UNIT 4:

GAS GIANTS

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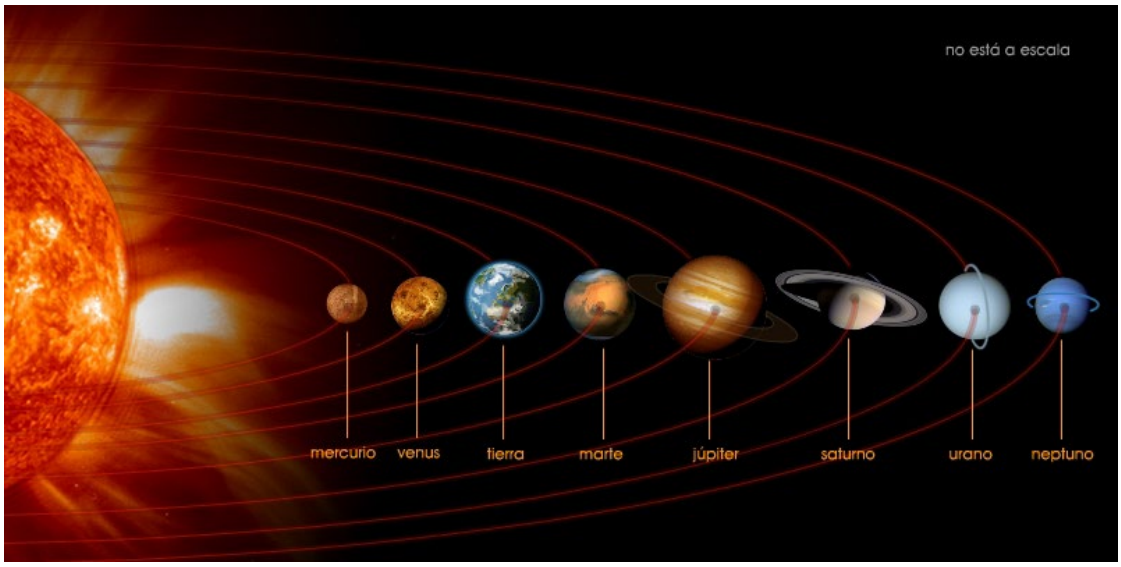
Terrestrial and gas planets.

Planets are celestial bodies that revolve in elliptical orbits around a star. So far we know of eight planets in our solar system, although others may be discovered as we continue to explore it. Unlike the Sun, the planets do not have their own light, but reflect the light coming from the star. The first four in distance from the Sun are: Mercury, Venus, Earth and Mars. They are considered **terrestrial or rocky planets**, because of their similarity to our planet, that is, they are small and mostly solid, with a high density, a slow rotational motion, with no or few moons, no rings and a fairly round shape. The next four are Jupiter, Saturn, Uranus and Neptune. These are often called **gas planets or gas giants**, as they are huge compared to our planet and are very light for their large size, since they are made up mainly of gases such as hydrogen and helium. They rotate around themselves faster than the Earth, have a more flattened shape, have many satellites orbiting around them and all of them have rings surrounding them, although they are not always visible.

The formation of the planets and that of the Sun are closely related. The matter that now forms the solar system was part of a nebula of hydrogen, helium and interstellar dust, which contained a small proportion of the rest of the elements. About 4.6 billion years ago, this cloud of gas and dust began to concentrate and accumulate matter around it by gravitational attraction until it formed a kind of flat, rotating disk. The gravitational attraction caused the amount of matter in its central part to increase greatly, thereby increasing the pressure and temperature

so high that the main component, hydrogen atoms, began to collide and bond, giving rise to new helium atoms and producing enormous amounts of energy. This process ignited a colossal thermonuclear furnace that eventually gave rise to the star we call the Sun.



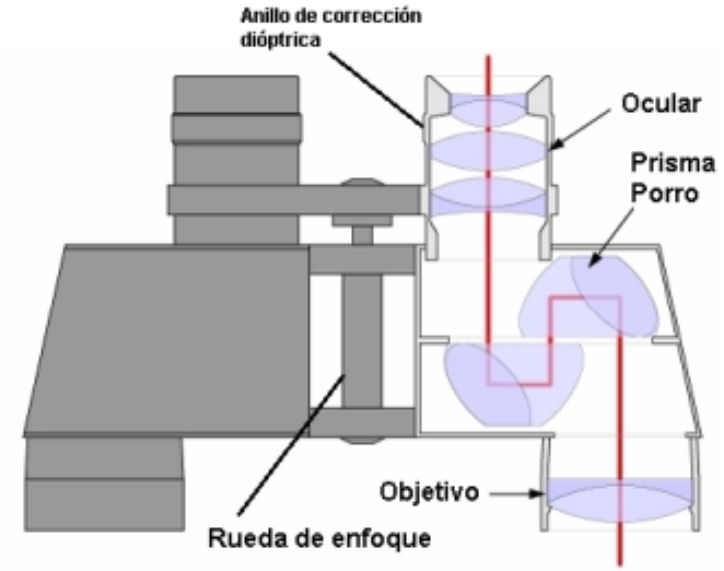
The materials that originated the planets were located approximately in the plane of the disk, rotating around the newly formed Sun and colliding against each other, forming larger and larger objects. The various components were naturally distributed at certain distances from the Sun by the action of heat, the solar wind, gravity, etc. In the vicinity of the Sun, the lighter materials disappeared, so that the rocky nature is dominant in the first four planets. The planets farther away from the influence of the Sun acquired greater mass and, with it, greater gravity, so they were better able to retain light gases, such as methane, ammonia, nitrogen and water.

A different event occurred in the belt between the orbits of Mars and Jupiter. The great gravitational effect of nearby Jupiter prevented the collisions between the particles located in that zone from creating a planet, resulting in a large number of fragments of different sizes that we know as the “asteroid belt”.

Binoculars and telescopes, instruments for observation

When we look at an astronomy book or search the Internet, we are amazed by the magnificent images of celestial objects; colorful nebulae and galaxies. But when we look at these objects directly through a telescope, we may be disappointed. Many of the objects are faint and when we look at them through a small telescope we do not see them with those spectacular colors, at most we see a faint grayish nebulosity. The reason is that our eye has a limited sensitivity and with low light we cannot discern colors, we see only in black and white. Hence the phrase: “at night all cats are brown”. On the other hand, a photograph can accumulate the light that reaches it for hours, making photographic devices much more sensitive than our vision. But there are bright celestial objects whose vision through an optical instrument can amaze us, especially when we observe them for the first time.

If we have **binoculars** at home, we can make use of them for astronomical observation. Binoculars are two small glasses, mounted side by side, which, like the telescope, allow us to see distant objects with greater size and detail than with the naked eye, but, in addition, produce a three-dimensional vision with an impression of depth (by being able to use both eyes at the same time). Each binocular has a lens located at the front, which is called an objective. The larger its diameter, the more light it collects and the better we can distinguish dim objects. The collected light is reflected by a pair of prisms inside the tube, which orient the image and allow a reduction in the size of the instrument. At the other end of the binoculars we have two lenses called eyepieces (this is where we place our eyes), which move to focus the image. The binoculars have two numbers that identify them, for example 7x40, 7x50, 11x80, etc. The first refers to the number of magnifications provided and the second to the diameter of the objective lens in millimeters. In binoculars, the diameter of the objective is more important than the number of magnifications.



Schematic of the optics of binoculars. By Agguizar at en.wikipedia, Wikimedia Commons

With binoculars we can distinguish some craters and mountains on the Moon, the satellites of Jupiter and Saturn, planets not visible to the naked eye such as Uranus and Neptune, comets, open and globular clusters, nebulae and some galaxies. Their ease of use and low cost make them an excellent tool for learning astronomy and a highly recommended step before purchasing a telescope.

When you have become familiar with the sky, recognizing it with the naked eye and binoculars, the next step will be to use a telescope, as there will probably be objects that you have not been able to see well because they are too small or too faint.

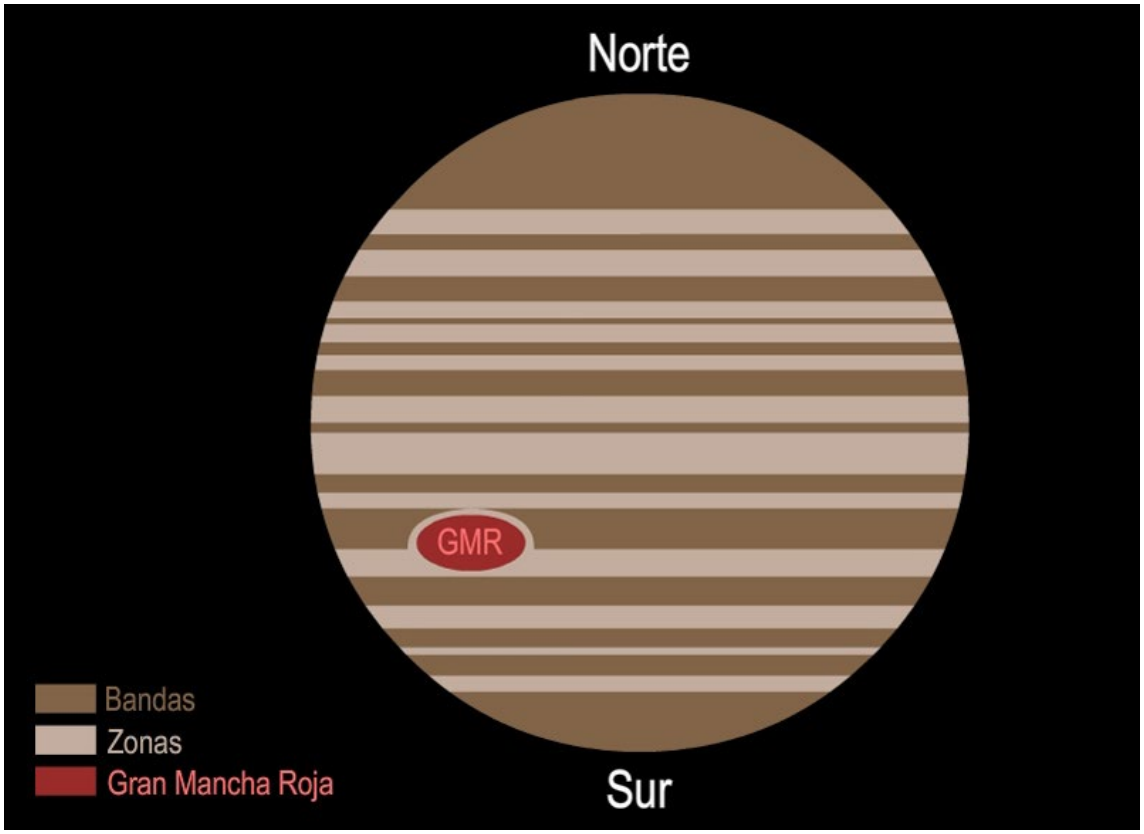
A **telescope** is an optical instrument that allows us to capture much more light as the diameter of the objective lens is larger than that of a pair of binoculars. In addition, the larger the objective lens, the smaller the details we can see. In a telescope, the diameter of the objective is also more important than the number of magnifications, although they are closely related.

There are two main types of telescopes: **refractors**, which have a lens that concentrates the light on a point called focus; and **reflectors**, where the objective is a parabolic mirror that concentrates the reflected rays on a point also called focus. In a telescope we can change the magnification by replacing the eyepiece we place behind it. The smaller the focal length of the telescope (usually represented by the letter ‘f’), the higher the magnification of the telescope.

With a telescope we can observe objects that with binoculars we can barely distinguish, such as mountains and craters on the Moon, details in nebulae and structures in galaxies, but what is most striking is the view of the planets. With it we can see the phases of the inner planets (Mercury and especially Venus), the polar caps of the planet Mars, the dark bands of Jupiter's atmosphere with its Great Red Spot, the four large satellites of Jupiter and, especially, the impressive ring of Saturn, perhaps the most unforgettable thing one can see when observing for the first time with a telescope.

Jupiter

Jupiter is the largest planet in the Solar System and the fifth closest to the Sun. It is named after the Roman god Jupiter (Zeus in Greek mythology). It is so large that it could fit more than a thousand planets like the Earth. It has a mass more than twice that of all the other planets in the solar system combined. Through a telescope we can immediately see that it is not completely spherical, but slightly flattened at the poles due to the fast rotational motion of the planet, the fastest in our solar system (Jupiter spins around itself in less than 10 hours). We can also observe a series of bands parallel to its equator, which are atmospheric features called “bands” or “zones”. The fundamental difference between them (apart from the dark tone of the bands and the light one of the zones) is that in the dark ones the winds move in one direction, while in the other ones they move in the opposite direction. Winds at the equator blow at speeds of around 360 *km/h*.



If there is one thing that stands out in Jupiter's atmosphere, it is undoubtedly its Great Red Spot (GRS). This huge anticyclone located in the southern hemisphere of the planet has remained visible since it was discovered more than 300 years

ago, when Jupiter was first observed. We do not know how long it had been there before it was observed. During this time, it has varied in color and size. It is a gigantic whirlpool rotating counterclockwise, with winds exceeding 500 *km/h* and so large that several planets like the Earth could fit inside it.

The first to point a telescope at Jupiter was Galileo Galilei, who, in January 1610, discovered that this planet was in the company of four satellites that revolved around it. This discovery showed that there were other bodies revolving around a body that was not the Earth, thus overthrowing the geocentric model. To date, more than 95 satellites have been found orbiting this planet[1], many of them only a few kilometers in diameter, and the number is increasing every year. The four largest, with a size similar to our Moon, are visible with a small telescope.

After the visit of several space probes to Jupiter, it was found that it has a system of rings surrounding it, with a very weak brightness and composed of microscopic or submicroscopic dust particles.

View of Jupiter through an amateur telescope. Author: O. González

[1] NASA Solar System Jupiter Moons

Saturn

Saturn ranks sixth in distance of the planets from the Sun, almost 10 times farther than the Earth is from our star. It is named after the Roman god *Saturn* (*Chronos* in Greek mythology). It is the second largest planet in the solar system and, like Jupiter, is flattened at the poles due to its rapid rotation (its rotation period is about 10 hours and a quarter). Its atmosphere is composed mainly of hydrogen, although it also has some helium and methane. It has a yellowish color and also shows bands like Jupiter, but less noticeable.

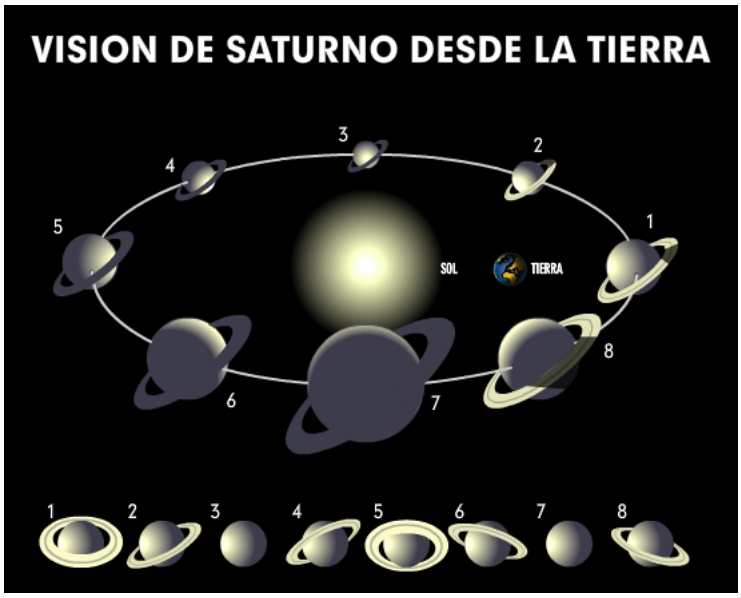
The planet's large size, which could contain some 740 Earths, and its relatively small mass (only 95 times the Earth's), make it a rather unique planet, as it is the only one with a density less than that of water. While a liter of water weighs 1 *kg*, if we could take the same volume of Saturn, it would weigh only 690 grams. If there were a container of water large enough to hold Saturn, it would float.

View of Saturn through an amateur telescope. Author: O. González

But if Saturn has something that makes it unique, it is its system of rings, the only ones visible from Earth and that can be observed even with a small telescope.

Galileo Galilei was the first to observe them when he pointed his telescope at Saturn but, due to the small size and low quality of the instrument, he thought they were moons on the sides of the planet. In the rings, dark areas can be seen in which there is practically no matter. The largest of these is the Cassini division, which separates rings of different brightnesses. The rings are composed of ice fragments, ranging in size from a few centimeters to meters, and a large amount of dust, so it is thought that they were formed from the impacts of Saturn's moons with meteoroids and comets.

Saturn's rings are tilted with respect to the plane in which it moves around the Sun. Since it takes about 29.5 years to complete its orbit, approximately every 15 years the rings disappear from our view for a few months, because we are seeing them edge-on. During this period, they are invisible even with the largest telescopes, as their thickness is barely 1 *km*.



Representation of Saturn's orbit, not to scale.

Saturn, as Jupiter, has a large number of satellites. In March 2025, 128 small moons (the size of a stadium) had to be added to the 146 known, bringing the total to 274[2] (and counting...). The largest of these, Titan, is the only one with an atmosphere and is larger in diameter than the planet Mercury.

[2]NASA Solar System. Saturn Moons

For further information, visit our website: **www.iac.es/peter**

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