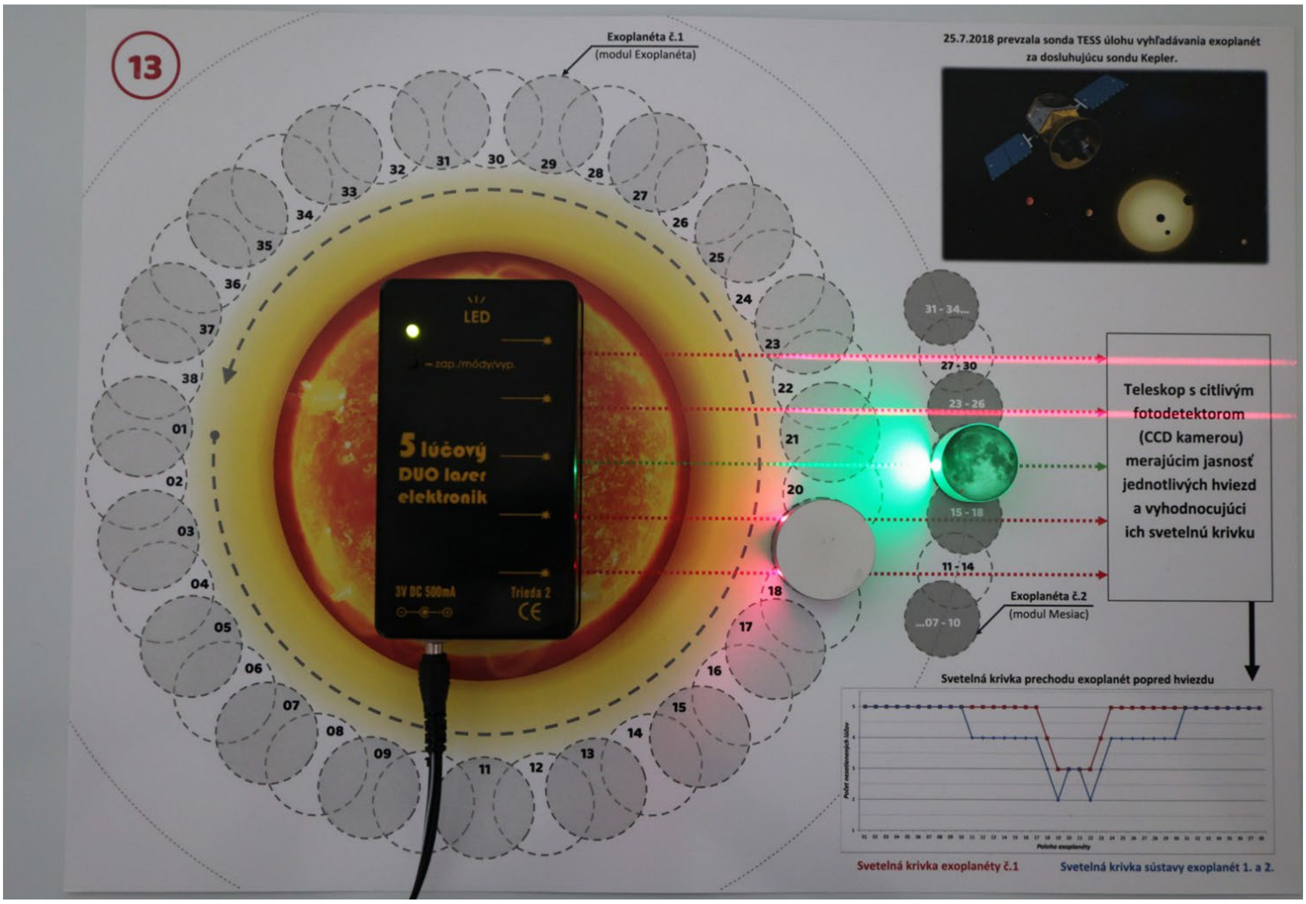
Activity:

The procedure is similar to the previous assignment, but the task is now to observe and record the light (transition) curve of the planetary system in front of the star.
Moves with Exoplanet no. 1 at intervals of two seconds in the direction of the arrow in the drawing from position 1 to 38. Exoplanet no. 2 (in this case the auxiliary module Moon) is moved with exoplanet no. 1 so that the numbers of their positions coincide. Every four displacements of exoplanet no. 1 correspond to one displacement of exoplanet no. 2.
The task is intended for 3 people. The first moves the Exoplanet modules every 2 seconds, the second monitors the rays and the third writes the number of unshaded rays in each position in a table. After completing the exoplanets cycle, create a graph from the measured data (x-axis = position number, y-axis = number of unshaded rays). The result of the task is a graph - a light curve of the passageway of a planetary system in front of the star.

Summary:

By observing the light curves of planetary systems, we can determine the size, number and time of orbits of individual exoplanets.




13
Exoplanéta č.1
(modul Exoplanéta)
25.7.2018 prevzala sonda TESS úlohu vyhľadávania exoplanét
za dosluhujúcu sondu Kepler.
LED
zap./módy/vyp.
5 lúčový
DUO laser
elektronik
3V DC 500mA
Trieda 2
Teleskop s citlivým fotodetektorom (CCD kamerou) merajúcim jasnosť jednotlivých hviezd a vyhodnocujúci ich svetelnú krivku
Exoplanéta č.2
(modul Mesiac)
Svetelná krivka prechodu exoplanét popred hviezdu
Svetelná krivka exoplanéty č.1
Svetelná krivka sústavy exoplanét 1. a 2.

TASK 14A: VARIABLE STAR

Task number: 28

Equipment:

Sheet no. 14, laser light source, polarizing filter, Newton primary mirror - white surface

Preparation:

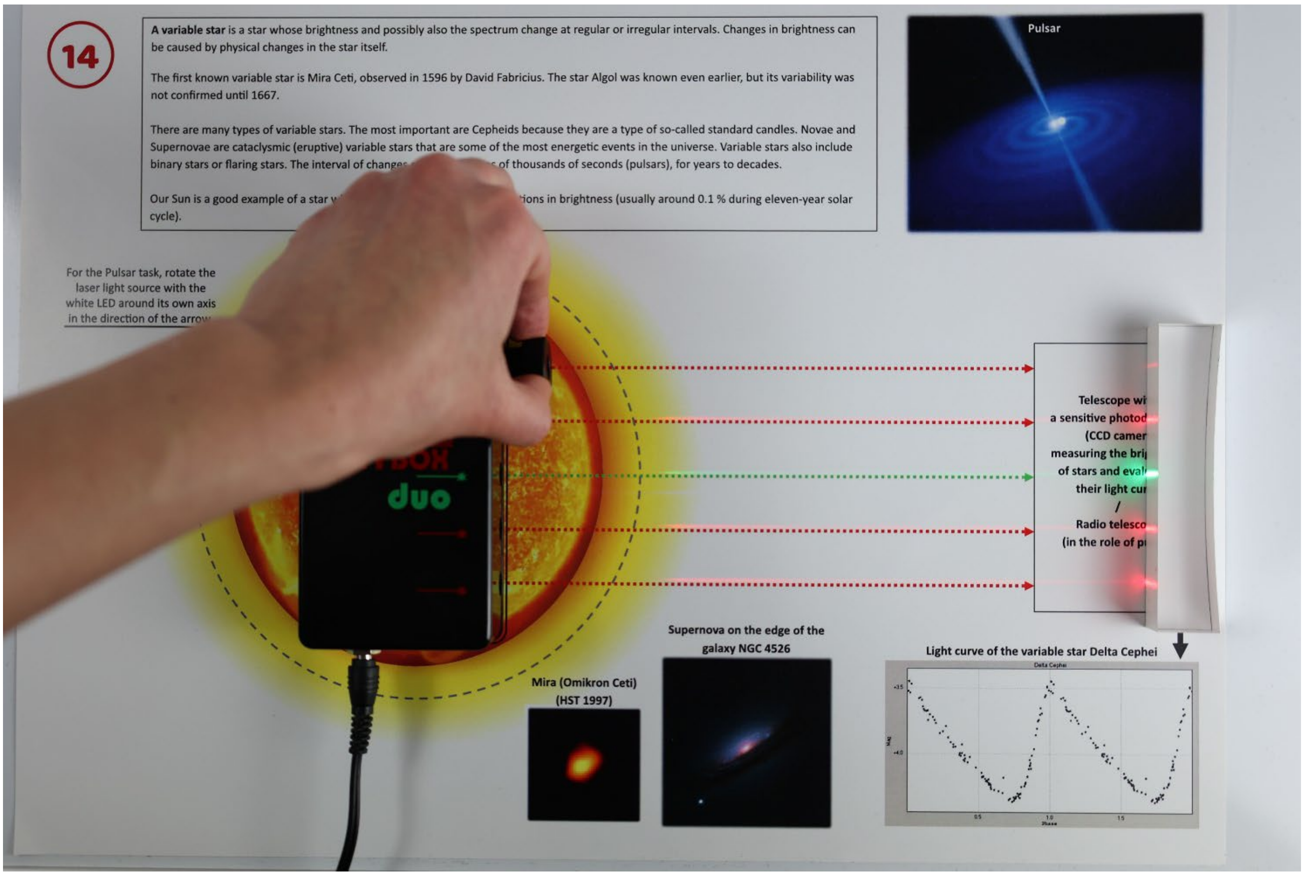
Place the laser light source representing a variable star in the marked area on the sheet. Use the light mode switch button to turn on 3 beams - first, third and fifth. Adjust the position of the laser light source so that the center (green) beam shines in the optical axis.
Place a shade (white area of the Newton primary mirror module) on the edge of the drawing in place of the Telescope with a sensitive photodetector. Observe how the stars and their spectra shine invariably.

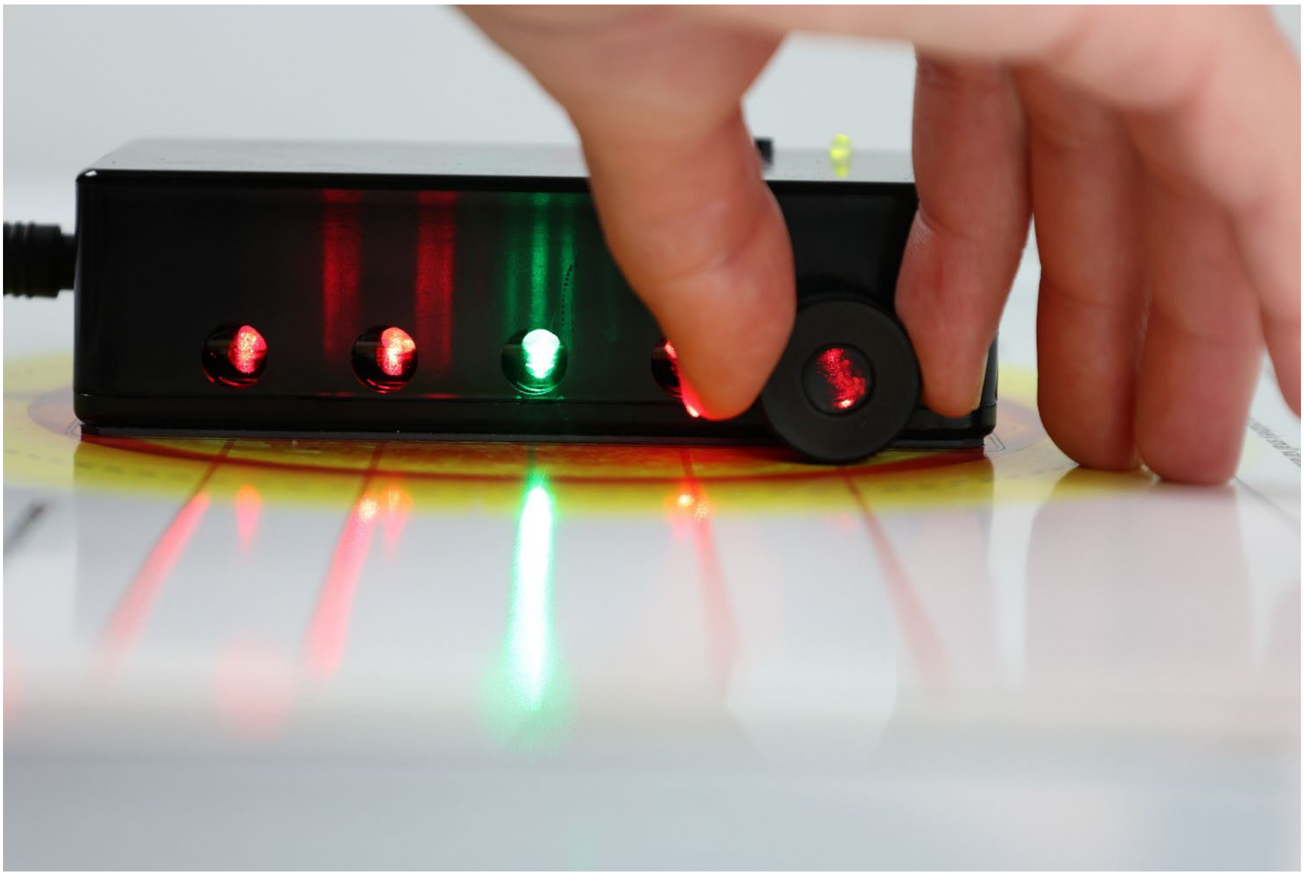
Activity:

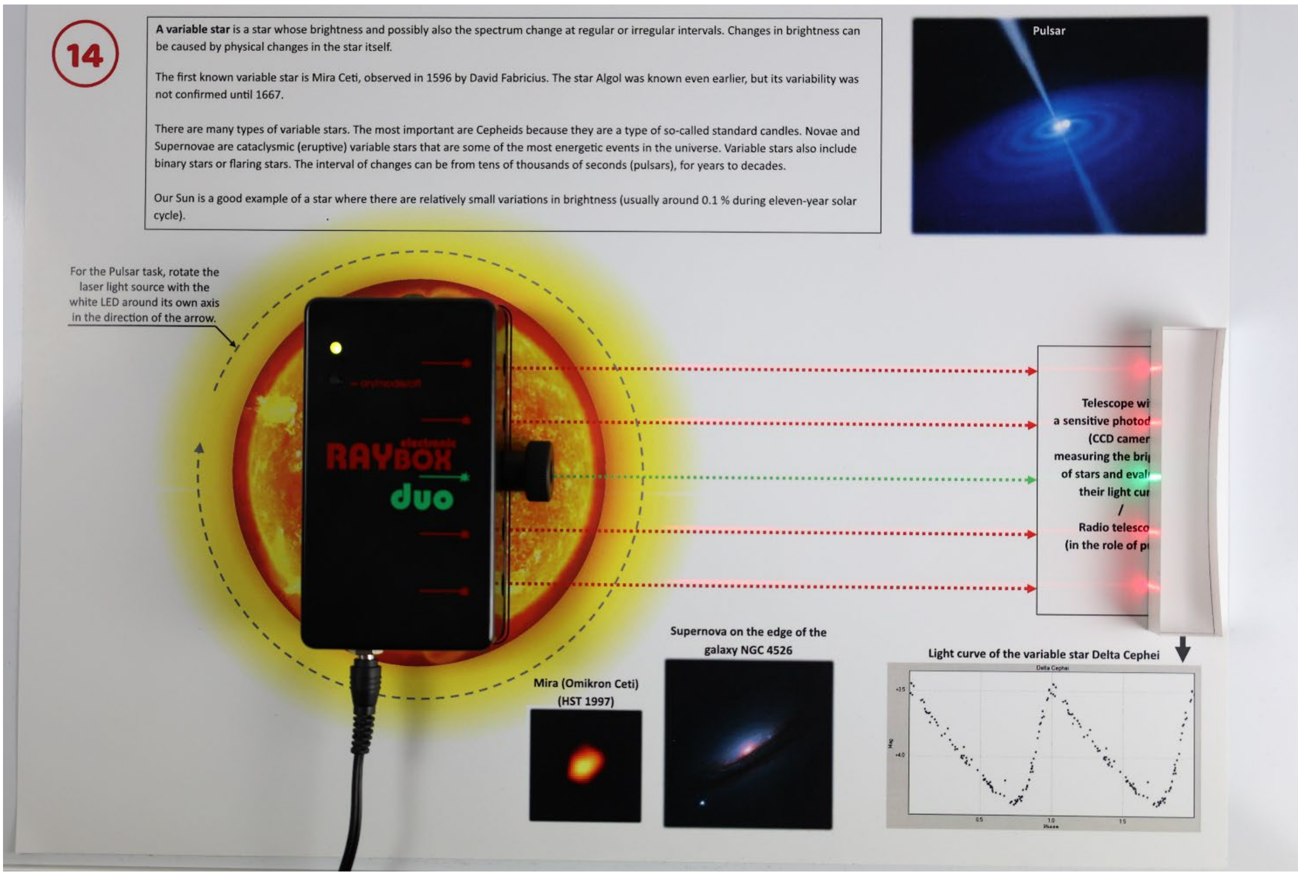
Place the polarizing filter in front of where the red laser beam emits and slowly rotate it around the axis at a constant speed. On the shade, observe the brightness change - star size. Also, try a green beam with a different rotation speed. These are irregular changes in the brightness of the stars.

Summary:

Changes in brightness can be caused by physical changes in the star itself. There are many types of variable stars. The most important are Cepheids because they are a type of so-called standard candles. Novae and supernovae are cataclysmic (eruptive) variable stars that are one of the most energetic events in the universe. Variable stars also include binary stars or flaring stars. Our Sun is a good example of a star where there are relatively small variations in brightness (usually around 0.1 % during the eleven-year solar cycle).


14
A variable star is a star whose brightness and possibly also the spectrum change at regular or irregular intervals. Changes in brightness can be caused by physical changes in the star itself.
The first known variable star is Mira Ceti, observed in 1596 by David Fabricius. The star Algol was known even earlier, but its variability was not confirmed until 1667.
There are many types of variable stars. The most important are Cepheids because they are a type of so-called standard candles. Novae and Supernovae are cataclysmic (eruptive) variable stars that are some of the most energetic events in the universe. Variable stars also include binary stars or flaring stars. The interval of change
of thousands of seconds (pulsars), for years to decades.
Our Sun is a good example of a star
tions in brightness (usually around 0.1 % during eleven-year solar cycle).
Pulsar
For the Pulsar task, rotate the laser light source with the white LED around its own axis in the direction of the
duo
Supernova on the edge of the galaxy NGC 4526
Mira (Omikron Ceti) (HST 1997)
Light curve of the variable star Delta Cephei




14
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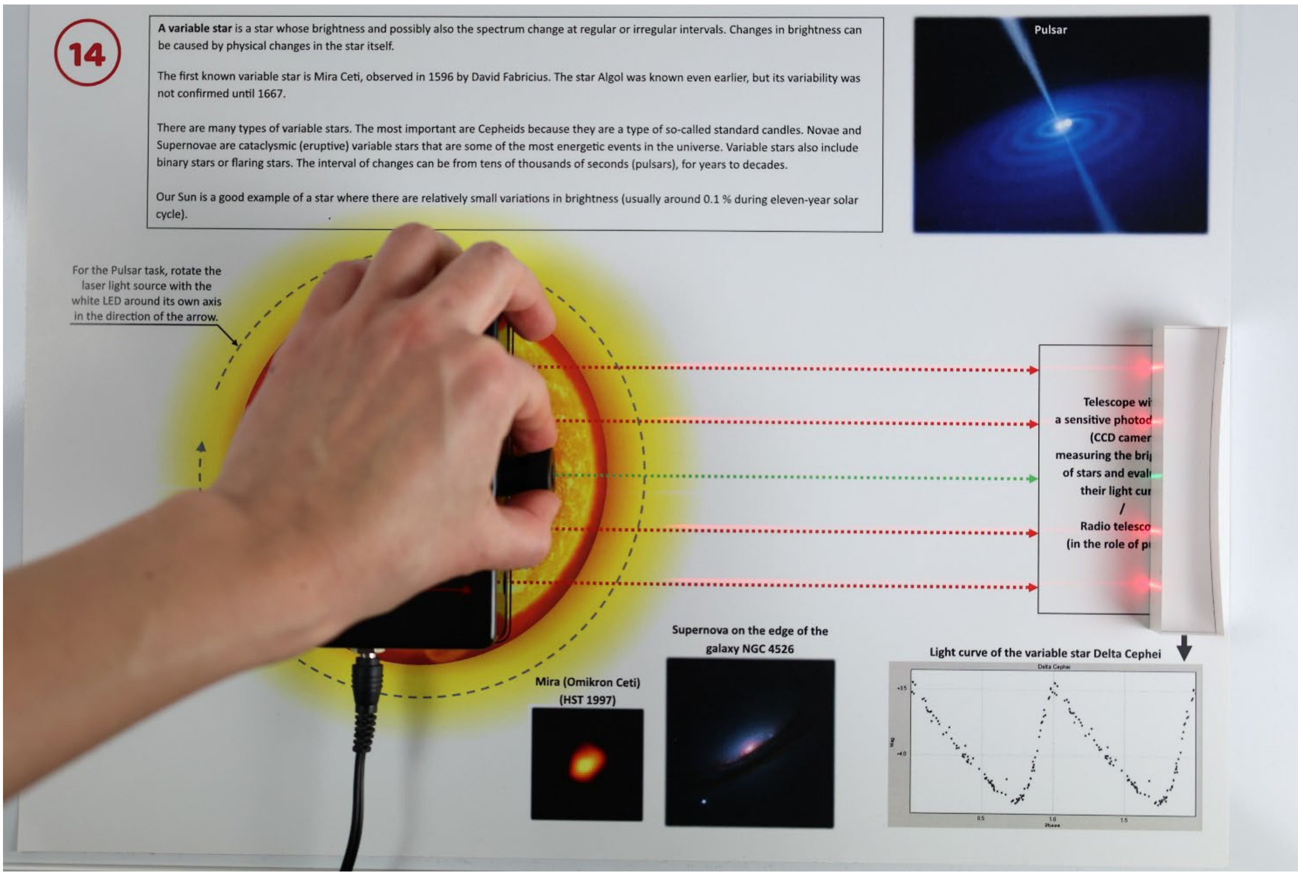
The first known variable star is Mira Ceti, observed in 1596 by David Fabricius. The star Algol was known even earlier, but its variability was not confirmed until 1667.
There are many types of variable stars. The most important are Cepheids because they are a type of so-called standard candles. Novae and Supernovae are cataclysmic (eruptive) variable stars that are some of the most energetic events in the universe. Variable stars also include binary stars or flaring stars. The interval of changes can be from tens of thousands of seconds (pulsars), for years to decades.
Our Sun is a good example of a star where there are relatively small variations in brightness (usually around 0.1 % during eleven-year solar cycle).
Pulsar
For the Pulsar task, rotate the laser light source with the white LED around its own axis in the direction of the arrow.
RAYBOX
duo
Supernova on the edge of the galaxy NGC 4526
Mira (Omikron Ceti) (HST 1997)
Light curve of the variable star Delta Cephei


14
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Our Sun is a good example of a star where there are relatively small variations in brightness (usually around 0.1 % during eleven-year solar cycle).
Pulsar
For the Pulsar task, rotate the laser light source with the white LED around its own axis in the direction of the arrow.
Supernova on the edge of the galaxy NGC 4526
Mira (Omikron Ceti) (HST 1997)
Light curve of the variable star Delta Cephei

TASK 14B: PULSAR

Task number: 29

Equipment:

Sheet no. 14, white LED in laser light source

Preparation:

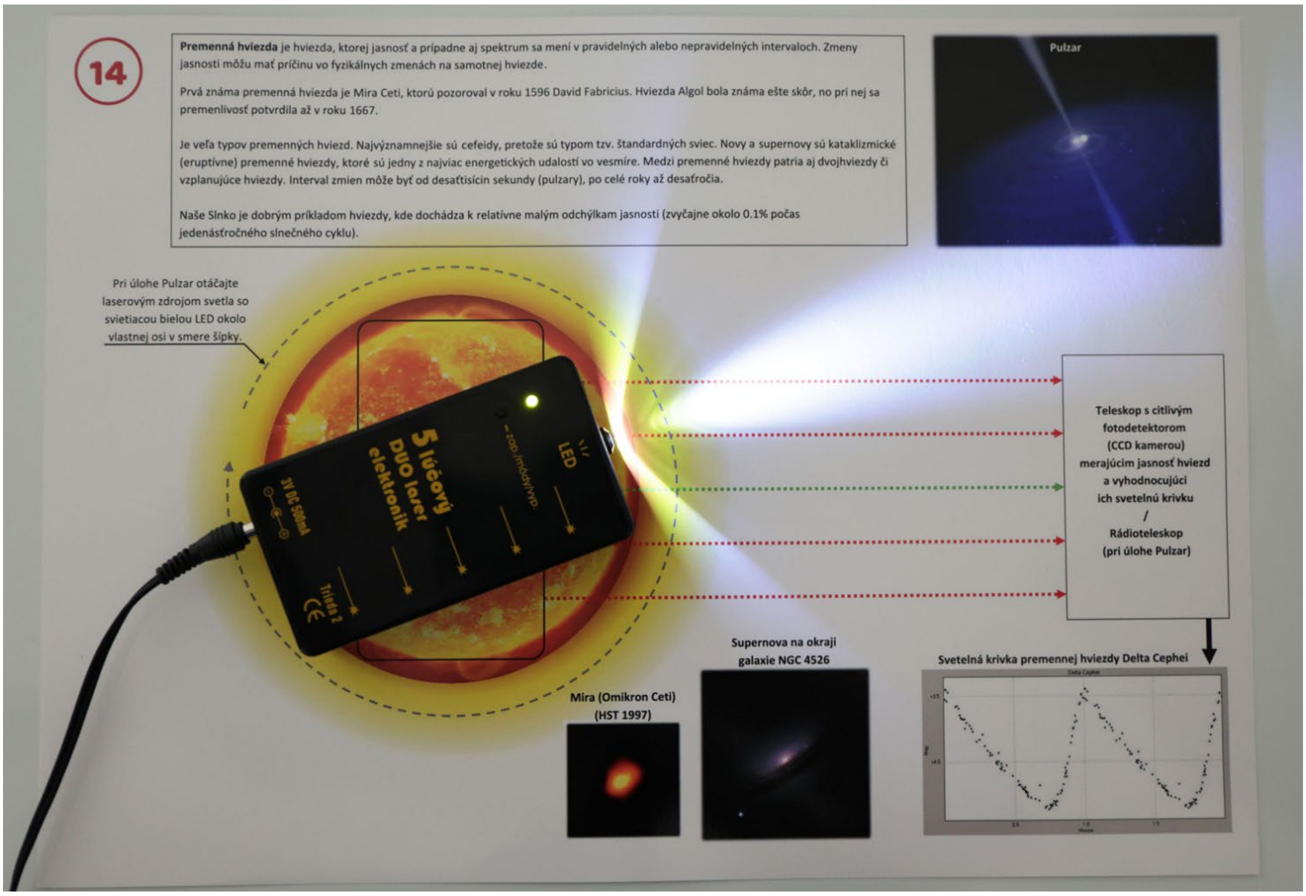
Attach the laser light source with a white LED, which represents a pulsar, to the marked area on the sheet. Press the button to turn on the white LED.

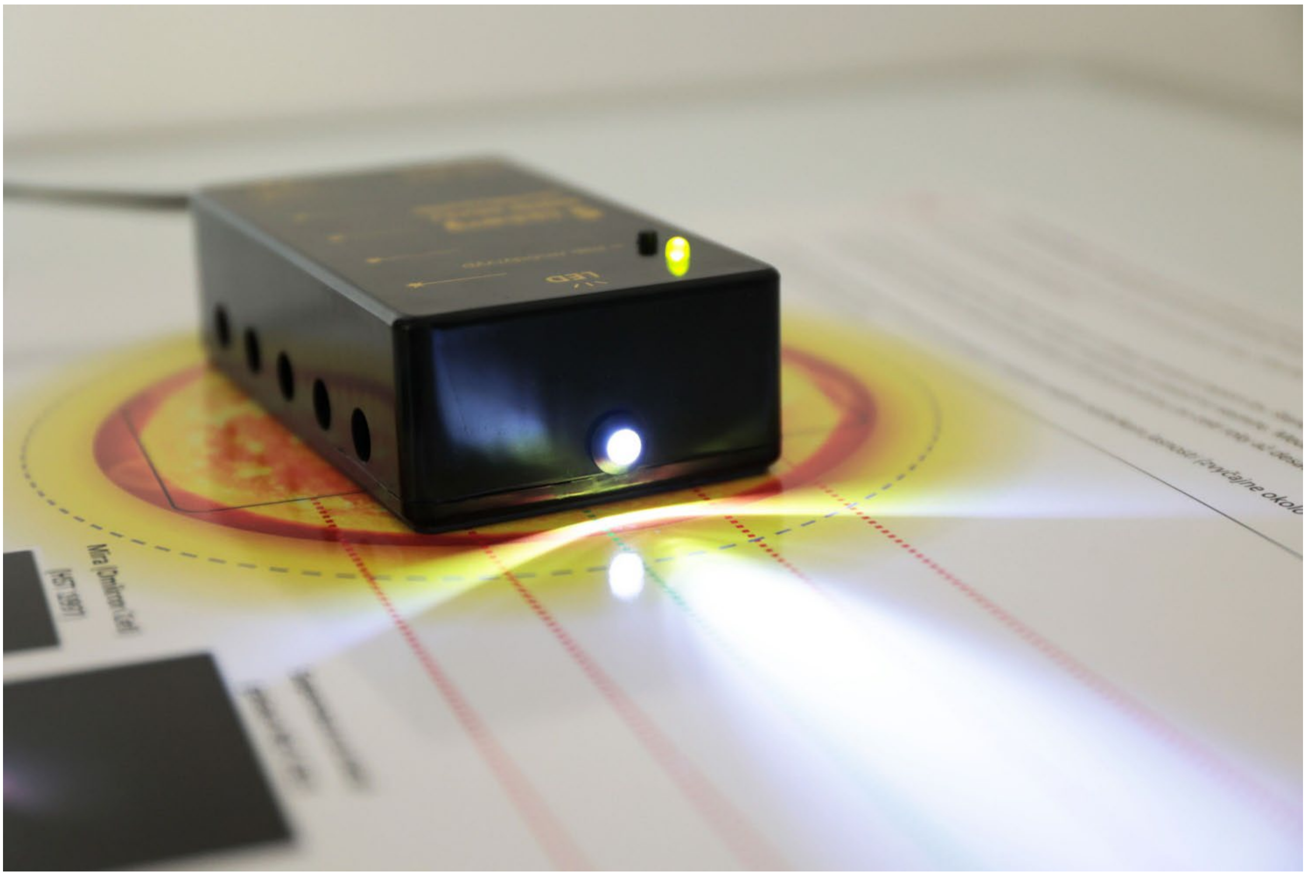
Activity:

Gradually rotate the entire light source (the whole box) around the axis so that the white light emitted from the LED is first directed to the telescope shown as an observation point. Imagine that if you rotated the light source at high speed, you would only observe short flashes.

Summary:

Pulsar is a rapidly rotating and very mass star that emits energy emission from its disc. We only get a short flash, which we capture in the form of a strong flow of energy - a lot of radiation. The interval of these flashes can be as much as tens of thousands of seconds and we observe them with a radio telescope.


14
Premenná hviezda je hviezda, ktorej jasnosť a prípadne aj spektrum sa mení v pravidelných alebo nepravidelných intervaloch. Zmeny jasnosti môžu mať príčinu vo fyzikálnych zmenách na samotnej hviezde.
Prvá známa premenná hviezda je Mira Ceti, ktorú pozoroval v roku 1596 David Fabricius. Hviezda Algol bola známa ešte skôr, no pri nej sa premenlivosť potvrdila až v roku 1667.
Je veľa typov premenných hviezd. Najvýznamnejšie sú cefeidy, pretože sú typom tzv. štandardných sviec. Novy a supernovy sú kataklizmické (eruptívne) premenné hviezdy, ktoré sú jedny z najviac energetických udalostí vo vesmíre. Medzi premenné hviezdy patria aj dvojhviezdy či vzplanujúce hviezdy. Interval zmien môže byť od desaťtisícin sekundy (pulzary), po celé roky až desaťročia.
Naše Slnko je dobrým príkladom hviezdy, kde dochádza k relatívne malým odchýlkam jasnosti (zvyčajne okolo 0.1% počas jedenásťročného slnečného cyklu).
Pulzar
Pri úlohe Pulzar otáčajte laserovým zdrojom svetla so svietiacou bielou LED okolo vlastnej osi v smere šípky.
5 lúčový DUO laser elektronik
LED
3V DC 500mA
Trieda 2
Teleskop s citlivým fotodetektorom (CCD kamerou) merajúcim jasnosť hviezd a vyhodnocujúci ich svetelnú krivku / Rádioteleskop (pri úlohe Pulzar)
Supernova na okraji galaxie NGC 4526
Mira (Omikron Ceti) (HST 1997)
Svetelná krivka premennej hviezdy Delta Cephei



LED LIGHT SOURCE

The planar LED light source contains 31 pieces of white LED diodes, which are mounted on a printed circuit board. It is mounted in an aluminium profile with an anodized finish. One side of the source is sealed with a magnetic foil, which serves to attach the source to the magnetic board.

TECHNICAL SPECIFICATIONS: LED LIGHT SOURCE

Input voltage:	3V DC
Input current:	650 mA
Operating temperature:	0 – 40 ^{0}C
Dimensions (L x W x H):	230 x 18 x 19 mm
LED diode diameter:	5 mm
LED diode colour:	white cold (9 500 K)
LED diode luminosity:	23 500 – 33 000 mcd

LASER LIGHT SOURCE – 5 BEAM DUO LASER RAY BOX ELECTRONIC WITH WHITE LED

The laser light source (5 beam DUO laser ray box electronic with white LED) is delicate optical and electronics equipment. It consists of five independent laser modules **(1., 2., 4., 5. are red with wavelength 635 nm and 3. is green with wavelength 520 nm)** which are optically adjusted to give the pattern required. This product refers to the Class 2 laser product.

The device contains laser diode modules that emit only **red** and **green** visible light. Ultra-violet, infrared, x-ray or other non-visible radiation is not emitted. Try to avoid direct contact with a laser beam with eyes and skin, do not stare directly into a laser beam or at its reflections. Laser diode modules are not suitable to be used for cutting, drilling or burning. Use only for intentions that are suitable for this device.

APLICATION: 5 BEAM DUO LASER RAY BOX ELECTRONIC WITH WHITE LED

The 5 beam DUO laser ray box electronic with white LED is the source of five laser beams and one white LED light. Their unidirectional stretching with a cylindrical lens makes it possible to obtain parallel line laser light sources clearly visible on the magnetic board.
Use the button to switch to the default modes (see pictures 1 - 5).

<u>The following steps will introduce you to how to properly use the device with the power adapter:</u>

1. Plug the power adapter into an electrical power network.

2. Connect the power adapter cable to the device.

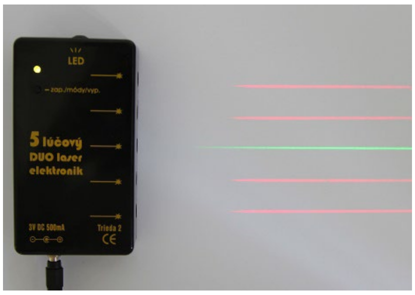
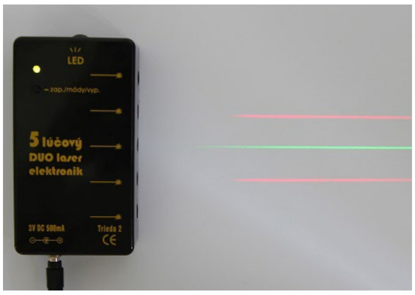
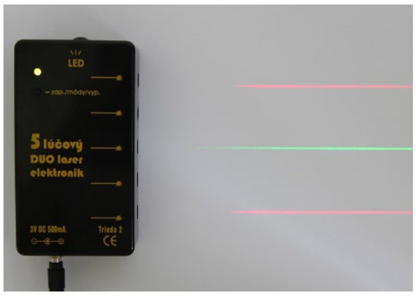
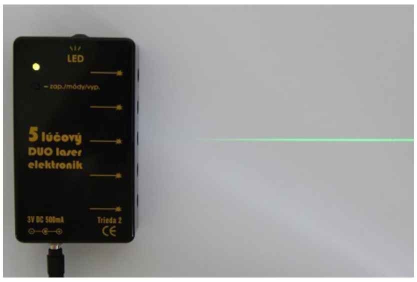
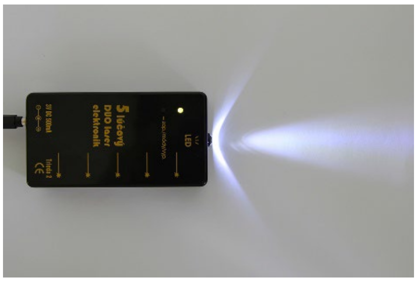
3. The indicator on the device should illuminate orange which means the device is in standby mode.

4. If the indicator on the device illuminates green or red, disconnect the power adapter, then connect it again.

5. Press the *on/mode/off* button and now you should see 5 parallel laser beams emitted from the apertures on the side of the device. The indicator should illuminate green.

6. Press the *on/mode/off* button to switch for among the modes shown in pictures 1 – 5.

7. By holding the *on/mode/off* button for 1.5 seconds you can switch back to standby mode. The indicator should indicate orange. In standby mode, you can disconnect the power adapter.


LED
zap./módy/vyp.
5 lúčový
DUO laser
elektronik
3V DC 500mA
Trieda 2

LED
zap./módy/vyp.
5 lúčový
DUO laser
elektronik
3V DC 500mA
Trieda 2

LED
zap./módy/vyp.
5 lúčový
DUO laser
elektronik
3V DC 500mA
Trieda 2

LED
zap./módy/vyp.
5 lúčový
DUO laser
elektronik
3V DC 500mA
Trieda 2

5 lúčový
DUO laser
elektronik

TECHNICAL SPECIFICATIONS: 5 BEAM DUO LASER RAY BOX ELECTRONIC WITH WHITE LED

Input voltage:	3V DC
Input current:	500 mA
Operating temperature:	0 – 40 ^{0}C
Power optical output (per beam):	Pmax < 1 mW
Distances between beams:	18 mm
Dimensions (L x W x H):	112 x 62 x 32 mm
Laser product:	Class 2
Laser type:	Diode
Wavelength: (1st, 2nd, 4th, 5th)	635 nm
Wavelength: (3rd)	520 nm
LED diode diameter:	5 mm
LED diode colour:	white (cold)
LED diode luminosity:	30000 – 50000 mcd

WARNING!

BE SURE TO PLUG FIRST THE POWER ADAPTER INTO A GROUNDED CIRCUIT AND JUST THEN PLUG IT INTO THE DUO LASER RAY BOX ELECTRONIC. NEVER INTERCHANGE THESE STEPS. IN SUCH A CASE THE DUO LASER RAY BOX ELECTRONIC WOULD NOT GET TO THE STAND BY MODE, BUT IMMEDIATELY TO LIGHTNING MODE. IF IT HAPPENS IMMEDIATELY DISCONNECT THE POWER ADAPTER FROM THE DUO LASER RAY BOX ELECTRONIC AND REPEAT THE STEPS IN THE CORRECT ORDER.

ELECTRICAL SAFETY PRACAUTIONS AND WARRANTY

The LED light source and laser light source are safety devices because they use a low value of voltage and current. When using any electrical device, you must observe certain precautions:

Do not open the cover of the power adapter under any conditions, there is a risk of direct contact with live parts of the electrical device and a voltage of 230V.

Do not disassemble the device or its components - you could cause an electric shock.

The warranty is invalid if the damage is caused by incorrect use or inappropriate handling.

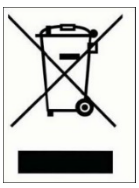
LASER SAFETY INSTRUCTIOS - GENERAL

Light amplification by stimulated emission of radiation (LASER) is a mechanism for emitting electromagnetic radiation, typically visible light, infrared or ultraviolet radiation. This mechanism produces intense beams of light. LASER is used mainly in measurement, industrial processing, medical diagnostics and surgery, for communication via optical fibres and many others. It is strictly forbidden to stare directly into the LASER. It may cause eye damage or blindness.
The norm EN 60825-1 categorizes lasers as follows:
Laser devices of classes 1, 1M, 2, 2M, 3R, 3B and 4
Short-time irradiation (0.25 sec.) in a wavelength range between 400 nm and 700 nm is not considered to be dangerous (except for classes 3B and 4). However, you should not point the beam at people for a long time.

Rules for laser safety:

- Lasers produce a very intense beam of light. Treat them carefully. Majority of the lasers have an output less than 1 mW and will not harm the skin.
- Never look into the laser aperture while the laser is turned on! PERMANENT EYE DAMAGE COULD RESULT.
- Never stare into the oncoming beam. Never use magnifiers (such as binoculars or telescopes) to look at the beam as it travels or when it strikes a surface.
- Never point a laser at anyone's eyes or face, no matter how far away they are.
- When using a laser in the classroom or laboratory, always use a beam stop or project the beam to areas which people won't enter or pass through.
- Never leave a laser unattended while it is turned on and always unplug it when it's not actually being used.
- Never disassemble or try to adjust the laser's internal components. Electric shock could result.
- Do not drop the product or expose it to moisture or dust – it can be easily damaged.

INFORMATIVE AND WARNING LABELS



This symbol on the product or on its packaging indicates that this product must not be disposed of with your other household waste. Instead, it is your responsibility to dispose of your waste equipment by handing it over to a designated collection point for the recycling of waste electrical and electronic equipment (WEEE). For more information about where you can drop off your waste equipment for recycling, please contact your local city office, our household waste disposal service or the shop where you purchased the product.

LIST OF THE AUTHORS OF PHOTOGRAPHS

Sheet: 02
Photography: Isaac Newton
Author: National Geographic Society/Corbis
(Modern portrait, 1974, by Jean-Leon Huens)

Sheet: 04
Photography: Solar corona during a total solar eclipse
Author: Miloslav Druckmüller, Peter Aniol, Vojtech Rušin, Ľubomír Klocok, Karel Martišek, Martin Dietzel (2009)

Sheet: 04
Photography: Annular solar eclipse
Author: Kevin Baird

Sheet: 04
Photography: Blood Moon
Author: Getty
(BLOOD MOON 2018)

Sheet: 04
Photography: Gradual course of partial lunar eclipse
Author: Anthony Ayiomamitis, Twan

Sheet: 05
Photography: Original joint photograph comparing the brightness of different asteroids in the visible and infrared spectra
Author: NASA/JPL-Caltech

Sheet: 06
Photography: Galileo against the pope
Author: Orthodox magazine FOMA

Sheet: 09
Photography: The original Newton‘s telescope
Author: Photos.com/Jupiterimages

Sheet: 11
Photography: Hubble deep fields
Author: NASA, ESA
(G. Illingworth, D. Magee, and P. Oesch, University of California, Santa Cruz; R. Bouwens, Leiden University and the HUDF09 Team)

Sheet: 11
Photography: James Webb Space Telescope
Author: Northrop Grumman
(An artist’s representation of the completed James Webb Space Telescope)

Sheet: 12
Photography: Parkes Radio Telescope
Author: Ian Sutton
(Parkes Observatory, New South Wales, Australia)

Sheet: 12
Photography: Telescope FAST
Author: Xinhua News Agency

Sheet: 13
Photography: TESS
Author: NASA's Goddard Space Flight Center
(NASA's Transiting Exoplanet Survey Satellite (TESS), shown here in a conceptual illustration, is identifying exoplanets orbiting the brightest stars just outside our Solar System)

Sheet: 14
Photography: Pulsar
Author: ESO/L. Calçada
(A rotating neutron star in the accompany of a white dwarf)

Sheet: 14
Photography: Mira (Omikron Ceti)
Author: Hubble Space Telescope image (1997)

Sheet: 14
Photography: Supernova on the edge of the galaxy NGC 4526
Author: Hubble Space Telescope image
(Type 1a supernova 1994D in the galaxy NGC 4526)