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STRUCTURE AND PHYSICAL PARAMETERS OF A GALAXY

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Abstract: This article is dedicated to the complex structure and fundamental physical characteristics of our Milky Way galaxy. It provides a detailed analysis of the galaxy's main components, such as the disk, halo, and central bulge, as well as the distribution of stars, gas, dust, and dark matter within them. The article highlights important physical parameters of our galaxy, including its total mass, diameter, rotation speed, and star formation processes. It also discusses the interaction of our galaxy with neighboring galaxies, particularly the Andromeda galaxy, and future changes and discoveries.

Keywords: Milky Way, Appearance of our galaxy, Star clusters Gas and dust nebulae.

The Milky Way Galaxy and the Study of Astronomy
Astronomy is one of the oldest and most interesting branches of science. It helps us understand the Universe and everything that exists beyond the Earth. In astronomy, we study celestial bodies such as the Sun, planets, moons, stars, asteroids, comets, meteors, meteorites, galaxies, and many other space objects. We also learn about natural phenomena that occur in space, including eclipses, meteor showers, supernova explosions, black holes, and the expansion of the Universe.One of the most important objects studied in astronomy is our Galaxy, the Milky Way. The Milky Way is a giant spiral galaxy that contains more than 100–400 billion stars, along with gas, dust, nebulae, star clusters, and dark matter. Our Solar System is located in one of the Milky Way's spiral arms, called the Orion Arm, about 26,000 light-years from the Galactic Center.When we look at the sky on a dark, clear night, the Milky Way appears as a bright, cloudy band stretching across the sky. This band is actually made up of millions of distant stars that cannot be seen individually with the naked eye. The Milky Way divides the sky into two parts along the Galactic Equator.The Milky Way passes through many constellations, including Gemini, Taurus, Auriga, Cassiopeia, Cepheus, Cygnus, Scutum, Sagittarius, Orion, Canis Major, Ophiuchus, Scorpius, Centaurus, Monoceros, Carina, and Vela. The Galactic Center is located in the direction of the constellation Sagittarius. Scientists believe that a supermassive black hole, called Sagittarius A*, is located at the center of our Galaxy.The apparent width of the Milky Way reaches about 18° in the sky. The great circle running through the middle of the Milky Way is called the Galactic Equator. It is inclined to the Celestial Equator by approximately 62.6°. Astronomy also studies objects beyond our Galaxy. Scientists have discovered billions of other galaxies in the Universe. These galaxies differ in size, shape, and structure. By studying them, astronomers learn about the origin, evolution, and future of the Universe.Modern astronomy uses powerful ground-based telescopes, space telescopes, satellites, and space probes to observe distant objects. These technologies allow scientists to explore planets, stars, galaxies, and many other celestial bodies with great accuracy. In conclusion, astronomy helps us understand the structure of our Galaxy, the Solar System, and the Universe as a whole. It expands our knowledge about space, inspires scientific discoveries, and encourages people to explore the mysteries of the cosmos. In astronomy, we study many fascinating topics, especially celestial bodies and natural phenomena in space. We learn about the planets, Earth,

the Moon, asteroids, meteors, meteorites, and all the objects and phenomena related to our Galaxy and other galaxies. We also study the structure and physical properties of our Galaxy. The Milky Way appears as a bright band across the dark night sky, dividing the celestial sphere into two parts along the Galactic Equator. It passes through the constellations of Gemini, Taurus, Auriga, Cassiopeia, Cepheus, Cygnus, Scutum, Sagittarius, Orion, Canis Major, Ophiuchus, Scorpius, Centaurus, Monoceros, Carina, and Vela. The center of the Galaxy is located in the constellation Sagittarius. The Milky Way reaches a maximum apparent width of about 18°. The great circle passing through the middle of the Milky Way is called the Galactic Equator, and it is inclined to the Celestial Equator by an angle of approximately 62.6°.

Galaxy

The Milky Way Galaxy: Structure and Physical Characteristics.Our Galaxy is called the Milky Way, and it is one of billions of galaxies in the Universe. It is a barred spiral galaxy composed of enormous numbers of stars, gas, dust, and dark matter. The Milky Way is the home of our Solar System and is one of the most important objects studied in astronomy.Structure of the Milky Way.The Milky Way consists of several main components:

1. Galactic Disk.The disk is the most visible part of the Galaxy. It is a flat, spiral-shaped region containing young stars, gas, and interstellar dust. The Solar System is located in one of the spiral arms, known as the Orion Arm. The disk has a diameter of about 100,000 light-years and a thickness of about 1,000 light-years.

2. Galactic Bulge.The bulge is the dense central region of the Galaxy. It is mainly composed of old red giant stars and low-mass dwarf stars. The Galactic Center is located in the direction of the Sagittarius constellation and is surrounded by thick clouds of dust and gas. At its center lies a supermassive black hole called Sagittarius A*, whose mass is about 4 million times greater than the mass of the Sun.

3. Galactic Halo.The halo is a huge spherical region surrounding the disk. It contains old stars, globular star clusters, and large amounts of dark matter. Halo stars are much older than those found in the Galactic disk.

4. Galactic Coron. The corona is the outermost and least explored part of the Milky Way. Scientists believe that it consists mainly of dark matter, which accounts for most of the Galaxy's total mass.

Physical Characteristics of the Milky Way

Type: Barred spiral galaxy.

Diameter: Approximately 100,000 light-years (about 30,000 parsecs).

Age: About 13.6 billion years.

Number of stars: Estimated to contain between 200 and 400 billion stars.

Mass: Most of the Galaxy's mass is believed to be dark matter, making up as much as 90% of its total mass.

Composition: Stars, interstellar gas (mainly hydrogen and helium), cosmic dust, dark matter, and sources of infrared, X-ray, and gamma-ray radiation.

Motion of the Solar System.

The Solar System orbits the center of the Milky Way at a speed of approximately 250 km/s. It takes about 230 million years to complete one orbit around the Galactic Center. This period is known as a galactic year.

Interesting Facts about the Milky Way.The name Milky Way comes from ancient legends because it appears as a bright, milky band across the night sky.

On dark, clear nights, the Milky Way can be seen stretching across the sky as a luminous path.The Milky Way's width varies from about 4–5° to 30° in different regions of the sky.The

faintest part of the Milky Way is located near the Auriga constellation.In 1610, Galileo Galilei observed the Milky Way with a telescope and proved that it is composed of countless faint stars.The North Galactic Pole lies in the constellation Coma Berenices.The Milky Way extends across many constellations and is brightest toward the Sagittarius region, where the Galactic Center is located.

Future of the Milky Way. Astronomers predict that the Milky Way will collide with the Andromeda Galaxy in approximately 4.5 billion years. Although this collision will dramatically change the shape of both galaxies, the enormous distances between individual stars make direct stellar collisions extremely unlikely.

Conclusion. The Milky Way is a vast barred spiral galaxy that contains hundreds of billions of stars, including our Sun. It is constantly studied by astronomers to better understand its structure, evolution, and the origin of the Universe. Advances in modern astronomy continue to reveal new discoveries about our Galaxy, making the Milky Way one of the most fascinating objects in space science. Dark Matter in the Milky Way.Although stars and gas are visible, they represent only a small fraction of the Milky Way's total mass. Scientists believe that most of the Galaxy consists of dark matter, an invisible substance that does not emit or reflect light. Dark matter creates the gravitational force needed to hold the Galaxy together and influences the motion of stars.

The Rotation of the Milky Way The Milky Way rotates around its center, but not all parts rotate at the same speed. Stars closer to the center move differently from those farther away. One complete rotation of the Galaxy takes about 225–250 million years, known as a Galactic Year.

Exploration of the Milky Way.Modern astronomers study the Milky Way using powerful telescopes on Earth and in space. Space missions such as the Gaia Space Observatory have mapped the positions and motions of billions of stars with remarkable accuracy. Radio telescopes, infrared telescopes, and X-ray observatories also help scientists study regions hidden by clouds of dust.

THE MILKY WAY

Star Clusters and Stars.A star cluster is a group of stars that formed from the same giant molecular cloud and are physically and gravitationally bound to one another. The stars in a cluster have nearly the same age and chemical composition, making them important objects for studying stellar evolution. Based on their shape, age, and mass, star clusters are divided into two main types: open clusters and globular clusters. Open clusters are relatively young groups of stars, with ages ranging from a few million to several hundred million years. Their masses are usually between a few hundred and several thousand times the mass of the Sun. These clusters are found mainly in the Galactic disk, especially within the spiral arms of the Milky Way, where new stars are continuously formed. More than 2,000 open clusters have been discovered in our Galaxy, although astronomers estimate that nearly 20,000 may exist. Many remain hidden because they are obscured by clouds of interstellar gas and dust. Open clusters consist mainly of main-sequence stars, along with a smaller number of giant stars. Well-known examples include the Pleiades (M45) and the Hyades star clusters. Globular clusters are among the oldest objects in the Milky Way. Their ages are typically 10–13 billion years, meaning they formed shortly after the birth of our Galaxy. They contain tens of thousands to several million stars packed into a nearly spherical shape. The masses of globular clusters range from 10^4 to 10^6 solar masses. They are located primarily in the Galactic halo and around the Galactic bulge. These clusters are composed mainly of red giant stars, low-mass main-sequence stars, and RR Lyrae variable stars. Astronomers have identified about 150 globular clusters in the Milky Way, although the total

number is estimated to be between 200 and 250.A star is a massive, luminous sphere of hot plasma held together by its own gravity. The nearest star to Earth is the Sun, which provides the light and energy necessary for life on our planet. Stars produce energy through nuclear fusion in their cores. During this process, hydrogen atoms fuse into helium, releasing enormous amounts of energy in the form of light and heat. As stars evolve, they also produce heavier chemical elements such as carbon, oxygen, silicon, and iron through stellar nucleosynthesis. These elements are later distributed throughout space when stars explode as supernovae, contributing to the formation of new stars and planets. Astronomers determine a star's mass, age, temperature, chemical composition, luminosity, radius, and motion by studying its spectrum and brightness. Among these properties, mass is the most important because it determines how a star evolves and how it will end its life. The relationship between a star's luminosity and surface temperature is shown in the Hertzsprung–Russell (H–R) Diagram. This diagram is one of the most important tools in astronomy because it helps scientists classify stars and understand their evolutionary stages. Depending on their mass, stars may end their lives as white dwarfs, neutron stars, or black holes. Massive stars often explode as supernovae, releasing enormous amounts of energy and enriching the Universe with heavy elements.

Conclusion. Star clusters and stars are essential components of the Universe. Studying them helps astronomers understand the formation, evolution, and future of galaxies. Open clusters provide information about young stellar populations, while globular clusters reveal the early history of the Milky Way. The study of stars continues to expand our knowledge of the Universe and the origin of cosmic matter.

M 53 Star Cluster

Diffuse Nebulae and Galactic Nebulae

Diffuse Nebulae:Diffuse nebulae are large clouds of gas, dust, or a mixture of both found in space. They are among the most beautiful objects in the Universe and are often regions where new stars are born. Some of the best-known diffuse nebulae are located in the Orion and Pleiades (Seven Sisters) constellations. Diffuse nebulae can either emit their own light or reflect the light of nearby stars. They play an important role in the life cycle of stars because they contain the raw materials needed for star formation. Galactic Nebulae.Galactic nebulae are clouds of gas and dust located within the Milky Way Galaxy. They are classified into several main types according to their appearance and origin:
1. Emission Nebulae.Emission nebulae glow because they are illuminated by the intense ultraviolet radiation from nearby hot, massive stars. This radiation ionizes hydrogen gas, causing it to emit a characteristic red light. Their typical properties are:.Temperature: about 8,000–10,000 K.Composition: mainly hydrogen and helium.Mass: from one to several tens of solar masses.Importance: active regions of star formation.The Orion Nebula (M42) is one of the best-known examples of an emission nebula.2. Reflection Nebulae.Reflection nebulae do not produce their own light. Instead, they reflect the light of nearby stars. They usually appear blue because blue light is scattered more efficiently by tiny dust particles. A famous example is the Pleiades Reflection Nebula.3. Dark Nebulae.Dark nebulae are dense clouds of gas and dust that block the light coming from stars or bright nebulae behind them. Since they are not illuminated by nearby stars, they appear as dark patches in the sky. Their characteristics include:Temperature: about 5–50 K.Very dense molecular gas and dust.Excellent regions for future star formation.The Horsehead Nebula is one of the most famous dark nebulae in the Milky Way.4. Planetary NebulaePlanetary nebulae are expanding shells of gas ejected by dying red giant stars. Despite their name, they have nothing to do with planets. The name was given because early telescopes showed them as small, planet-like disks. At the center of every

planetary nebula is a very hot white dwarf, whose intense radiation causes the surrounding gas to glow.Supernova remnants are created when a massive star explodes as a supernova. The explosion sends enormous amounts of gas and dust into space, producing beautiful filament-like clouds. Many supernova remnants emit radio waves, X-rays, and gamma rays. Some also contain a pulsar, which is the rapidly rotating neutron star left behind after the explosion. The most famous example is the Crab Nebula (M1). Nebulae are among the most important objects in astronomy because they represent both the birthplaces and the final stages of stars. They recycle gas and dust throughout the Galaxy, allowing new generations of stars and planetary systems to form. By studying nebulae, astronomers gain valuable information about stellar evolution, the chemical composition of the Universe, and the structure of the Milky Way.

Horsehead Nebula (Barnard 33):

The Horsehead Nebula is one of the most famous dark nebulae in the night sky. It is located in the constellation Orion, near the bright star Alnitak, the easternmost star in Orion's Belt. The nebula gets its name because its dark cloud of dust resembles the shape of a horse's head. The Horsehead Nebula is approximately 1,300 light-years away from Earth and is part of the much larger Orion Molecular Cloud Complex, one of the closest and most active star-forming regions in our Galaxy. It was first discovered in 1888 by the Scottish astronomer Williamina Fleming while examining photographic plates taken at the Harvard College Observatory.The nebula itself is made of cold gas and dense interstellar dust. It appears dark because the dust blocks the light coming from the bright emission nebula IC 434, which lies behind it. The reddish glow seen around the Horsehead Nebula is produced by ionized hydrogen gas excited by the intense ultraviolet radiation from nearby massive stars. The Horsehead Nebula is about 3.5 light-years across. Inside the nebula, new stars are forming as gravity causes clouds of gas and dust to collapse. Astronomers study this region to better understand the processes of star formation and the evolution of molecular clouds.

The shape of the Horsehead Nebula is constantly changing. Strong ultraviolet radiation and stellar winds from nearby hot stars slowly erode the cloud. Scientists estimate that the Horsehead Nebula may eventually disappear over the next few million years. Today, the Horsehead Nebula is one of the most photographed deep-sky objects. It has been observed by many powerful telescopes, including the Hubble Space Telescope and the James Webb Space Telescope, which have revealed its intricate structure and the newborn stars hidden within its dusty clouds.

Horsehead Nebula

Conclusion

The Milky Way Galaxy is our cosmic home and one of the most fascinating structures in the Universe. It is a vast barred spiral galaxy consisting of a central bulge, a rotating disk with spiral arms, a surrounding halo, and a massive dark matter halo. It contains 200–400 billion stars, including our Sun, as well as planets, nebulae, gas, dust, star clusters, and a supermassive black hole at its center. The Milky Way has a diameter of about 100,000 light-years and is approximately 13.6 billion years old. Our Solar System is located in the Orion Arm and orbits the Galactic Center at a speed of about 220–250 km/s, completing one revolution in approximately 230 million years. The study of the Milky Way helps astronomers understand the formation, structure, evolution, and future of galaxies. It also provides valuable information about the origin of stars, planetary systems, and the Universe itself. Scientists continue to investigate many mysteries of our Galaxy, including the nature of dark matter, the activity of the supermassive black hole Sagittarius A*, and the predicted collision between the Milky Way and the Andromeda Galaxy in about 4.5 billion years. In

conclusion, the Milky Way is not only the home of our Solar System but also a unique laboratory for exploring the Universe. Ongoing observations and scientific discoveries continue to deepen our understanding of the cosmos and humanity's place within it.

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