FUTURE SPACE

Lesson outline

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Saturn's e-moon - mission project

Key words:
Saturn
Cassini-Huygens space mission

Subjects:
geography
physics

Topic: Saturn and its moons

Students' age: 15-19

Time: 3 lessons

CBK PAN
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LESSONS IDEA

- The launch of the Cassini-Huygens spacecraft took place in 1997, the probe reached the vicinity of the planet in 2004, its task was to study the moons and rings of Saturn. The lessons will consist in introducing students to the tasks of the Cassini mission and familiarizing them with the most interesting moons of the planet. The result of these lessons will be for students to plan a research mission to the selected moon.
- It is proposed to use the reverse lesson method, where students become familiar with the general knowledge of Saturn and its moons in advance.

PowerPoint presentation of the general characteristics of the planet Saturn and its moons by a teacher or a pre-designated student prepared

The lesson should begin with a presentation prepared in advance by students introducing students to the characteristics of Saturn and its moons. The presentation should include such points as:

- characteristics of the planet Saturn, its rings and physical characteristics (composition of the atmosphere, pressure, size of the planet, number of moons),
- a brief description of the most interesting moons of Saturn, e.g. Enceladus, Titan, Mimas, Hyperion, Pan with a short comparison of them. The presentation should include some information about the Cassini spacecraft and the Huygens lander.

Viewing Cassini data – images from NASA's Eyes websites and program

It is worth installing free astronomy programs that allow you to explore planets and missions:

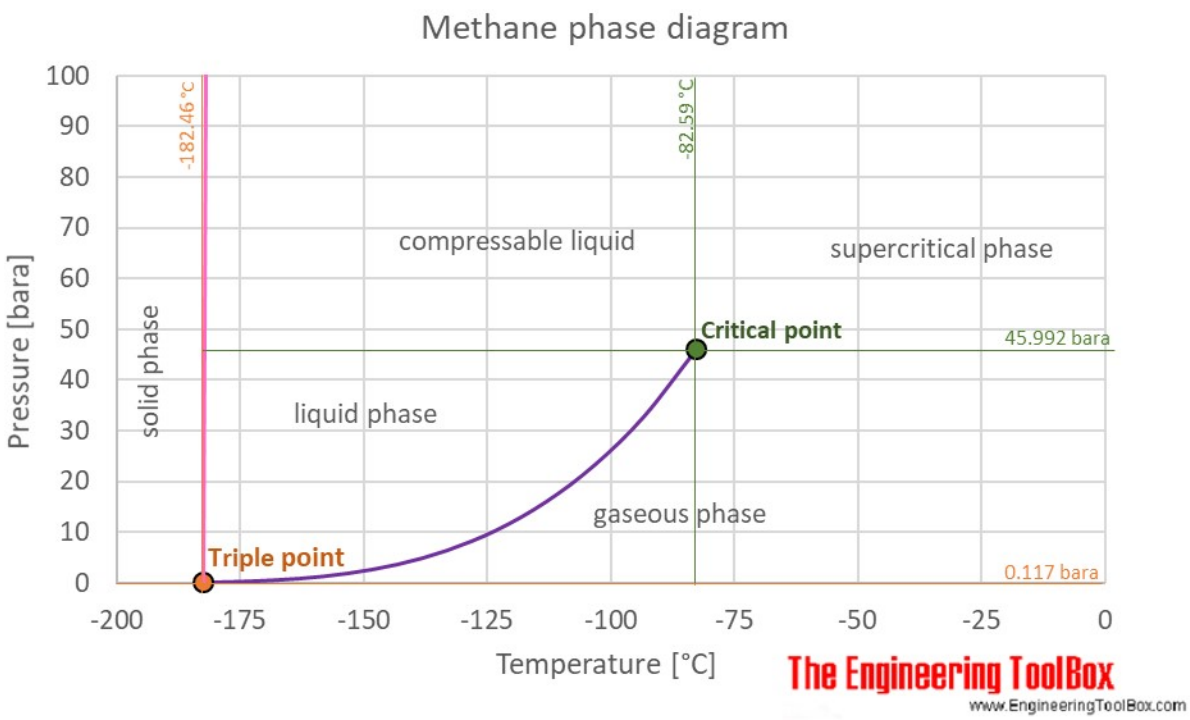
- NASA's Eyes – visualization of the Cassini mission and all the moons of Saturn
- World Wide Telescope - visualization of Saturn's moons and imagery from the Cassini mission

Volcanism

When looking at the pictures, they should arrange with the teacher of phenomena about volcanism: what it is and what types of volcanoes can be formed. Volcanism occurs on one of Saturn's moons, Titan. It is necessary to take into account such a kind of volcanism as fumes – fumaroles and solfatary.

Another phenomenon that is worth paying attention to students is cryovolcanoism. Phenomena of this type occur on Enceladus and Titan. They consist in ejecting a cold liquid or gas under the influence of expansion.

When discussing Titan's moon, students should learn about the physical conditions of methane, which is Titan's main gas and liquid, and emphasize that the main feature of the moon is its thick atmosphere composed primarily of nitrogen and the pressure is 50% higher than on Earth. Methane known as a gas on Earth, on Titan in the circumpolar zones, is in liquid form. This state of matter of this gas takes place at very low temperatures of d -80° C to -175° C at a pressure of 0 to 100 ba. See the diagram of the triple methane point:



Experiment – volcanic eruption

- For the experience you will need: sand or flour, protective film for the floor, balloon, needle, safety glasses.

We start by inflating the balloon, after which the balloon is placed on a protective film and covered with a layer of sand or flour, forming a volcanic cone. It is necessary to put on protective glasses so that sand or flour does not get into the eyes. We pierce the buried balloon with a needle and observe the explosion and the formation of the caldera after the explosion. The experiment is best carried out outside due to the spillage of the material during the explosion. There should be enough sand or flour to be able to completely cover the balloon. Experience shows the mechanism of the explosion and formation of the caldera. It is an illustration of volcanism on many Earth-type planets and moons of giant planets.

When discussing the moon Enceladus, students learn about plumes and tiger belts on Enceladus and learn about different models of this phenomenon. Model of the ocean and hydrothermal vents, cryovolcanic model, i.e. low-temperature volcanism consisting in the explosion of cold gases or liquids under the influence of expansion.

Additional observation during the lesson

- For observation you will need: dry ice, cardboard box - box, bowl or litter box, water, scissors or knife

The experiment will consist in observing the plumes of Enceladus. In the bottom of the cardboard we cut a 20 cm gap. Pour a small amount of dry ice into the litter box, pouring it with a small amount of water so that it begins to sublimate. We cover the cuvette with a cardboard box, a gap upwards and watch how sublimating CO2 comes out of the gap.

✍ *NOTE: it is necessary to take care of the safety of students when performing experiments with dry ice, its temperature is about -70 deg. Students who are to come into contact with dry ice should wear glasses and protective gloves.*

The experiment illustrates Enceladus' plumes discovered by the Cassini spacecraft. With this experience, it should be explained to students that it does not fully explain the mechanism of the formation of plumes, but is intended to illustrate the phenomenon. The mechanism can be discussed further, emphasizing that the fissures are formed by the gravitational pull of Saturn and the ocean located below the surface of Enceladus.

- When discussing the moon Mimas, you need to pay attention to the huge 130 km crater which is the central form of Mimas.
- When discussing Hyperion's moon, it is necessary to pay attention to the unusual shape of the moon and numerous impact craters.
- When discussing the Lord's moon, it is necessary to pay attention to the pronounced equatorial shaft.

⌛ **Additional experiment (beyond the time of the lesson)**

- For the experience you will need: water, litter box, freezer, possibly dry ice CO_2

Students are offered to do a cryogenic experiment in the freezer. The layer of sand placed inthe litter box is covered with a layer of ice (there may be ice cubes) and again with a layer of sand. Then you need to freeze the whole thing and then thaw after removing, then freeze again and thaw again. As a result of this experience, students should observe polygonal patterns on the sand and melt holes. This experiment demonstrates the cryogenic phenomenon, i.e. associated with low temperatures consisting in thawing and freezing of the area.

- In the experiment, instead of water ice, you can also use frozen carbon dioxide, the so-called dry ice, which can be easily ordered via Internet.

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🕓 ***Getting acquainted with the construction of selected moons of Saturn based on NASA's Eyes- and World Wide Telescope programs and websites***

Based on first lesson, students select the most interesting moons of Saturn to discuss and choose as the mission target. For example, these can be moons: Enceladus, Titan, Mimas, Hyperion, Pan.

In this way, students will get acquainted with the characteristics of the above-mentioned moons – they will learn about the physical conditions prevailing on these bodies, they will be able to use this knowledge to discuss the diversity of planets, the possibility of forming and existing life in such conditions, etc.

Enceladus:

- small diameter of the moon

- plumes of ice crystals, with organic compounds - hydrocarbons and nitrogen
- tiger belts - cracks from which ice crystals and organic compounds come out
- surface covered with faults
- hypothesis of the subsurface ocean
- the possibility of hydrothermal vents under the surface and therefore microorganisms
- Saturn's E-ring is the result of matter ejected by Enceladus' plumes
- Enceladus loses mass by ejecting matter from tiger belts https://pl.wikipedia.org/wiki/Enceladus_(ksi%C4%99%C5%BCyc)

Titanium:

- Saturn's largest moon, larger than our Moon
- It has an atmosphere 1.5 times denser than ours, 98% composed of nitrogen
- It has rivers and lakes from liquid methane
- The Huygens lander took pictures of Titan's surface

Hyperion:

- A moon consisting of a large percentage of ice
- Non-spherical shape
- Porous structure, probably voids in the middle
- Chaotic tumbling vortex motion - different from the most common - synchronous, characteristic of moons

Mimas:

- It resembles the Death Star from Star Wars due to the 130 km crater on its surface
- It is only about 400 km in diameter and yet it is spherical
- Crater-covered surface

Frying pan:

- Walnut-like moon – thanks to its characteristic equatorial ridge
- It is located in the center of the Ring of Saturn A in the so-called Encke gap
- Numerous hypotheses about the appearance of the moon - e.g. after a collision with another moon, or clumping together from other small bodies of the ring.

The teacher should then lead a discussion on the diversity of physical conditions prevailing on celestial bodies in the Universe (planets, moons) and their impact on the possibility of forming and surviving the search for life.

➲ **Cassini instruments (based on Wikipedia websites)**

Based on the available data, students should find out what the most important apparatus on the Cassini probe is and what it is for. What instruments did the Huygens probe sent to Titan have and what he managed to study.

Instruments used for specific scientific issues:

- **Mineralogical composition and ice studies:** UV spectrometry, photometry, infrared spectrometry, mirror telescopes, refractors, dust detectors, radars, radiometry.
- **Studies of the composition of the atmosphere, ionosphere and magnetosphere**: infrared spectrometers, interferometers, Cassegrain infrared telescope, UV spectrometers, photometers, H2 and O2 detectors, cameras, mass

spectrometers, electrostatic analyzers, dust detectors, magnetometers, ion detectors, radio and plasma wave receiver.

- **Surface imagery:** Wide and narrow-angle cameras, refractors, mirror telescopes, IR spectrometers, VIS, diffraction imaging spectrometers, radars, radiometry

Voting in groups for a potential object to be investigated. Designing the stages for the probe and the sequence of the studies.

After learning about the basic knowledge about Saturn and its moons, students decide to choose the object(s) to study. This can be done by voting for one object or in groups of several people, each group choosing a different moon. You can also design a mission to several objects at once

Once an object is selected, students decide what should be examined on the selected object, what has not been studied by Cassini, or what should be investigated more closely.

Then the students select the appropriate instruments that would have to be on the probe in order to examine the goals chosen by the students. They can decide whether the probe should have a probe, a rover or a lander.

Example of a proposed mission:

- ✓ Selected Moon - Titan
- ✓ Characteristics:
- ✓ Methane rivers and lakes, thick atmosphere
- ✓ Research objective:
- ✓ Studying the depth of lakes, elemental composition, possibilities of life
- ✓ Selected probes:
- ✓ Orbiter, bathyscaphe
- ✓ Probe equipment:
- ✓ Orbiter: mirror telescope, imaging spectrometer, radar altimeter
- ✓ Bathyscaphe: radar, UV VIS spectrometer, infrared spectrometer, wide-angle camera, photometer, chromatograph, etc.

You can also come up with names for individual instruments, the names can be in English.

ADDITIONAL MATERIALS

- NASA's Eyes
- World Wide Telescope ⇒link
- Cassini-Huygens mission
- Volcanism
- Saturn
- Metan
- Tytan
- Enceladus
- Hydrothermal vent
- Mimas
- Hyperion
- Pan

Other:

- videos to discuss life on the planets:
- Enceladus plume model
- Enceladus: Cassini Cracks the Case of the Icy Moon

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