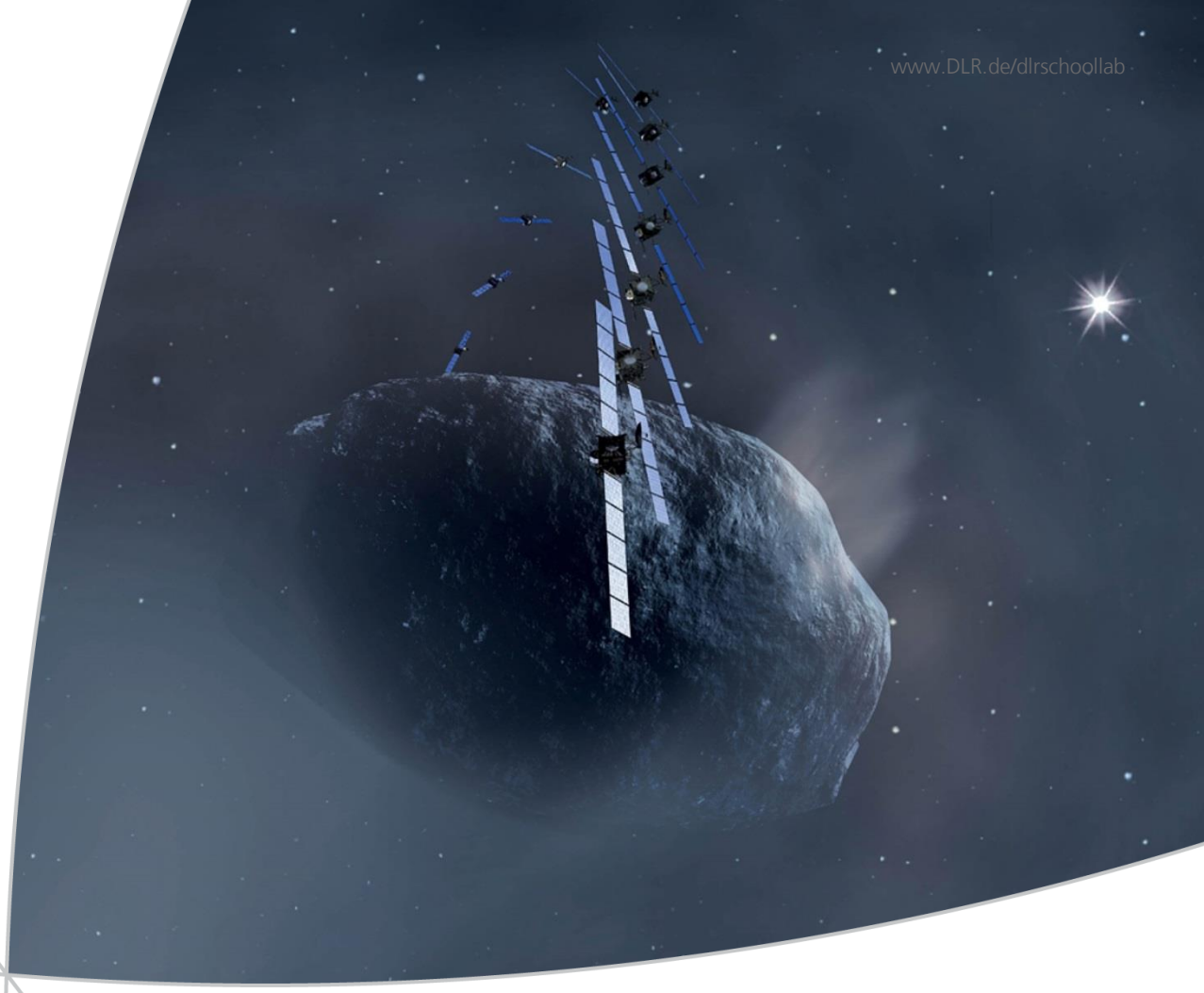
DLR



DLR_School_Lab

Köln

Artificial comets

Snowballs with tails

„... and, lo, the star, which they saw in the east, went before them, till it came and stood over where the young child was. (Matthew 2:9)". Despite what the Christmas lights might make us believe, the "Star of Bethlehem" probably was not a comet. Comets are not even stars. But we humans have been interested in comets for millennia. After all, it is very hard to miss a comet that is close to Earth.

In this experiment, we will try and find out more about comets by making an artificial one and observing it in a simulation chamber. Similar experiments were carried out at the DLR as preparation for missions to "proper" comets.

From heralds of evil to objects of research

The many documents on and pictures of comets are proof that people have long been fascinated by comets. The word "comet" (from the Greek ***κομήτης***) means hairy or tailed star. Comets were thought to be heralds of important things to come. It was thought, for example, that King Harold's defeat and death at Hastings in 1066 was foreshadowed by Halley's Comet. The events of the Norman conquest are depicted in the Bayeux Tapestry.

Depiction of Halley's Comet on the Bayeux Tapestry, around 1070.

About 230 years later, the painter Giotto used Halley's Comet as a guideline for his painting in the Scrovegni Chapel in Padua. If you want to see Halley's Comet for yourself, you will have to wait until 2061.

Adoration of the Magi, Giotto di Bondone, Padua, 1303.

Dirty snowballs

Our solar system was formed about 4.5 billion years ago. Comets are comparatively small remnants from this time. About a hundred billion comets surround the solar system beyond the orbit of Neptune and form the so-called Kuiper Belt and the Oort Cloud.

Some comets - due to collisions with each other or influenced by the gravity of other celestial bodies - leave their "parking position". They then move around the sun in highly eccentric orbits - if they get that far and are not first attracted by one of the large planets.

Comets take between a few years and many millennia to orbit the sun. Halley's comet needs 76 years to do this.

Halley's Comet, photograph taken through a large telescope on 9th January 1986 (by courtesy of Max Planck Institute for Astronomy). The comet is a few hundred million kilometres long. However, its nucleus is a body of ice and minerals about 13 km in size.

Comets spend the majority of their existence in a frozen state. Only when they come close to the sun (distance less than 3 astronomical units[1]) do they heat up. The ice of the comet nucleus sublimates, water vapour shoots out of the nucleus and carries dust particles with it: a tail of gas and dust forms.

Peter Bienewitz, referred to as Apianus: passage of (Halley's) Comet with the appropriate solar position (Landshut, 1531).

As early as 1531, Peter Bienewitz observed that this tail is always directed away from the sun. This is due to the solar wind, which pulls the dust and plasma particles along with it.

The tail of an active comet can be several hundred million kilometres long and is then the largest object in our solar system. Sometimes it can be observed with the naked eye from Earth. - Who saw the comet Neowise in 2020?

Comet Neowise 2020: the plasma and dust tails are clearly visible. (Image: CC BY-SA 4.0 S. Ziegenbalg)

But even if the tail is huge: it only hides a small core: a "dirty snowball" (or an "icy dirtball") of 1 to 10 km in diameter.

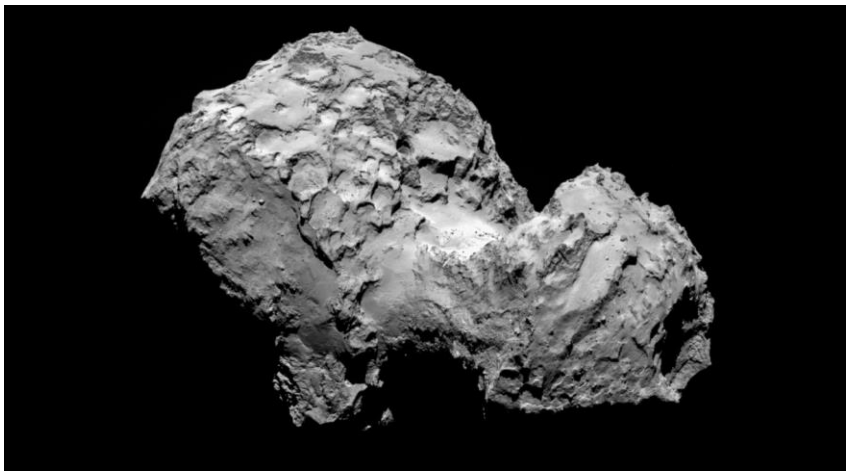
Comets have preserved material from the formation of our solar system. What does this material look like, from which not only the planets but finally also we ourselves have originated? In 2006, NASA's Stardust spacecraft was able to reach comet Wild2, collect comet dust and send it back to Earth.

But what is the nucleus of a comet like? In 2014, ESA's Rosetta mission reached comet Churyumov-Gerasimenko after a 10-year flight. It succeeded in landing on a comet for the first time - although not completely according to plan. The space probe and lander accompanied the comet on its way around the sun for two years and sent thousands of images and measurement data back to Earth.

If you want to land on a celestial body, you have to have an idea of what the ground is like there. For the planning of the Rosetta mission, simulation tests were therefore carried out at DLR Cologne, similar to those you will be doing.

During your visit, you will also see the control centre from which the Rosetta mission's Philae lander was monitored.

[1] one astronomical unit is the mean distance between the Earth and the Sun = 149.6 Million km



Comet Churyumov-Gerasimenko photographed by the Rosetta probe in 2014. (Picture: ESA)

Our experiment

In the DLR_School_Lab, we will make our own comet material and observe it in space-like conditions in our pressure chamber.

Caution! You will be working with liquid nitrogen. It is extremely cold (-196 °C). Wear protective gloves and goggles during the experiment!

Getting liquid nitrogen into your eyes can lead to blindness. Make sure it does not come into contact with your skin, as frostbite can occur very quickly!

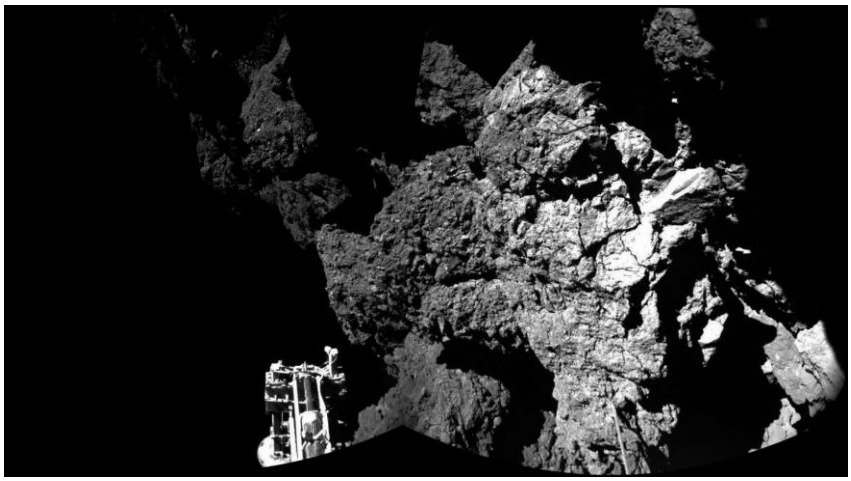
Open shoes and short clothing are prohibited.

Only work with your instructors and follow their instructions at all times. It is in your own interest to adhere to these precautions as they ensure your safety.

Artificial comet material

The basis for our artificial comet is slurry of 10 per cent by weight of minerals (olivine) and 1 per cent by weight of carbon black for the colour.

This suspension is then nebulised with the help of a high-pressure spray valve and the resultant particles are frozen in liquid nitrogen. The material forms small, icy particles that look like black snow.



Comet Churyumov-Gerasimenko landing site of Philae. In front left one of the legs of the lander. (Picture: ESA)

It is then transferred from the nitrogen tank to the DLR_School_Lab, where we fill it into our pressure chamber. Measure the hardness of the surface of our comet mass before closing the chamber.

Space-like conditions

We use our pressure chamber to simulate the heat, light, temperature and pressure conditions of space. Obviously, we cannot influence gravity. The pressure within the chamber is reduced to 0.4 mbar and the temperature down to -50°C. After we have tilted the chamber (illustration next page), we can turn on our "Sun" – a floodlight. We can adjust the intensity of the light with the help of an aperture: higher light intensity corresponds to the comet being closer to the Sun.

The light that falls on the surface of the comet during our experiment is very bright. Therefore, do not look directly at it, but use the protective goggles provided!

This is an experiment that takes some time. Therefore all three groups will share the work between them. You will not be able to see any results until after the lunch break. You should have a look at what has become of the comet before the third and final group takes it out of the pressure chamber, or you will miss the most important part of the experiment!

Observe the comet

> Does the surface change?

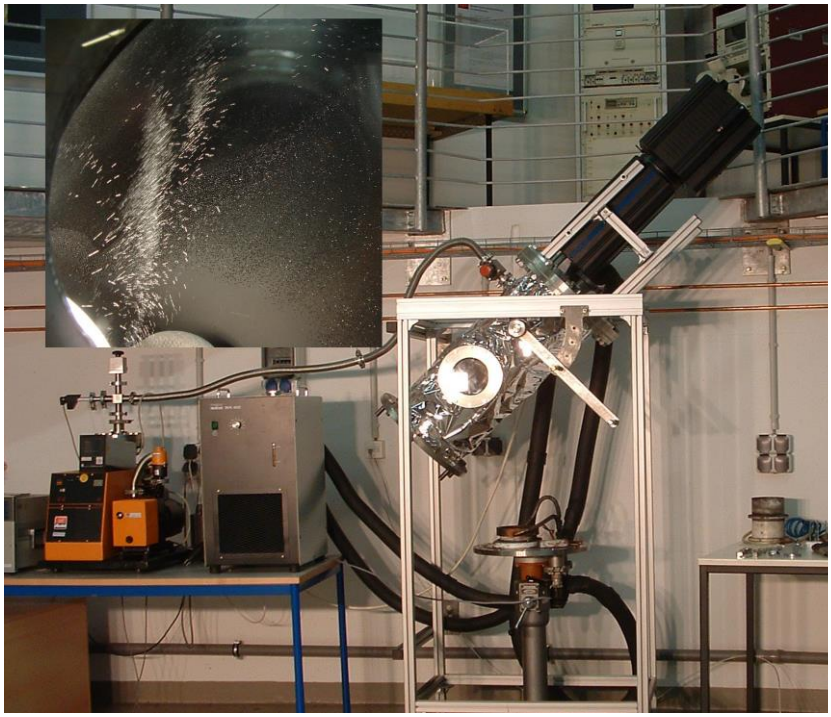
> Can you observe a tail?

> If so: In what way does it differ from your expectations? Why?

After you have taken the comet out of the chamber, measure the hardness of the surface.

> What has changed? What consequences should that have for the construction of a comet lander?

…and then we should probably talk about why we even want to know all of this.



Experimental chamber for comet simulation at DLR_School_Lab Cologne

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About DLR

DLR is the Federal Republic of Germany's research centre for aeronautics and space. We conduct research and development activities in the fields of aeronautics, space, energy, transport, security and digitalisation. The German Space Agency at DLR plans and implements the national space programme on behalf of the federal government. Two DLR project management agencies oversee funding programmes and support knowledge transfer.

Climate, mobility and technology are changing globally. DLR uses the expertise of its 55 research institutes and facilities to develop solutions to these challenges. Our 10,000 employees share a mission – to explore Earth and space and develop technologies for a sustainable future. In doing so, DLR contributes to strengthening Germany's position as a prime location for research and industry.

DLR Cologne

Aviation, space travel, transportation, energy and safety are the research areas pursued in the nine research facilities at DLR Cologne. The basis of the research and development carried out on site are the large testing facilities such as wind tunnels, turbine and materials test benches and a high-flux density solar furnace. The 55 hectare/ 136 acre site is home not only to the research and administrative facilities of the DLR, but also to the European Space Agency's (ESA) European Astronaut Centre (EAC). The DLR has around 1400 employees in Cologne.

Deutsches Zentrum für Luft- und Raumfahrt

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About the experiment:

Recommended for grade(s): 9 to 13
Group size: 5 to 6
Duration: 50 minutes
Subject matter:
Astronomy
Physics