# Astronomy Glossary

This glossary provides a listing of some words and terms that you might hear in your night viewing session and that might be unfamiliar. Some of them refer to the sky itself, while others are more connected to the objects in the sky, their properties and the physics underlying them.

1. **Aperture** - This is the diameter of a telescope or camera. The larger the aperture, the more light is able to fall into the device. While camera lenses generally have adjustable apertures (the aperture is characterized by the f-number and is adjusted using a set up baffles inside the lens), telescopes have a fixed aperture. It can only be adjusted by placing some sort of mask or screen over the opening of the telescope. This is sometimes done, for example, if an astronomical telescope is going to be used to view the Sun, in which case and appropriate solar filter must also be used to avoid damaging the instrument or, much more importantly, the eyes of anyone viewing with the setup. In astronomy, larger apertures are generally considered desirable because astronomical objects, being so faint, usually must have their light amplified by a large amount in order to be seen. This light amplification is by far the most important function of an astronomical telescope. Contrast this with terrestrial telescopes and binoculars (two telescopes mounted side-by-side), the main purpose of which is often to magnify distant, but fairly bright, objects.

2. **Asterism** - An unofficial, or informal, group of stars. Examples are the Big Dipper, the Little Dipper, the Summer Triangle, etc.

3. **Atom** - An atom is the smallest unit of a chemical element. There are 92 naturally occurring kinds of atoms that in combination comprise all the materials we see around us. Atoms consist of a small massive nucleus surrounded by a diffuse cloud of electrons. The nucleus contains the heavy particles, protons and neutrons (collectively called baryons or nucleons), while the electrons are arrayed in orbitals surrounding the nucleus. Hydrogen is the simplest and lightest kind of atom, uranium is the heaviest. Most atoms come in various forms that are distinguished by having different numbers of neutrons in their nucleus; these different forms are called isotopes. Isotopes of a given atomic species differ only in the number of neutrons: the numbers of protons and electrons are always the same for a given kind of atom. What distinguishes different kinds of atoms from each other (hydrogen from helium from oxygen from silicon, for example) is the number of protons in the nucleus, and hence the number of electrons in the atom. These two must be the

same to give the atom overall electrical neutrality. It is the number of electrons, and specifically the outer electrons called valence electrons, that determines the chemistry of the atom. And of course, chemistry is how atoms were originally classified, before their underlying structure and composition were understood.

4. **Big Bang** - The term “big bang” refers to the current cosmological theory of the formation and evolution of the universe. It posits that approximately 14 billion years ago, an event termed the “big bang” happened that created the space, time and matter/energy, i.e., the universe, that we see around us today. The theory explains the structures and materials that we see in the universe, and it explains the timeline of formation and change of these structures and materials and how they will continue to change going into the future. The theory specifically does not address what came “before” the big bang, or even if the phrase “before the big bang” even has any meaning. It also does not address what is “outside” of the universe, or if that concept has any meaning. Future expansions of the theory necessitated by new observations or new understandings in physics might address these ideas, but in its current form it does not.

5. **CCD Camera -** A camera that uses a solid state detector called a CCD, or charge-couple device. These are quite similar to consumer digital cameras which use CMOS (complementary metal-oxide semiconductor) detectors, the main difference being the way the two types of devices read the light signal from the detector. CCD cameras are often cooled to diminish thermal noise (charge caused by thermal vibrations instead of light falling on the detector). They are almost always monochrome; color information is only obtained by placing different color filters in front of the camera aperture and taking separate images through a variety of filters. These are then combined into a color image using software to merge the separate images.

6. **Constellation** - Groups of stars in the sky that are used to delineate regions. There are 88 official constellations. Most of them, at least in the Northern Hemisphere, are based on ancient Greek mythology. Examples are Orion, Lyra, Gemini, etc.

7. **Cosmology** - Cosmology is the branch of astrophysics that is concerned with understanding the formation and evolution of the universe and its structures.

8. **Dark Matter** - This is the name given to the material, as yet undetected directly, that astronomers think comprises the vast majority of the matter in the universe. It is called dark matter after the German term, Dunkelmaterie, coined by the Swiss/American astronomer Fritz Zwicky in the 1930s. Zwicky found that galaxy clusters could not be gravitationally bound unless they contained much more matter than he

was able to see directly. Evidence for dark matter was bolstered in the 1970s and 1980s when scientists, most prominently Vera Rubin, found that the same was true for individual galaxies: their stars are moving too fast to be bound by the gravity of the visible matter alone, so extra matter is needed to hold them together. This proposed matter is invisible; it does not interact with light in any way. So maybe "invisible matter" would be a better name, but we seem to be stuck with dark matter. Note that dark matter is specifically not the dark clouds we see in the Milky Way and other galaxies. Those are dust, and they interact quite strongly with light: they block light, which is why we see them in silhouette against the bright stellar background of the galaxies in which they are located.

9. **Electromagnetic Spectrum** See Light.

10. **Electron** - Electrons are small subatomic particles and are the lightest of the three particles (the others being protons and neutrons) that collectively form atoms. Electrons have negative electric charge and are attracted to positively charged protons. Since both particles have the same amount of charge, just with opposite sign, atoms generally contain equal numbers of protons and electrons, though electrons can be removed under the right conditions. Such atoms are said to be ionized. Electrons are about 1800 times less massive than protons and neutrons.

11. **eV** - electron-volts. The energy gained by an electron (or a proton) when dropped through an electric potential difference of 1 volt. This is equivalent to $1.602 \times 10^{-19}$ J. The energy of visible light photons is around a couple eV.

12. **Galaxy** - A large collection of stars, gas, and often dust. There are several types of galaxy, and the Milky Way is an example of the spiral type. Galaxies are generally immensely far away, with the closest to ours being the Andromeda Galaxy, M31, which lies 2.5 million light years away. Large galaxies like ours contain upwards of 100 billion stars. The smallest galaxies are a few percent as massive as the Milky Way, while the largest exceed its mass by much more than ten times.

13. **Galaxy Cluster** - A gravitationally bound grouping of anywhere from several hundred to several thousand galaxies and galaxy groups. These are among the largest coherent structures we see in the universe.

14. **Galaxy Group** - A gravitationally bound group of typically a few dozen galaxies, often with one or two large members and many much smaller satellite galaxies of those. For example, the Milky Way and Andromeda form the Local Group of galaxies. These two dominate the group, and each of them has a dozen or so dwarf

galaxy companions. The vast majority of the galaxies we see in the universe are members of groups, and these groups are in turn members of much larger galaxy clusters.

15. **Globular Cluster** - A type of star cluster found in the oldest region of large galaxies, called the halo. Globular clusters contain anywhere from a few thousand to about a million individual stars. They are gravitationally bound systems that were formed early in the history of the universe, typically long before galactic disks formed in disk galaxies. Because of there very great age, more than 12 billion years, globular clusters contain almost exclusively low-mass, metal-poor stars. The exceptions are stars that have merged late in their evolution to form more massive stars with higher metal content.

16. **H-II -** hydrogen II (hydrogen-two) is a form of hydrogen gas in which the electron has been removed from the atom. Such gas is said to be ionized. HII is seen in many parts of the universe, specifically where high energy photons in the ultraviolet, x-ray or gamma-ray regimes are present. These photons carry enough energy to completely remove the electron from a neutral hydrogen atom, the threshold for which is $13.6\,\mathrm{eV}$. Neutral hydrogen, that still possesses its electron, is called H-I (H-one).

17. **Helium** - Helium is the second most common kind of atom in the universe. About ten of every hundred atoms is a helium atom. The most common kind of helium has a nucleus with two protons and two neutrons; this nucleus is sometimes called an $\alpha$ -particle (alpha particle). An isotope with only one neutron also exists and is stable, though it is extremely rare. Together with hydrogen, helium is one of the few kinds of atom to be formed in the big bang. Almost all other atoms are created in stars.

18. **Hydrogen** - Hydrogen is the most abundant kind of atom in the universe: 90% of all atoms are hydrogen atoms. It is also the simplest kind of atom, consisting, in its most common form, of a single proton (in the nucleus) and a single electron. Other forms (isotopes) of hydrogen also exist. One, with a nucleus comprised of one proton and one neutron, is called deuterium. About 1.5% of hydrogen atoms on Earth is deuterium, though its cosmic abundance is about a thousand times lower. Another isotope of hydrogen exists that has a proton and two neutrons in its nucleus. This form is called tritium and is radioactive with a half life of just over 12 years. It is sometimes used to illuminate the dials of wristwatches, or it used to be. Together with helium, hydrogen was one of the few atoms to be formed in the big bang. Almost all other kinds of atoms are created inside stars.

19. **Isotope** - Atoms of a given type can have different numbers of neutrons in their nucleus, while having the same number of protons. It is the number of protons that determine the type of atom: hydrogen has a single proton, helium has two, lithium three, and so on. Naturally occurring hydrogen can have either no neutrons or one neutron. Naturally occurring helium can have one neutron or two neutrons. This tendency continues for all atoms, and the different forms of a given atom that have different numbers of neutrons are called isotopes of that atom. Most atoms have several stable isotopes, and often many unstable ones.

20. **Kelvin** - Temperature scale used in physics and astrophysics. It differs from the Celsius temperature scale, commonly used in chemistry, by 273.16 degrees: $0^\circ\,\mathrm{C} = 273.16\,\mathrm{K}$. Kelvin are the SI unit of temperature - they are not degrees, though a change of $1\,\mathrm{K}$ is the same as a change of $1^\circ\,\mathrm{C}$. The temperature of the Sun is roughly $6{,}000\,\mathrm{K}$, and at these high temperatures, kelvin and Celsius temperatures are nearly the same. Fahrenheit temperatures are nearly twice as high, so the Sun has a Fahrenheit temperature of around $10{,}300^\circ\,\mathrm{F}$.

21. **Light** - Collectively, the electromagnetic spectrum. Light is distinguished by its wavelength (or frequency or energy). While we often think only of the visible part of the spectrum as light, in fact, light has many other forms that are invisible. These include, at the high energy end, gamma-rays, x-rays and ultraviolet. These all have higher frequency than visible light, shorter wavelength, and higher energy; in the case of x-rays and gamma-rays the energy is much, much higher. At the other end, from the low-energy end, there are radio waves, microwaves and infrared. All these forms of light are fundamentally the same, they differ only in their energy/frequency/wavelength. It is the difference in energy that causes different waves to interact radically differently with different forms of matter, and that make them seem like completely different phenomena.

22. **Metal** - The term “metal” has a very different meaning in astronomy than in other fields. In astronomy, metal refers to any atom heavier than helium. So hydrogen and helium are considered non-metals, whereas the other 90 elements are all called “metals.” This usage differs greatly from the way, say, chemists use the term. Ask me why astronomers do this; I’ll be happy to explain.

23. **Nebula** - Nebula is the latin word for “cloud” or “mist.” In astronomy this refers to a glowing region of gas or dust. This material can be caused to glow because it is hot and emitting light, or because it is adjacent to a bright object like a star and is reflecting some of its light. Examples of the former are HII regions like the Orion Nebula and planetary nebula like the Ring Nebula or the Dumbbell Nebula. Examples of reflection nebula are the faint glowing clouds around the Pleiades stars

and the faint blue cloud reflecting light from stars in the Trifid Nebula. There are also dark nebula, seen in relief against brighter background gas. Examples of these include the dark lanes that give the Trifid its name, and the Horsehead Nebula in Orion.

24. **Neutrino** - Neutrinos are a kind of subatomic particle that partakes in certain nuclear reactions involving the Weak interaction. Neutrinos have a very low probability of interacting and are able to pass through the entire Earth as if it wasn't there. Prodigious numbers of neutrinos are produced when stars go supernova. They are also produced by the fusion reactions that happen inside stars. Neutrinos have exceedingly low mass, about a billion times less mass than protons and neutrons.

25. **Neutron** - Neutrons are type of a subatomic particle that is found in atomic nuclei, along with the proton. Neutrons have no net electrical charge - they are neutral. They are needed inside the nucleus to increase its stability, as a nucleus comprised of protons alone would not be stable. When outside of an atomic nucleus, neutrons decay to an electron, a neutrino and a proton with a half-life of about 11 minutes. An exception to this is when neutrons are found in neutron stars, where they remain stable due to the gravity of the star. Neutrons, like protons, are about 1800 times more massive than electrons.

26. **Nucleosynthesis** - This is the process by which new atomic nuclei are created. There are two known sights for this to happen naturally. The first and by far most common site is in stars. High temperatures and densities in stellar cores allow nuclear reactions to fuse light elements into heavier ones, up to iron and nickel, at least for the most massive stars. To create heavier nuclei, processes of neutron capture outside the core, or during supernova explosions, are needed. The other site of nucleosynthesis occurred in the first few minutes after the big bang. At that time, the entire universe was hot enough and dense enough that nuclear reactions were able to convert about twenty percent of the matter (by mass) from hydrogen into helium. Some additional light elements, namely lithium, were also produced then. But the rapid expansion and resultant cooling halted this early era of nucleosynthesis before any heavier elements could be made. Nonetheless, most of the helium and lithium in the universe now was created at that time. This early epoch of nucleosynthesis gave us our current ratio of the matter in the universe being 90% hydrogen atoms, 10% helium atoms, and only trace amounts of heavier atoms that have been formed in stars since that time.

27. **Open Cluster** - A collection of youngish stars, recently emerged from the cloud in which they formed. These clusters, in contrast to globular clusters, are not

gravitationally bound and do not adhere to any particular shape. Over time they gradually disperse as they orbit the galaxy and their members diffuse out into interstellar space.

28. **Photon** - Photons are particles of light. High energy photons correspond to light with short wavelength/high frequency. Low energy photons correspond to light with long wavelength/low frequency.

29. **Planetary Nebula** - A cloud of ionized gas (plasma), the remnants of the ejected atmosphere of a star, surrounding the dead core of that star after it has exhausted its supply of core-hydrogen and has ceased nuclear fusion as a result. The remnants of the stellar core form a very small and dense object called a white dwarf. The white dwarf, being very hot, with a temperature around 100,000 kelvin, emits large amounts of ultraviolet light which ionizes the surrounding atmospheric gases, causing them to glow and forming the nebula we see.

30. **Plasma** - In the physics/astrophysics context, plasma refers to an ionized gas, i.e., a gas in which one or more electrons have been removed from the atoms. Stars are formed of plasma, and very low-density plasma fills the space between stars and galaxies. On Earth, plasma is rare. It occurs naturally, and briefly, in lightning strikes, for example. It can also occur in a few other places, in devices like fluorescent light bulbs and spark-type fire starters.

31. **Proton** - Protons are a kind of subatomic particle that is found in the nucleus of atoms, along with the neutrons. Protons have a positive electric charge; it is the same charge as is found on the electron, but with opposite sign. Thus atoms are formed when the positive protons attract negative electrons to form a neutral bound system; neutrons are required in the nucleus to increase its stability, else it would fall apart. Like neutrons, protons are roughly 1800 times more massive than electrons.

32. **Radioactivity** - Atoms are radioactive when the number of neutrons in their nucleus is either too low or too high. They are stable when the number of neutrons is just right to hold the nucleus together. One process of radioactive decay happens when one of the neutrons converts into a proton (plus an electron and neutrino), or when a proton captures an electron and converts to a neutron (and a neutrino). Which process occurs depends on whether the nucleus has too many or too few neutrons to be stable. This form of decay is referred to as $\beta$-decay (beta decay) because it always involves electrons, which historically were called $\beta$-rays. In very heavy atoms, like uranium, for example, the nucleus can eject a helium nucleus (also called an $\alpha$-particle, or alpha particle) in order to bring its ratio of protons to neutrons into

a stable configuration. Sometimes multiple emissions of $\alpha$-particles are required to reach a stable nucleus. Gamma rays - high energy photons - are also often emitted as a by product of radioactive decay.

33. **Solar Luminosity** - This refers to the total energy out put of the Sun, $4 \times 10^{26}$ W. A solar luminosity is represented by the symbol $L_\odot$, pronounced “L-sun.” This is also the unit to describe the brightness of other stars, of galaxies and of other astrophysical objects. So, for example, the brightest stars have luminosity around $10^6\,L_\odot$, a million solar luminosities. The dimmest stars, on the other hand, have energy output far less than a percent $L_\odot$. Galaxies have luminosities that typically range from a few hundred thousand $L_\odot$ to hundreds of billions of $L_\odot$. Quasars, the active nuclei of a certain class of galaxies, can also have luminosities in the hundreds of billion $L_\odot$ range.

34. **Solar Mass** - The mass of the Sun, $2 \times 10^{30}$ kg. This is the unit of mass used by astronomers to describe the masses of other stars and galaxies. It is given the symbol $M_\odot$ and called “M-sun.” The most massive stars currently found in the universe are about 50 or $60\,M_\odot$, though in the early universe stars well in excess of $100\,M_\odot$ existed. The smallest object that can be a star has a mass around $0.08\,M_\odot$. Smaller objects lack the mass to heat their cores to the point at which nuclear fusion begins, thus they are not considered to be stars. For comparison, Earth’s mass is about $6 \times 10^{24}$ kg, so it would take about 300,000 Earths to equal the mass of one $M_\odot$. The Milky Way galaxy, like other large galaxies, contains about a trillion solar masses, or about $10^{12}\,M_\odot$ worth of material. Most of that is dark matter.

35. **Star** - a self-gravitating ball of glowing plasma (ionized gas) supported by thermal pressure against gravitational collapse. Stars are the tiny points of light in the night sky.

36. **Stellar Class** - Stars are divided into seven different stellar classes, each designated by a letter. The classes, which came about historically, are called O, B, A, F, G, K and M. The hottest stars are O stars, followed by B and then so on to M, which are the coolest. The Sun is a G star. During the bulk of a star’s existence, when it is converting hydrogen into helium in its core, stellar class is also related to stellar mass, with O stars being most massive and M stars being least massive. As stars exhaust their core hydrogen and begin to burn heavier elements, first helium to

carbon, and then carbon to oxygen, neon, magnesium and so on, their atmospheres expand and cool, and their stellar class tends to evolve to K and M as a result. If you look carefully, you can notice that some stars are faintly red or orange. These are K or M stars. Other stars are bluish white. These are usually A stars, or occasionally O or B stars.  Stars that appear to be pale yellow are generally G stars. Sometimes you might even notice that a star has a greenish hue. That would be an F star.

37. **Twilight** - Twilight is the time between day and night during which the sky brightness changes continuously. It occurs in the evening and in the morning. There are three arbitrarily designated phases of twilight. The first is civil twilight. It happens when the Sun is between the horizon and six degrees below the horizon. The second phase is called nautical twilight. It happens when the Sun is between six degrees and twelve degrees below the horizon. The third phase of twilight is called astronomical twilight. This happens when the Sun is between twelve and eighteen degrees below the horizon. When the Sun is more than eighteen degrees below the horizon its rays do not light up any part of the visible sky, and so the sky maintains a constant brightness. During this time twilight does not pertain. The order in which these phases occur is opposite in evening and morning. At the end of evening nautical twilight most people will not notice the sky darkening anymore. However, sensitive instruments like cameras will easily notice the sky brightness continuing to change as the Sun moves between twelve and eighteen degrees.

38. **White Dwarf** - A white dwarf is the remnant core of a dead star. White dwarfs are formed when a low-mass star runs out of fuel for nuclear fusion in its core. The star blows away its outer layers, leaving the core exposed. White dwarfs are small, comparable in size to Earth, but they are very massive, with a mass comparable to the mass of the Sun. So they are very dense; a sugar-cube size piece of white dwarf has a mass of several tons. They are also very hot, with temperatures around 100,000 kelvin. The Sun will evolve into a white dwarf when it runs out of nuclear fuel in about four billion years.