

The Universe in my pocket



The realm of galaxies



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The Milky Way with Orion seen from Lake Tahoe in Nevada (USA).



Galileo's drawing of the Milky Way near Orion: small asterisks represent faint stars.

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We have all seen the large band of hazy light crossing the sky on dark nights. The ancient Greeks called it the Milky Way. For the ancient Egyptians and the ancient Chinese, it was a celestial river, while Siberians saw it as the seam in the tent of the sky.

Since the oldest times scientists have tried to understand its nature. Many, like Anaxagoras in ancient Greece or Al Biruni in medieval Persia, considered that it was made of many stars seen close together.

This idea was proven correct when Galileo Galilei observed the Milky Way with his telescope in 1610 and showed that it was really composed of a large number of faint stars.

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From nebulae to galaxies



The Large Magellanic Cloud, the galaxy that is closest to the Milky Way.



M31, the Andromeda Galaxy, the nearest spiral galaxy. This picture was taken with a small telescope by Lorenzo Comolli.

Other cloudy patches can be seen in the sky. In 1781, Charles Messier listed 104 of them in his famous catalogue.

Spectroscopy (pioneered by the amateur astronomer Huggins in 1863) showed that there were two types of nebulae: gaseous nebulae and stellar nebulae.

Whether these clumps were located inside or outside the Milky Way was harshly debated until Edwin Hubble measured the distance to one of them in 1924.

It was then shown that many of these nebulae were in fact 'island universes' similar to our galaxy, the Milky Way. Such nebulae are now called galaxies.

Spiral galaxies

This is the most common type of large galaxies in the local Universe. They have spiral 'arms' that unwind outwards from a central bulge.

Along the spiral arms, we find clouds of gas and dust where new stars are being formed. In between the arms and in the bulge, the stars are older. They are yellow and typically are billions of years old, while in the arms the stars are blue, and only about a million years old.

Spiral galaxies typically contain 10^{11} * stars.

The Milky Way is a spiral galaxy.

*one hundred billion



The spiral galaxy NGC 1232 and its small companion NGC 1232A. This picture was obtained with the Very Large Telescope at ESO in Chile.



NGC 4565: a spiral galaxy seen edge-on. This image was obtained by Keith Quattrocchi, with a 40 cm telescope.

Elliptical galaxies

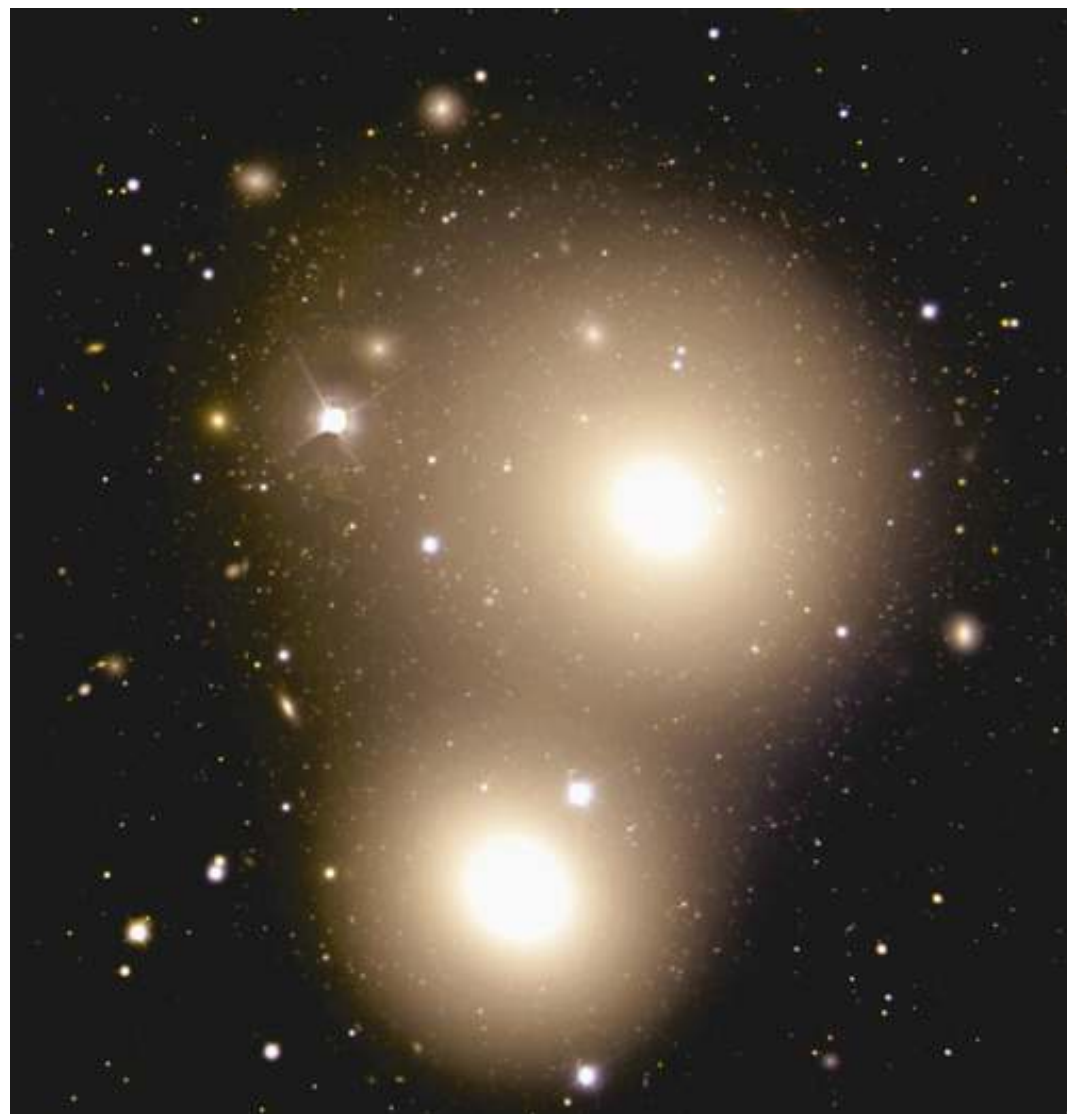
Elliptical galaxies can be round or elongated. Unlike spiral galaxies, they are smooth and dim. They are formed of old stars which gives them a reddish color. They contain little gas or dust.

The smallest elliptical galaxies, called 'dwarf ellipticals' have diameters of ten thousand light-years (ten times smaller than the Milky Way galaxy) and contain only ten million stars. The largest elliptical galaxies have diameters of a million light-years, and contain more than 10^{13} * stars.

In elliptical galaxies, contrary to spirals, stars move in all directions without coherent rotation.

* ten trillion

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Two elliptical galaxies: NGC 3311 and NGC 3309.

This is an image obtained at the Gemini-South telescope by Elizabeth Wehner and William Harris.

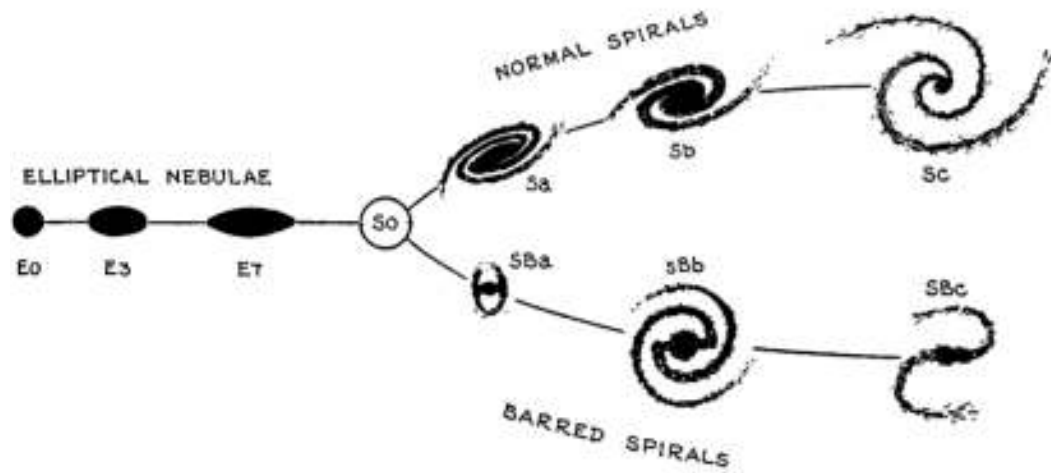
The Hubble tuning fork

After analyzing the images of about 400 galaxies, Edwin Hubble invented a way to classify their shapes (see opposite page).

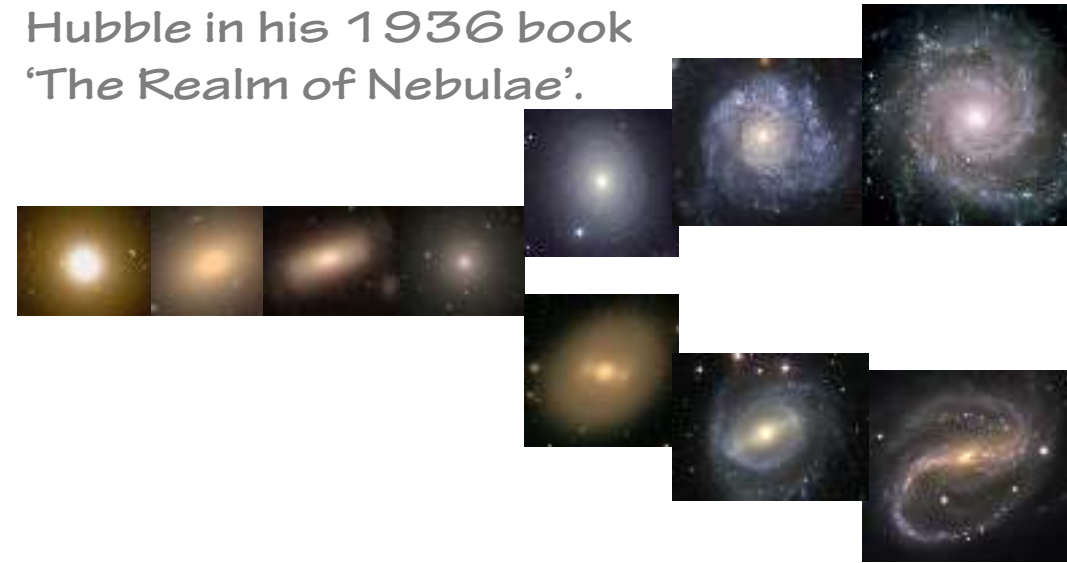
Even after some changes, for example to include irregular galaxies, Hubble's classification remains the most popular one.

Nowadays, astronomers can measure the masses of galaxies and it turns out that the Hubble sequence - from ellipticals to spirals - is a sequence of decreasing galactic mass.

It is not yet fully understood why galaxy shapes and masses are so tightly linked together.



The tuning fork diagram was drawn by Hubble in his 1936 book 'The Realm of Nebulae'.



The tuning fork as seen with modern photos:

NGC 1407 (E0), NGC 1052 (E3), NGC 4270 (E7), NGC 7192 (S0), NGC 488 (Sa), NGC 1039 (Sb), NGC 628 (Sc), NGC 936 (SBa), NGC 5850 (SBb), NGC 7479 (SBc).

Galaxy interactions

Galaxies do not live alone. While spiral galaxies tend to be found in rather isolated regions of the Universe, ellipticals tend to cluster together.

Galaxies that are close to each other may interact in different ways: Colliding spiral galaxies may merge and form an elliptical. A galaxy passing near another one will drag a long tail of stars.

Interactions change more than the shapes of galaxies: they stimulate the formation of new generations of stars.

Most galaxies have probably interacted in the past.

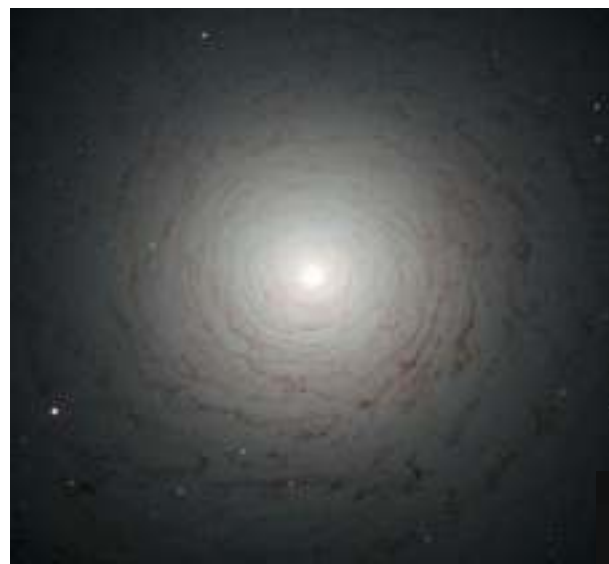
ESO 593-8: a pair of interacting galaxies. The two components will probably form a single galaxy in the future.



NGC 6621 and NGC 6622, a pair of interacting galaxies. The encounter has pulled a long tail out of NGC 6621.

Faint stellar streams around the edge-on spiral galaxy NGC 5907.

Image by J. Gabany
Blackbird Observatory.



Which one of these is not a galaxy?



Intermediate between an elliptical and a spiral



NGC 4361

a planetary nebula

Quiz



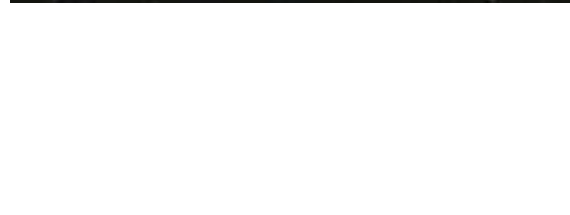
NGC 3628

the Hamburger galaxy



NGC 2442

the meat-hook galaxy



M 104, the Sombrero

An edge-on galaxy of type Sa



Solutions on overleaf

The Universe in my pocket No. 3

This booklet was written in 2015 by Grażyna Stasińska from Paris Observatory (France) and revised by Stan Kurtz from the UNAM Radio Astronomy Institute in Morelia (Mexico).

Most photos were obtained with the ESO large telescopes and with the Hubble Space Telescope. They are provided by NASA, the STScI and by ESA.

The photo of the Milky Way with Orion is by Wally Pacholka (TWAN).

The cover photo represents the system of interacting galaxies Arp 22; see www.annesastronomynews.com/photo-gallery-ii/galaxies-clusters/arp-227/



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