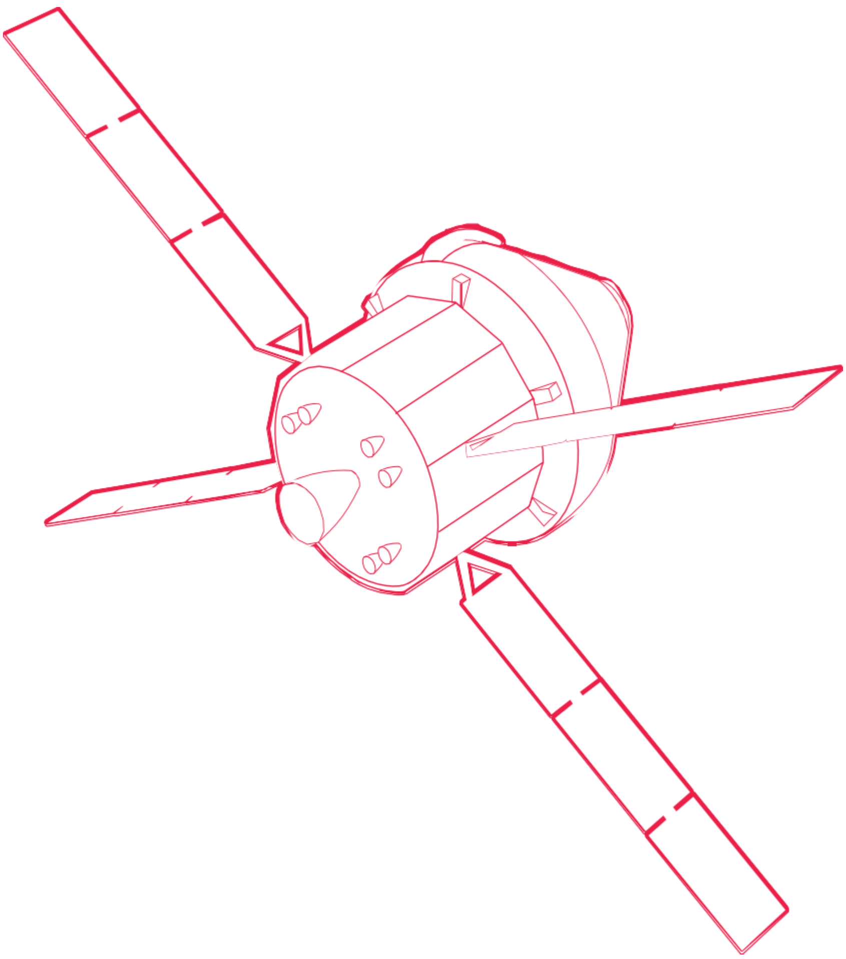
# Teaching with space

## → SPACECRAFT MATERIALS KIT – PLAYING WITH LIGHT

Discover the light reflection properties of materials

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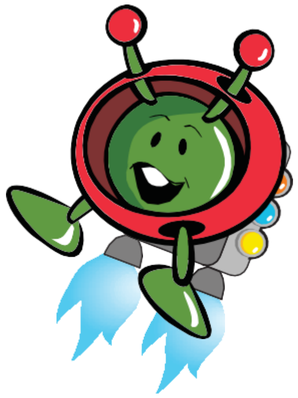
# →SPACECRAFT MATERIALS KIT



*Discover the light-reflecting properties of materials*

## Overview

**Age group:** 10-12 years

**Type:** group activity

**Complexity:** easy

**Duration of the lesson required:** 1 to 2 hours

**Cost per activity:** low (less than 10 euros)

**Location:** indoor (any classroom)

**Includes the use of :** Material provided free of charge by ESERO

## Main lines

The ESA Spacecraft Materials Kit for Primary Schools is a useful resource that can be used by pupils to study a range of space-themed materials.

Using a range of different materials, they will investigate which properties are best suited to the parts of a space telescope such as the Solar Orbiter satellite.

This extension focuses on the light-reflecting properties of these materials, a useful property for satellites trying to capture as much light as possible from the stars.

## Students will learn

Compare and group everyday materials on the basis of their light reflection properties.

## Students will improve

- How can experiments be planned to answer questions, including recognising and controlling variables where necessary?
- How to take accurate light measurements
- How to take repeated readings when appropriate
- How to record data and results using scientific communication tools?
- How to report and present the results of experiments in oral and written form?
- How do you identify scientific evidence that can be used to support or refute ideas or arguments?

# → CONTEXT OF THE KIT

Students can test and explore ten different materials. These are a mixture of metals and non-metals. Each material is a 2 cm x 2 cm x 2 cm cube made of one of the following materials:

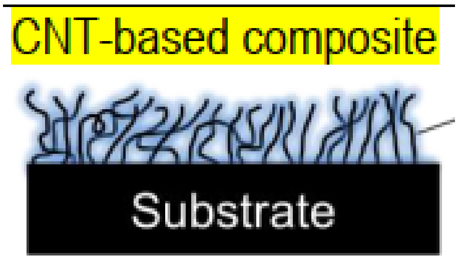
| | |
|---|---|
| Aluminium | Polystyrene |
| Aluminium with **gold on** one side | Pierre |
| Aluminium with **superblack** on one side | Pierre |
| Brass | Steel |
| Copper | Wood |

An alloy is a mixture of two or more elements, one of which is a metal.
Brass is an alloy of copper and zinc, and steel is a mixture of iron and carbon.

As alloys are not necessarily familiar materials, this provides an additional challenge for the students.

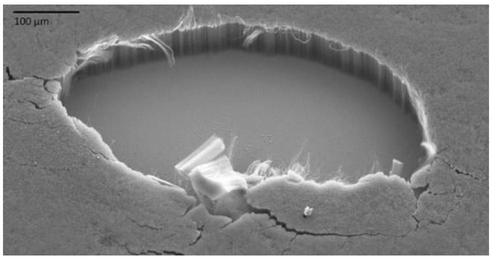
A **super-black material** is one that is capable of absorbing almost all of the incident light.

Optical observation from space requires the control of many optical parameters to ensure image quality. Among these parameters, stray light is an important factor in the optical performance of the instrument. Stray light rejection is very strict in most space telescopes, due to the presence of light sources such as the Sun, the Earth or the Moon.
A number of black coating solutions are available for space applications, although paints and anodising are the most common technologies.
Although generally easy to apply, paints can be expensive and have certain disadvantages such as those related to uniformity of thickness on small parts with sharp edges.




Among the black paint solutions, the best are able to achieve a light absorption of over 98.5%.

But the world record in terms of diffuse absorption comes from a chemical vapour deposited in layers of carbon nanotubes (CNT).




These CNTs are tubes made of carbon atoms whose diameter is usually measured in nanometres. These layers deposited on aluminium are capable of absorbing 99.5% of incident light.

## → EXPLORE MATERIALS: LOOK AND FEEL!

Start by distributing the activity sheets to the students and dividing them into groups. Then explore students' prior knowledge of metals and non-metals and preconceptions about why some materials are suitable for some things and not others. Examples: why a car is usually made of metal, but some parts are also made of plastic; why spoons can be made of plastic and metal, but not glass.

## Equipment

- 1 set of 2 cm x 2 cm x 2 cm cubes of different materials per group

### Exercise

1. Ask students to group the materials according to their look and feel and to justify why they arranged the groups as they did. Students can record their answers on the activity sheet.
2. Students should use scientific vocabulary to describe materials in terms of their look and feel (e.g. heavy/light, rough/smooth, warm/cold, shiny/matt).
3. Ask students to suggest tests they could carry out to compare materials. Ask them what materials and instruments they would need to carry out these tests.

# → REFLECTION OF LIGHT

Students will test which of the materials provided are best at reflecting light.

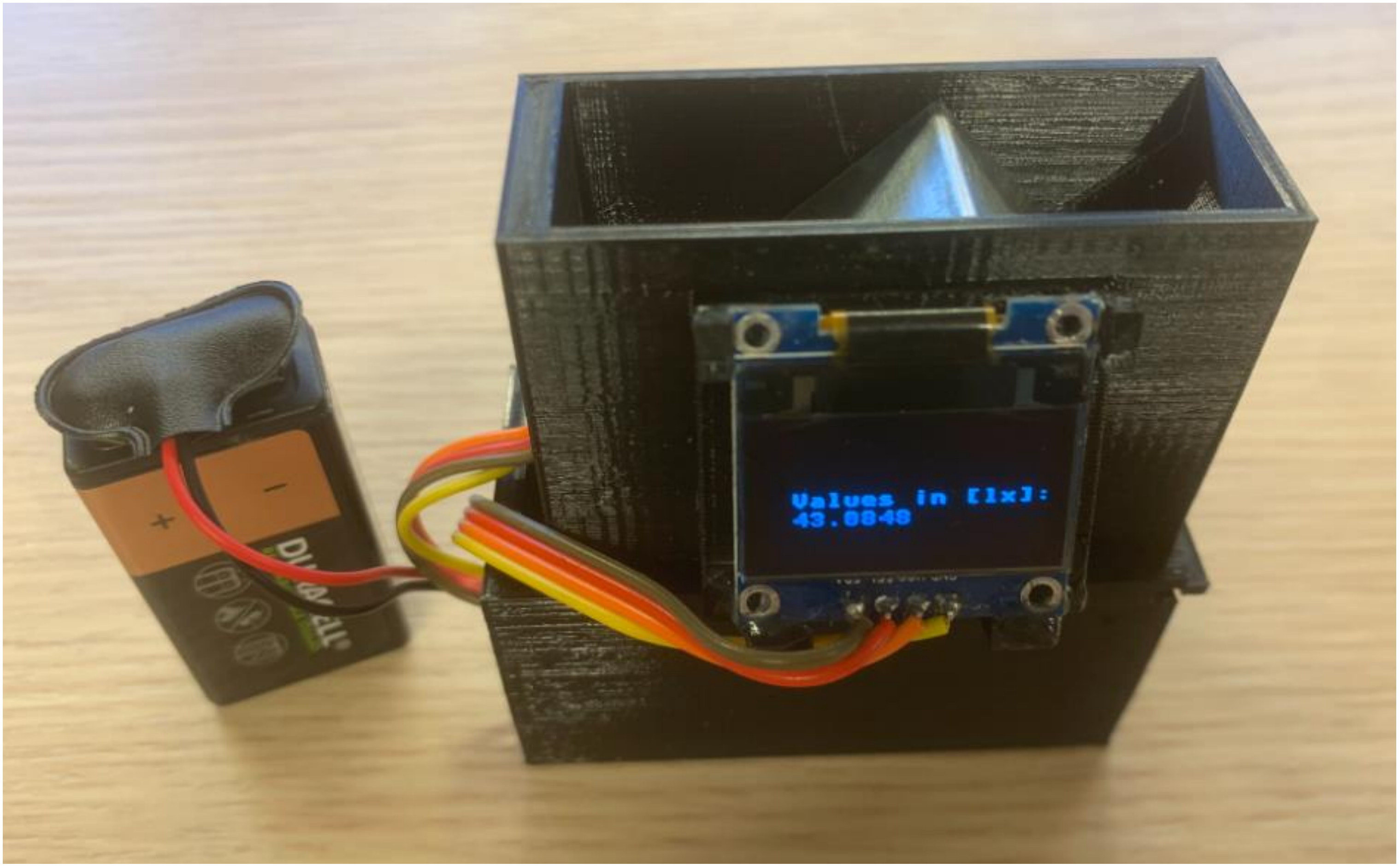
They test each cube in the darkroom and observe the amount of light received by the light sensor of the electronic device.

## Equipment

- 1 set of 2 cm x 2 cm x 2 cm cubes of different materials
- 1 battery (9 volts)
- 1 darkroom

### Exercise: testing the thinking ability of cubes

1. Put the first cube in the darkroom, making sure it is positioned at 90 degrees.
2. Connect the darkroom to the 9V battery as shown below
3. Students record the reflection value in the "Classroom Discussion" table.
4. Repeat with the other cubes.
   For the superblack cube, be careful to place the correct side towards the light in the darkroom.
   You can see the procedure on video HERE



# → MATERIALS AND SATELLITES

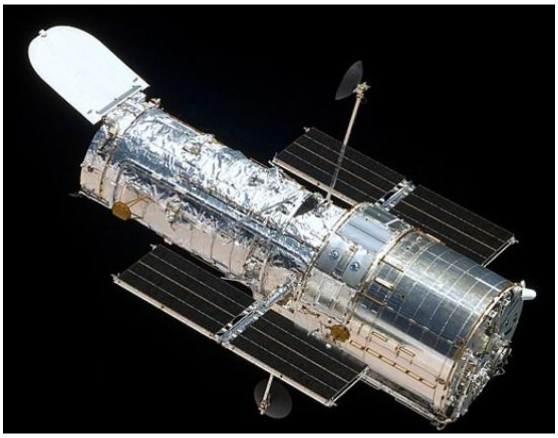
Super black materials are used in space telescopes to prevent stray light from polluting the telescope images.

Stray light and baffle testing is an important
part of the development of space imaging instruments.

Here are some examples of space telescopes that use this technology.

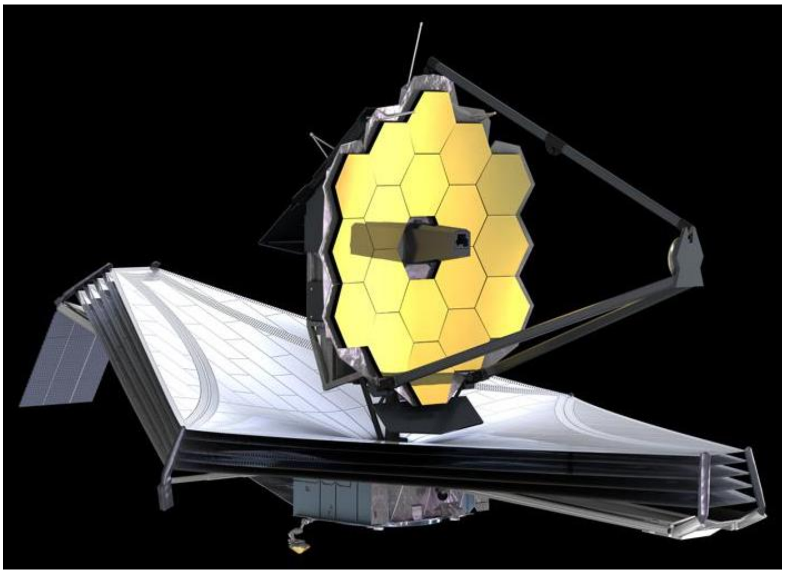
Solar Orbiter - **observing the Sun**

Hubble Telescope - **exploring the universe**



Some telescopes, on the other hand, need to collect as much light as possible from the most distant galaxies in the Universe, using gold mirrors!

**The** James Webb Telescope



## → CLASS DISCUSSION

### Which materials seem best suited to absorb stray light?

In this activity, help students to fill in the table below, where all their results can be displayed.

- Classify the cubes according to their light absorption.
- Initiate a class discussion and guide students in thinking about the different parts of the telescope and the materials best suited to each use.
- Ask them to write the reasons for their choices on the student activity sheet.

| Material | Reflection (lx) | Rank |
|---|---|---|
| Aluminium | | |
| Gold | | |
| Aluminium with superblack on one side | | |
| Brass | | |
| Copper | | |
| Polystyrene | | |
| Plastic | | |
| Pierre | | |
| Steel | | |
| Wood | | |

## → QUIZ

### Where are the darkest places in space?

### Black holes

Black holes are much more massive than Jupiter.

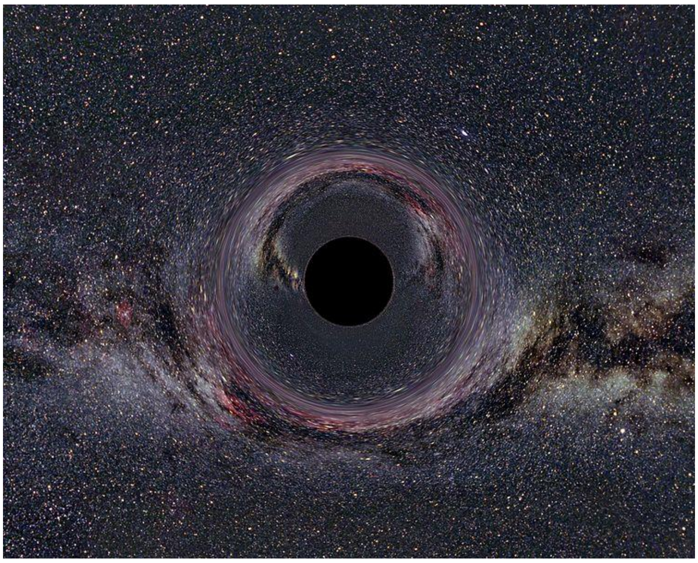
The diameter of one of the largest black holes known to date is 40 times larger than our solar system!

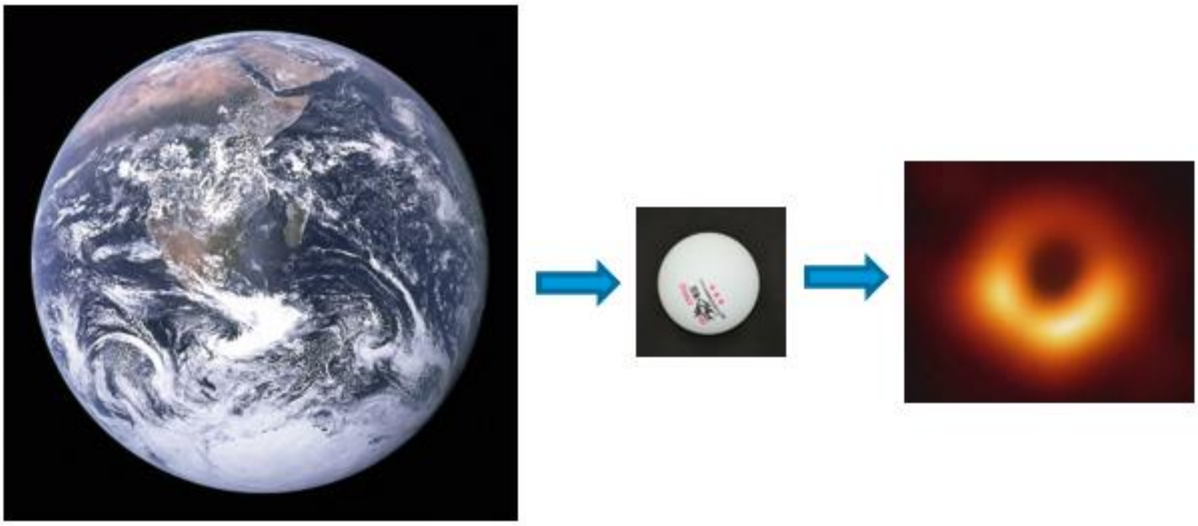
There is a black hole at the centre of our own Milky Way galaxy.

In fact, black holes are often found at the centre of galaxies.

In fact, a black hole forms when matter is compressed to an extreme pressure.

If we had enough energy to concentrate the whole earth into a ball the size of a ping-pong ball, it would turn into a small black hole.





Black holes concentrate so much matter that they are able to attract and absorb everything, even light!

## Big Bang Flash

13.6 billion years ago, at the beginning of our Universe, its expansion produced a huge flash of light filling all space.

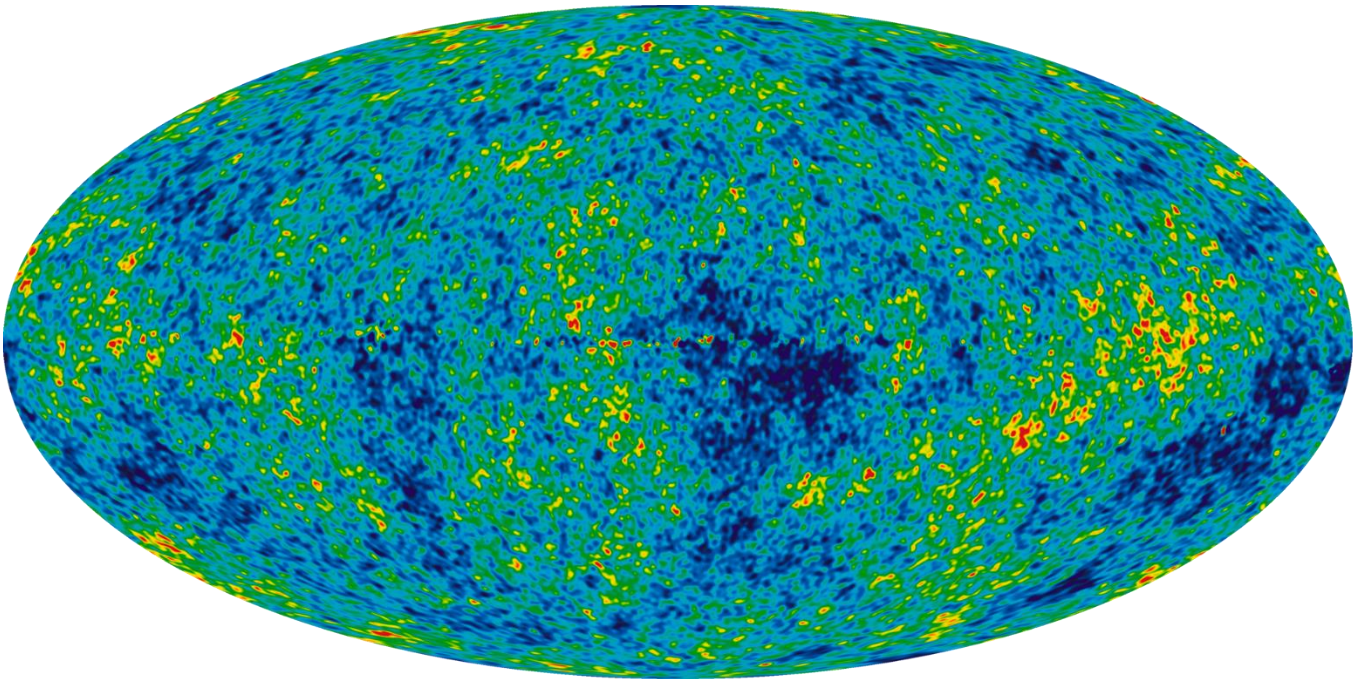
Today we can no longer see this 'flash' with our own eyes, but with sensitive radio telescopes we can still detect this faint relic radiation that fills all of space.

Indeed, in space, nothing can be blacker than this "flash" of the beginning of the Universe.

The image below, captured by the WMAP space telescope, shows the small temperature variations of this flash, visible across the sky.

The average temperature of lightning as seen today is 2.725 degrees Kelvin above absolute zero (absolute zero is -273.15 ºC), and the colours represent the minute fluctuations in temperature, as in a weather map.

The red regions are warmer and the blue regions are colder by about 0.0002 degrees.

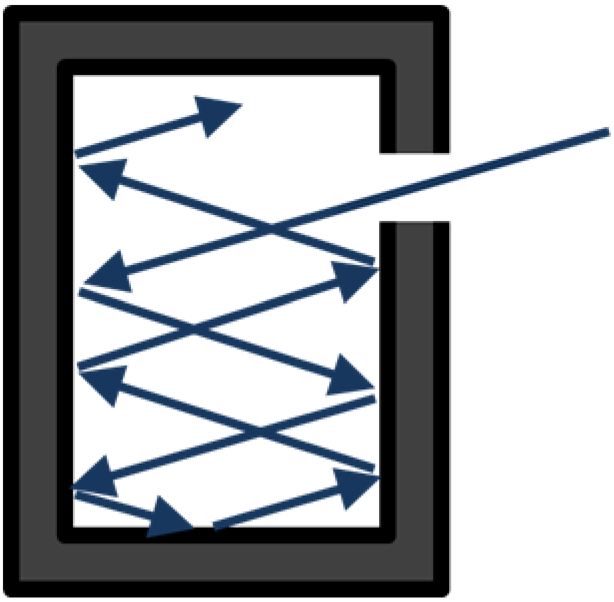


## Apart from super black, where do you find the blackest colour around you?

One solution is to use the darkroom:

- Disconnect the battery
- Remove the cube from inside the chamber if there is one.
- Close the darkroom with the top cover
- Look at the colour of the hole in the middle of the lid.

Light entering the hole has very little chance of escaping, which is why it looks so dark. The principle of the super-black material developed by the Luxembourg Institute of Science and Technology is similar: light is scattered in the material and has little chance of getting out.

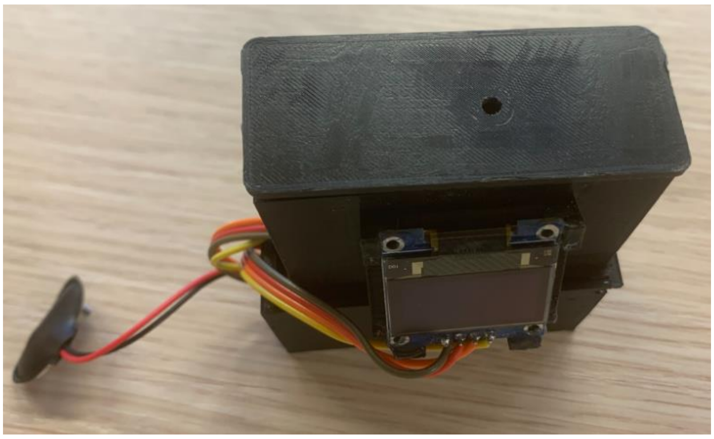


## With the equipment at your disposal, how can you simulate a light-absorbing black hole?

Just plug the darkroom battery back in, without the cube.

Place the lid on and put your finger on the hole in the middle of the lid.

No light can escape like in a real black hole.



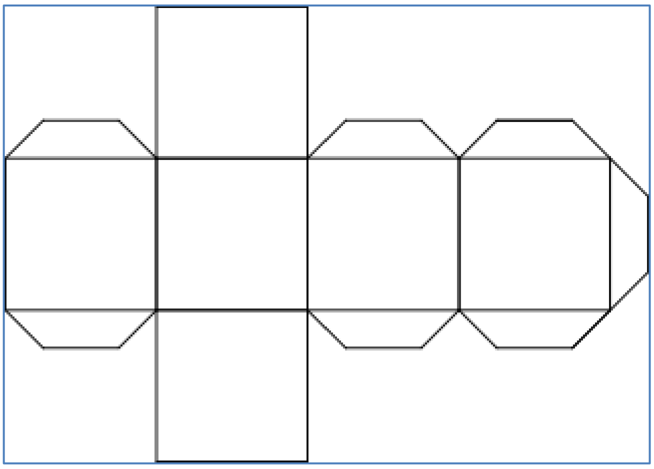
# → TEST WITH A COLOURED CUBE

## Equipment

- The same materials as for Activity 1 plus
- 1 sheet of cardboard
- 1 scissors
- 1 tube of glue
- coloured pencils or markers

## Exercise 1: Build your own coloured cube

- Cut around the cube model below
- Glue it flat to the cardboard sheet
- Colour 1 of the 6 square faces of the cube in black.
- Colour 4 of the 6 square sides of the cube with the colours of your choice.
- Apply glue to the rectangular tabs
- Fold the edges of the cube to form the final cube.



## Exercise 2: testing the reflection of light from the faces of a coloured cube

1. Follow the same procedure as in Activity 1 to test the reflection value of the white face.
2. Repeat with the other five coloured sides of the cube.
3. Compare

# → CLASS DISCUSSION

## Which colour seems to absorb the most light?

In this activity, help students to fill in the table below, where all their results can be displayed.

- Classify the cubes according to their light absorption.
- Discuss which of the tested materials could be used in a space telescope, and where this property could be useful.
- Ask them to write the reasons for their choices on the student activity sheet.

| Colour | Reflection (lx) | Rank |
|---|---|---|
| White | | |
| Red | | |
| Orange | | |
| Yellow | | |
| Green | | |
| Blue | | |
| Indigo | | |
| Violet | | |
| Black | | |

# → APPENDIX

## Glossary of terms used in the student activity sheets

**(Artificial) satellites:** objects put into orbit (which is a repeated trajectory) around the Earth or another planet. Satellites are designed to take measurements and photographs, which will help scientists, for example, to learn more about the Earth, the planets and beyond.

**Spacecraft: a** vehicle used for space travel, for example the International Space Station and the Orion spacecraft.

**Lux:** unit of illuminance, measuring the luminous flux per unit area.

**Carbon nanotube: a** tube made of carbon whose diameter is usually measured in nanometres.

**Black hole :** A region of space where gravity is so strong that nothing can escape.

# Links

## ESA Space telescopes using super dark materials

- Solar Orbiter
- James Webb Telescope Education Kit for Primary Schools

## Luxembourg Institute of Science and Technology – Superblack Laboratory

https://www.list.lu/fr/cooperations/secteurs-dactivite/espace/solutions-technologiques/technology/revetements-fonctionnels/

https://youtu.be/ZJ4P1pdzcKo?t=154

## ESA resources

Resources for the ESA classroom:
www.esa.int/Education/Classroom_resources

ESA homepage for children :
www.esa.int/esaKIDSen

Paxi Playbook:
http://esamultimedia.esa.int/multimedia/publications/PaxiFunBook

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