Stellar Classifications – Star and Planets

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A note to the reader/user of this article: however this article is drawn from official sources and lecture, using official classifications as used by NASA and others a base to start, this article is for internal use only since some things are modified/left out to suit our specific needs.

Should you have any questions concerning this article and the things in it feel free to ask or leave a message, however I cannot guarantee that I will know the answer to every question you might have, I will do my best to answer them.

In Astronomy, stellar classification is a classification of stars based initially on photospheric temperature and its associated spectral characteristics, and subsequently refined in terms of other characteristics. Stellar spectroscopy offers a way to classify stars according to their absorption lines, these lines can only be observed for a certain range of temperatures because only in that range are the involved atomic energy levels populated.

During the 1860s and 1870s, pioneering stellar spectroscopist Father Angelo Secchi created the **Secchi classes** in order to classify observed spectra. By 1868, he had developed four classes of stars:
Class I: white and blue stars with broad heavy hydrogen lines (modern class A)
Class II: yellow stars—hydrogen less strong, but evident metallic lines (modern classes G and K)
Class III: orange to red stars with complex band spectra (modern class M)
Class IV: red stars with significant carbon bands and lines also known as carbon stars, which are not mentioned in this article.

In 1878, he added a fifth class and in the late 1890s, this classification was superseded by the Harvard classification, which is the based for modern day classifications and will be used in the official charts as well, however the older Secchi classifications will probably used in the sims since they are easier in use thanks to the less accurate description.

Harvard one-dimensional (temperature) classification scheme (based on hydrogen Balmer line strengths) was developed at Harvard College Observatory in about 1912 by Annie Jump Cannon and Edward C. Pickering. The common classes are normally listed from hottest to coldest (with mass, radius and luminosity compared to the Sun) and are given in the following table:

Class	Temperature	Conventional color	Apparent color	Mass (solar masses)	Radius (solar radii)	Luminosity	Hydrogen lines	% of all Main Sequence Stars
O	30,000–60,000 K	blue	blue	64 $M_?$	16 $R_?$	1,400,000 $L_?$	Weak	~0.00003%
B	10,000–30,000 K	blue to blue white	blue white	18 $M_?$	7 $R_?$	20,000 $L_?$	Medium	0.13%
A	7,500–10,000 K	white	white	3.1 $M_?$	2.1 $R_?$	40 $L_?$	Strong	0.6%
F	6,000–7,500 K	yellowish white	white	1.7 $M_?$	1.4 $R_?$	6 $L_?$	Medium	3%
G	5,000–6,000 K	yellow	yellowish white	1.1 $M_?$	1.1 $R_?$	1.2 $L_?$	Weak	7.6%
K	3,500–5,000 K	orange	yellow orange	0.8 $M_?$	0.9 $R_?$	0.4 $L_?$	Very weak	12.1%
M	2,000–3,500 K	red	orange red	0.4 $M_?$	0.5 $R_?$	0.04 $L_?$	Very weak	76.45%

The mass, radius, and luminosity listed for each class are appropriate only for stars on the main sequence portion of their lives and so are not appropriate for red giants.

The reason for the odd arrangement of letters is historical. When people first started taking spectra of stars, they noticed that stars had very different hydrogen spectral lines strengths, and so they classified stars based on the strength of the hydrogen Balmer series lines from A (strongest) to Q (weakest). Other lines of neutral and ionized species then came into play (H and K lines of calcium, sodium D lines, etc). Later it was found that some of the classes were actually duplicates and those classes were removed. It was only much later that it was discovered that the strength of the hydrogen line was connected with the surface temperature of the star.

Spectral classes are further subdivided by Arabic numerals (0–9). For example, A0 denotes the hottest stars in the A class and A9 denotes the coolest ones. Because the classification sequence predates our understanding that it is a temperature sequence, the precise values of these digits depend upon (largely subjective) estimates of the strengths of absorption features in stellar spectra. As a result, the subclasses are not evenly divided into any sort of mathematically representable intervals. The Sun is classified as G2.

Class O

Class **O** stars are very hot and very luminous, being bluish in color; in fact, most of their output is in the ultraviolet range. These are the rarest of all main sequence stars, constituting as few as 1 in 3,000,000 in the solar neighbourhood *(Note: these proportions are fractions of stars brighter than absolute magnitude 16; lowering this limit will render earlier types even rarer while generally adding only to the M class).* O-stars shine with a power over a million times our Sun's output. These stars have dominant lines of absorption and sometimes emission for He II lines, prominent ionized (Si IV, O III, N III, and C III) and neutral helium lines, strengthening from O5 to O9, and prominent hydrogen Balmer lines, although not as strong as in later types. Because they are so huge, class O stars burn through their hydrogen fuel very quickly, and are the first stars to leave the main sequence. Recent observations by the Spitzer Space Telescope indicate that planetary formation does not occur around other stars in the vicinity of an O class star due to the photoevaporation effect.

Class B

Class **B** stars are extremely luminous and blue. Their spectra have neutral helium, which are most prominent at the B2 subclass, and moderate hydrogen lines. Ionized metal lines include Mg II and Si II. As O and B stars are so powerful, they only live for a very short time, and thus they do not stray far from the area in which they were formed. These stars tend to cluster together in what are called OB associations, which are associated with giant molecular clouds. The Orion OB1 association occupies a large portion of a spiral arm of our galaxy and contains many of the brighter stars of the constellation Orion. They constitute about 1 in 800 main sequence stars in the solar neighbourhood - rare, but much more common than those of class O.

Class A
Class **A** stars are amongst the more common naked eye stars, and are white or bluish-white. They have strong hydrogen lines, at a maximum by A0, and also lines of ionized metals (Fe II, Mg II, Si II) at a maximum at A5. The presence of Ca II lines is notably strengthening by this point. They comprise about 1 in 160 of the main sequence stars in the solar neighbourhood.

Class F
Class **F** stars have strengthening *H* and *K* lines of Ca II. Neutral metals (Fe I, Cr I) beginning to gain on ionized metal lines by late F. Their spectra are characterized by the weaker hydrogen lines and ionized metals. Their color is white with a slight tinge of yellow. These represent about 1 in 33 of the main sequence stars in the solar neighbourhood

Class G
Class **G** stars are probably the best known, if only for the reason that our Sun is of this class. Most notable are the *H* and *K* lines of Ca II, which are most prominent at G2. They have even weaker hydrogen lines than F, but along with the ionized metals, they have neutral metals. There is a prominent spike in the G band of CH molecules. G is host to the "Yellow Evolutionary Void". Supergiant stars often swing between O or B (blue) and K or M (red). While they do this, they do not stay for long in the G classification as this is an extremely unstable place for a supergiant to be. G stars represent about 1 in 13 of the main sequence stars in the solar neighbourhood.

Class K
Class **K** are orangish stars which are slightly cooler than our Sun. Some K stars are giants and supergiants, such as Arcturus, while others, like Alpha Centauri B, are main sequence stars. They have extremely weak hydrogen lines, if they are present at all, and mostly neutral metals (Mn I, Fe I, Si I). By late K, molecular bands of titanium oxide become present. These make up 1 in 8 of the main sequence stars in the solar neighbourhood.

Class M
Class **M** is by far the most common class. About 76% of the main sequence stars in the solar neighbourhood are red dwarfs (78.6% if we include all stars: see the note under Class O), such as Proxima Centauri. M is also host to most giants and some supergiants such as Antares and Betelgeuse, as well as Mira variables. The late-M group holds hotter brown dwarfs that are above the L spectrum. This is usually in the range of M6.5 to M9.5. The spectrum of an M star shows lines belonging to molecules and all neutral metals but hydrogen lines are usually absent. Titanium oxide can be strong in M stars, usually dominating by about M5. Vanadium oxide bands become present by late M.

This classification has been modified and additions have been made as more types of stars where discovered, the most common used classification will be listed below:

Cool red and brown dwarf classes
The novel spectral types L and T were created to classify infrared spectra of cool stars and brown dwarfs which were very faint in the visual spectrum. The hypothetical spectral type Y has been reserved for objects cooler than T dwarfs having spectra which are qualitatively distinct from T dwarfs.

Class L
Class **L** dwarfs get their designation because they are cooler than M stars and **L** is the remaining letter alphabetically closest to **M**. **L** does not mean lithium dwarf; a large fraction of these stars do not have lithium in their spectra. Some of these objects have mass large enough to support hydrogen fusion, but some are of substellar mass and do not, so collectively these objects should be referred to as *L dwarfs*, not *L stars*. They are a very dark red in color and brightest in infrared. Their atmosphere is cool enough to allow metal hydrides and alkali metals to be prominent in their spectra. Due to low gravities in giant stars, TiO- and VO-bearing condensates never form. Thus, larger L-type stars can never form in an isolated environment.

Class T: methane dwarfs
Class **T** dwarfs are cool brown dwarfs with surface temperatures of between ~1500 and 700K. Their emission peaks in the infrared. Methane is prominent in their spectra. Class T and L could be more common than all the other classes combined if recent research is accurate. From studying the number of proplyds (protoplanetary discs, clumps of gas in nebulae from which stars and solar systems are formed) then the number of stars in the galaxy should be several orders of magnitude higher than what we know about. It is theorized that these proplyds are in a race with each other. The first one to form will become a proto-star, which are very violent objects and will disrupt other proplyds in the vicinity, stripping them of their gas. The victim proplyds will then probably go on to become main sequence stars or brown dwarf stars of the L and T classes, but quite invisible to us. Since they live so long, these smaller stars will accumulate over time.

Class Y
Class **Y** dwarfs are expected to be much cooler than T-dwarfs. They have been modelled, though there is no well-defined spectral sequence yet with prototypes. In March 2008, a 620 kelvin brown dwarf named CFBDS J005910.90-011401.3 was discovered, displaying wide ammonia absorption in the near-infrared. It is believed to be the first prototype of a Y0 dwarf.

White dwarf classifications
The class **D** is the modern classification used for white dwarfs, low-mass stars that are no longer undergoing nuclear fusion and have shrunk to planetary size, slowly cooling down. Class D is further divided into spectral types DA, DB, DC, DO, DQ, DX, and DZ. The letters are not related to the letters used in the classification of other stars, but instead indicate the composition of the white dwarf's visible outer layer or atmosphere.

The white dwarf types are as follows:
DA: a hydrogen-rich atmosphere or outer layer, indicated by strong Balmer hydrogen spectral lines.
DB: a helium-rich atmosphere, indicated by neutral helium, He I, spectral lines.
DO: a helium-rich atmosphere, indicated by ionized helium, He II, spectral lines.
DQ: a carbon-rich atmosphere, indicated by atomic or molecular carbon lines.
DZ: a metal-rich atmosphere, indicated by metal spectral lines.
DC: no strong spectral lines indicating one of the above categories.
DX: spectral lines are insufficiently clear to classify into one of the above categories.

Two or more of the type letters may be used to indicate a white dwarf which displays more than one of the spectral features above. Also, the letter **V** is used to indicate a variable white dwarf.

Extended white dwarf spectral types:
DAB: a hydrogen- and helium-rich white dwarf displaying neutral helium lines.
DAO: a hydrogen- and helium-rich white dwarf displaying ionized helium lines.
DAZ: a hydrogen-rich metallic white dwarf.
DBZ: a helium-rich metallic white dwarf.

Non-stellar spectral types: Class P & Q
Finally, the classes **P** and **Q** are occasionally used for certain non-stellar objects. Type **P** objects are planetary nebulae and type **Q** objects are novae and nebula's.

Most of these classification can be extended even further but this doesn't contribute to the overall usability of these classification therefore they are included in this article, however when used the describe particular phenomena they will be explained if needed.

With this listing ofthe stellar classifications of stars finished, that what is left is the classification of planets in to their respective classes. Again I would like to emphasize that however based on scientific facts this classification on planets is more fiction than fact. The Star classification in this article are mainly scientific, the planetary classification however are initially developed by Gene Roddenberry, added with scientific facts.

Class D
Class **D** objects are planetoids like asteroids and some moons. The planet Regula, the site of the *Genesis* experiment in *Star Trek II: The Wrath of Khan*, was a Class D planetoid. The USS *Voyager* also encountered a Class D planet in the Delta Quadrant in the *Star Trek: Voyager* episode "Gravity".

Class H
Class **H** planets appear in the series as harsh desert worlds. The planet Tau Cygna V visited by the USS *Enterprise-D* in the *Star Trek: The Next Generation* episode "The Ensigns of Command" was designated as a Class H world.

Class J and Class T
Class **J** and Class **T** planets are designated gas giants. Class J are smaller than Class T which are considered "super", or "ultra", gas giants — possibly even brown dwarfs on

the verge of becoming stars. Jupiter and Saturn would fall under Class J-sized gas giant planets. In the *Star Trek: Deep Space Nine* episode "Starship Down", the USS *Defiant* entered the atmosphere of a Class J gas giant to rescue the crew of a Karemman ship attacked by the Jem'Hadar. The USS *Voyager* encountered a Class T Super-Giant in the Delta Quadrant with "radiogenic" rings in the Voyager episode "Good Shepherd".

Class K

Class **K** planets are barren worlds with no native life. However, through terraforming, they can be made into Class M worlds (see below). In the original *Star Trek* series episode "I, Mudd", the planet Mudd was designated in dialog as Class K.

Class L

Class **L** planets are barely habitable worlds with primitive ecosystems. In the Next Generation episode "The Chase", the planet Indri VIII was indicated in dialog as Class L. In the Voyager episode "The 37s", the planet on which Amelia Earhart and others were stranded was described as an Class L planet with an oxygen-argon atmosphere. In another Voyager episode "Muse", the planet on which B'Elanna Torres' shuttle crash lands is described as a Class L planet, which also supports bronze age humanoid life.

Class M (Minshara-Class)

Class **M**, or "Terrestrial", planets are the most commonly visited planets in the *Star Trek* series.They have atmospheres comprised of nitrogen and oxygen but most importantly, they have plenty of liquid water necessary for carbon-based life to exist. Life is almost always present and is often flourishing as extensive plant and animal life. Usually, a sentient race is also present. Earth is a textbook example of a Class M world. Other worlds in the series are mentioned as being Class M planets, such as Vulcan, Cardassia Prime, Risa (initially seen in the Next Generation episode "Captain's Holiday"), Bajor, Betazed, Romulus, and Qo'noS.

Class N

Class **N** planets have a reducing environment and are barren and rocky with extremely high surface temperatures caused by thick atmospheres containing carbon dioxide and corrosive sulfides. In this case, Venus could be considered Class N as it has a reducing (corrosive) atmosphere. In the Next Generation episode "Night Terrors", Class N environments were mentioned as the ideal places to use non-oxidizing explosives. However the MS-DOS game *Star Trek: The Next Generation - A Final Unity*, mentions that Class N planets are more related to Class M, with the key difference being a higher ratio of water to land. Tholian's are said to have come from this class of planets, and in Star Trek: The Lost Era book *The Sundred*, they board The USS Excelsior in N-Class environmental suits, and Captain Sulu goes to their flagship in a specially modified suit to duel.

Class Y

Class **Y** planets are referred to as "Demon" worlds, where surface conditions do not fall into any other recognized category. Such worlds are usually hostile and lethal to humanoid life. If life develops on these worlds they usually take on many bizarre forms, like living crystal or rock, liquid or gaseous physical states, or incorporeal, dimensional, or energy-based states. In the series, examples of Class Y "Demon" planets include, Tholia, the "Silver Blood" planet discovered by the USS *Voyager* in the Delta Quadrant in the episode "Demon" and later mentioned in "Course: Oblivion", and the home world of the incorporeal Medusans.

Other classes

Other planetary classes exist that are designated by all the letters of the alphabet from A to Z (with the exceptions of U, V, and W, which are not used). These other letter designations are considered semi-canon to the series.

Class A, B and C – Typically small, young planets whose class depends on their age and solidity of their cores.
Class E, F and G – Typically, Proto-Earth-sized planets whose class depends on their age and solidity of their cores.
Class I – Class of gas giant, larger than Class J, and smaller than Class S and T.
Class O and P – Planets covered almost completely with water (class O), or water-ice (Class P).
Class Q – Planets with continually changing environments caused by peculiar orbits, an orbit around a variable output star, or some other factor which causes conditions to drastically change overtime.
Class R – A rogue planetary body which is one that does not orbit a star but drifts freely in space.
Class S – Class of gas giant smaller than Class T and the next larger size up from Class I.
Class X and Z – Reserved for other designations of "demon" planets.