The Universe in my pocket

The sizes of celestial bodies

TUIMP No. 11 THE UNIVERSE IN MY POCKET

Grażyna Stasińska
Paris Observatory

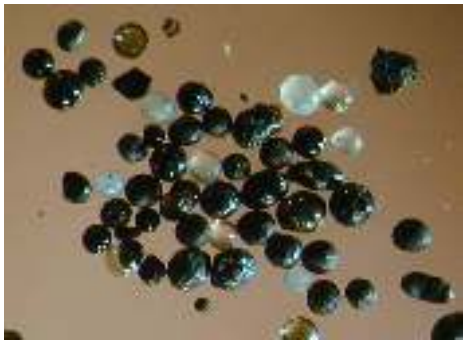
Stars and planets look like glittering dots on the sky, while the Sun and the Moon look rather like oranges on a tree. This is because all these objects lie at very different distances: The farther they are, the smaller they appear with respect to their true size.

Some celestial bodies are so far away (or so intrinsically faint) that they can be detected only by the largest telescopes.

But did you know that some celestial bodies can also be found on Earth?

In this booklet we explore celestial bodies from the smallest ones that we can see to the largest. On each page the size of the object shown is one thousand times larger than on the previous page. You will discover the amazing range of sizes in the Universe!

10^{-3} m: Micrometeorites



Micrometeorites are small debris of comets or of asteroids which have managed to reach the Earth as tiny spheres of roughly one millimeter in diameter. It is by melting during their journey through the Earth's atmosphere that they acquire their shape.

At night, micrometeorites can be observed as shooting stars.

30000tons of micrometeorites hit the ground each year, roughly one every square meter! This means that there are plenty of them around us.

The image on the right shows sand grains. They are similar in size and shape to micrometeorites

0.001m

1 m: Meteorites

Meteorites are also debris of comets or asteroids that have reached the ground, but they are larger than micrometeorites. Their sizes go to several meters.
They come in various shapes and compositions. The composition tells scientists about their origin.
The Murnpeowie Meteorite found in Australia in 1909 and shown above is made of iron and is about one meter in size.

Just like a four-year-old boy!

1 m

10^3 m: Asteroids

This is an asteroid threatening to impact the Earth as imagined by Oliver Denker.

In February 2018, the asteroid named 2002 AJ129 flew past the Earth at a distance of 4 million km. Its size is estimated to be 1 km. Scientists think that the impact of an asteroid only ten times larger than this killed all the dinosaurs on Earth, about 60 million years ago.

The tallest waterfall in the world, Kerepakupai-merú in Venezuela, is nearly 1 km high.

1000 m

10^6 m: Dwarf planets

Like a planet, a dwarf planet orbits a star, and is rounded by its own gravity. But, while planets are able to remove smaller bodies near their orbits by collision or capture, dwarf planets are not massive enough to do this. The dwarf planet Ceres, shown above, has a diameter of 1000 km. The planets of the Solar system have diameters between 5000 km and 140000 km.

Asteroids are smaller than dwarf planets and are not round.

The dwarf planet Ceres is about the size of Colombia.

1 000 000 m

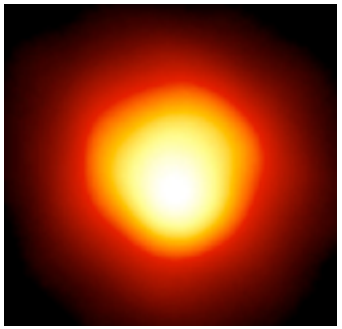
10^9 m: The Sun

This is a sunset at Cape Sounion, in Greece. Because the Sun lies so far from the Earth, it looks smaller than the ruins of the temple. But its real size exceeds one billion meters (to be exact it is 1.39 10^9 m).

Aristarchus of Samos, a Greek astronomer, was the first to estimate the size of the Sun, about 2 250 years ago. He also suggested that the Earth revolves around the Sun. That the Sun is just a nearby star had already been suggested by the Greek philosopher Anaxagoras, two hundred years earlier.

1 000 000 000 m

10^{12} m: A red supergiant star

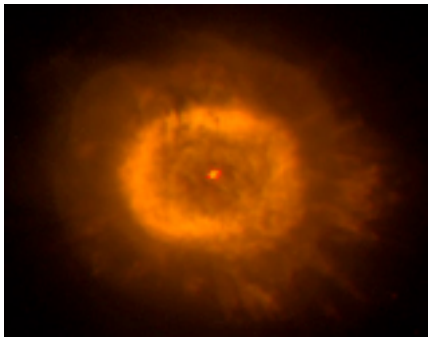


Shown above is a Hubble Space Telescope image of Betelgeuse. This is the first detailed image of the surface of a star other than the Sun. Betelgeuse is a `red supergiant'. It is 1000 times the size of the Sun. Ten million years ago, it was a blue star, only 5 times larger than the Sun and with a surface temperature of 30000° C (now it is 3600°C).

All stars evolve. During most of their lives, they burn hydrogen in their cores but they do not change on the surface. When the hydrogen fuel runs out, the cores shrink while the external layers swell and cool. A giant star forms.

1 000 000 000 000 m

10^{15} m: A planetary nebula



Shown above is a Hubble Space Telescope image of the planetary nebula BD+30-3639. Planetary nebulae have nothing to do with planets! They are the last episodes in the life of stars similar to the Sun. After a star has become a giant, it looses its external layers . What remains of the star is just a dense core which shrinks and heats up to very high temperatures and is able to excite the ejected matter.

BD+30-3639 is one of the smallest planetary nebulae studied in detail. Yet its diameter is 1.2 10^{15} m, and exceeds that of the Solar system.

1 000 000 000 000 000 m

10^{18} m: A globular cluster

Above is an image of M13, the Hercules Globular Cluster, taken by Martin Pugh. Its diameter is 120 light-years (one light-year, the distance travelled by light in one year, is almost 10^{16} m).

Globular clusters are dense groups of old stars. Most are older than one billion years. About 150 globular clusters are known in the Milky Way.

M13 contains about 300 000 stars. The central zone is densely populated. It contains more than 300 stars in a sphere of 2 light-years radius. In the same volume around the Sun there is only one star: the Sun itself!

1 000 000 000 000 000 000 m

10^{21} m: The Milky Way galaxy

This image is a combination of 37 000 exposures collected from all over the Earth by Nick Risinger to show the entire Milky-Way galaxy.

The Milky Way is a normal spiral galaxy whose disk has a diameter of more than 100 000 light years. It contains over 100 billion stars.

From Earth, it appears as a ribbon of light because the Sun is inside the disk. The light from the stars combines in a diffuse glow . The dark patches are due to interstellar dust hiding the light from the stars.

1 000 000 000 000 000 000 000 m

10^{24} m: A supercluster of galaxies

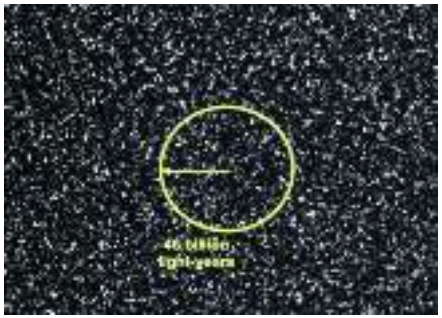
Most galaxies are clumped into clusters of galaxies, and clusters into superclusters, which are the largest structures known in the Universe.

The Shapley supercluster contains about 8000 galaxies and extends over 100 million light-years. It is permeated by hot gas whose mass dominates that of the galaxies.

The above image shows its core. We can see the hot gas detected in X-rays (in pink) and at microwave wavelengths (in blue), as well as hundreds of galaxies (the small white dots).

1 000 000 000 000 000 000 000 000 m

10^{27} m: The observable Universe



The observable Universe is a sphere containing all the matter that could in principle be observed. Its size depends on the age of the Universe and on its expansion rate. It is estimated to be almost 10^{27} m in diameter.

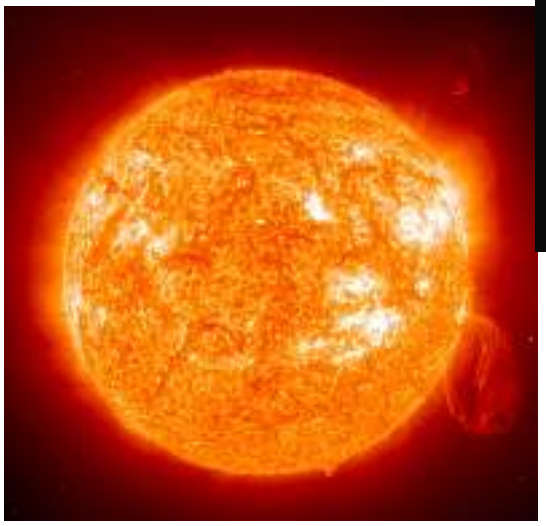
It is impossible for us to know what happens beyond this sphere, since the light emitted beyond has not had time to reach us in the 13.8 billion years that the Universe exists.

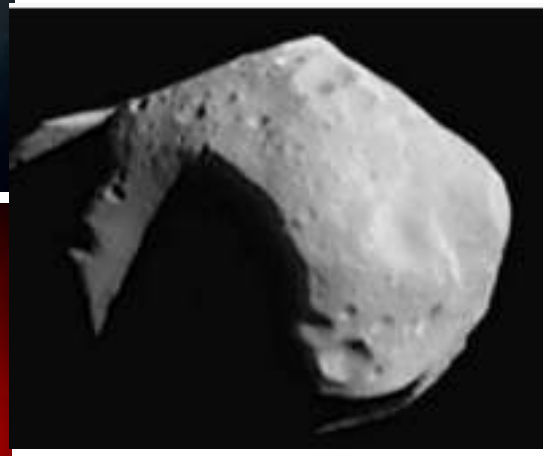
In the picture shown above, the Universe is the same outside the boundaries of the observable Universe.

1 000 000 000 000 000 000 000 000 000 m

Quiz

Classify these objects in order of increasing size





Answers on overleaf

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This booklet was written in 2018 by Grażyna Stasińska from Paris Observatory (France) . It is dedicated to Arsen, her 4 year-old grand son, for him to read with his parents.

Cover image: A logarithmic-scale illustration of the observable Universe by the Argentinian artist Pablo Carlos Budassi. It is based on the map of the Universe published by Richard Gott and his collaborators in 2005.
The image of the Shapley supercluster is a combination of data from ESA & Planck Collaboration / Rosat / Digitised Sky Survey.
Many images in this booklet are from non-professional astronomers.

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