The Digital Universe Definitions

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1.3 Computer Terminology

gadget
hypertext
radio button

1.4 Aberration

Imagine a rainstorm without wind, so that the drops are falling straight down. If you drive a car in such a rainstorm, you will notice that the drops hit the front windshield much more frequently than the back window. This is because the combination of your horizontal velocity with the rain's vertical motion makes the rain (from your point of view in the moving car) seem to fall at an angle, hitting the windshield.

The same phenomenon is experienced with starlight. If light were to travel towards us from straight overhead, the Earth's motion in its orbit about the Sun would make the object appear slightly ahead of its true position. Since light is travelling extremely quickly as compared to the Earth (299,792.458 km/sec vs. 29.7859 km/sec), the effect is much smaller than that of the rainstorm, but it is nonetheless detectable.

Since the Earth's direction of motion changes throughout its orbit about the Sun, aberration makes the position of stars appear to trace out small ellipses throughout the course of the year.

There are several different categories of aberration:

```
 1.  annual aberration    - Aberration caused by the motion of the Earth
                            around the Sun.
 2.  diurnal aberration   - Aberration caused by the motion of an observer
                            around the centre of the Earth, due to the Earth's
                            rotation
 3.  secular aberration   - Aberration caused by the movement of the solar
                            system through the universe.
 4.  stellar aberration   - The apparent displacement of an object due to
                            the cumulative effects of annual, diurnal, and
                            secular aberration.
 5.  planetary aberration - The apparent displacement of an object due to
                            stellar aberration and the object's motion.
                            Since light takes a finite amount of time to
                            travel, we really see the object in the position
                            it was in when the light left it.  This latter
                            correction is usually called the correction for
                            light travel time.
```

If you request "The Digital Universe" to include the effects of aberration in its calculations (from the Display Prefs Window), it will use the planetary aberration model, taking into account all effects.

1.5 Absolute Zero

As an object gets colder, its atoms move more and more slowly. Eventually, they stop moving altogether. At this point, the atoms cannot move any slower, and as a result it is impossible to get any colder. The temperature associated with the state is -273 degrees C, or 0 Kelvin.

1.6 Æther

Aristotle believed that all things in the sky were composed of this "element", unlike the four earthly elements of fire, air, water, and earth. Æther is derived from the Greek word 'aither', meaning 'blazing'.

1.7 Albedo

Albedo is a measure of the reflectivity of a surface. An albedo of 0 means that the surface absorbs all light (and appears completely black), while an albedo of 1 means that the surface reflects all light.

1.8 Altitude

The word "altitude" has two meanings in astronomy:

1. In the Horizon Coordinate System, the altitude is the angular distance of an object above or below the horizon. If the object is above the horizon, its altitude is specified as a positive number. If it is below the horizon, the altitude is a negative number.

2. Altitude can also be the height of an observer above sea level.

See also: azimuth.

1.9 Analemma

Due to the fact that the Earth's orbit is not entirely circular, it is sometimes slightly nearer to the Sun than at other times. According to Kepler's laws of planetary motion, when it is closer to the Sun it should move faster than when it is further. However, the rotation of the Earth stays more or less constant. The result is that the Sun does not appear at exactly the same position of the sky at the same time every day (disregarding its motion north and south due to the seasons).

For example, if we were to take a picture straight south at noon for every day of the year, we would find that the seasonal position of the Sun would make it appear to move up and down throughout our progression of pictures. However, it would also move slightly east and west due to the Earth's changing velocity in its orbit. The resulting two motions would combine to make a figure-8 pattern in the sky, known as an analemma.

If you get "The Digital Universe" to make an animation looking due south for a year you will be able to see the Sun tracing out an analemma.

See also: Equation of Time.

1.10 Annual

Annual means something which takes place either once a year, or over the course of a year. For example, a star's annual motion is the amount that the star moved in a year.

See also: diurnal

1.11 Angstrom

An Angstrom is a unit of distance equivalent to 1/10,000,000,000 of a meter. This extremely short measurement is commonly used in specifying wavelengths of light.

The unit derives its name from Anders Jonas Ångström, a Swedish physicist who made many important discoveries of light.

An angstrom is often denoted by the symbol 'Å'.

1.12 Apparent Position

The apparent position is the place on the celestial sphere where an object appears to be, as opposed to where it truly is. Effects such as refraction, aberration, nutation, precession, and parallax must be considered in determining an object's apparent position.

1.13 Aphelion

The aphelion is the furthest point from the Sun in an object's orbit around it.

See also: perihelion, perigee, apogee

1.14 Apogee

The apogee is the furthest point from the Earth in an object's orbit around it.

See also: perigee, perihelion, aphelion

1.15 Areographic

Of, or having to do with Mars. Areographic coordinates on Mars are the latitude and longitude equivalents of Earth's geographic coordinates.

1.16 Asterism

An asterism is a pattern of stars. It differs from a constellation in that asterisms are usually smaller, and make up part of a constellation.

1.17 Asteroid

An asteroid, or minor planet, is any of thousands of small rocky bodies orbiting within the solar system. They are typically smaller than a few hundred kilometres in diameter.

If such an object is orbiting a planet instead of the Sun, the object is termed a satellite, or moon of the planet, and not an asteroid.

There is currently no strict definition classifying an object as a planet, satellite, asteroid, comet, or meteoroid. As a result, sometimes an object's designation is subject to debate.

In general, objects are classified according to the following scheme:

```
 Asteroid  - Rock in orbit about the Sun
 Meteoroid - Asteroid on a collision course with the Earth
 Meteor    - Meteoroid which has entered the Earth's atmosphere
 Meteorite - Portion of a meteor which has survived its descent to the
             surface of the Earth.
```

For more information, see the descriptive chapter on Asteroids.

1.18 Astronomical Unit

One Astronomical Unit is defined as the radius of a circular orbit in which a body of negligible mass would revolve around the Sun in 2*Pi/k days where k is the Gaussian gravitation constant of 0.01720209895. At 149,597,870 km it is just slightly less than the average distance of the Earth from the Sun (149,598,023 km).

1.19 Autumnal Equinox

The autumnal equinox is the intersection of the ecliptic and the celestial equator that the Sun passes on its way south.

See also: vernal equinox, Motion of the Sun

1.20 Azimuth

When specifying the position of an object with the Horizon Coordinate System, the azimuth is the angular distance measured clockwise along the horizon from due north to the point on the horizon directly below the object.

See also: altitude.

1.21 Bayer designation

In 1603, Johann Bayer published one of the first star atlases. In it, he devised a method of identifying stars by Greek letters. This "Bayer designation" became very popular and is still in wide use today.

Bayer assigned a letter of the Greek alphabet to the brightest stars in each constellation. Usually, he lettered the stars in order of increasing brightness, with "alpha" being the brightest star. However, this rule was not always strictly followed. For example, the stars forming the "Big Dipper" (part of the constellation of "Ursa Major") are lettered in order around the bowl and handle.

The complete Bayer designation of a star consists of the Greek letter followed by the "genitive" form of the constellation name. Thus, the brightest star in the constellation of Ursa Minor (the "Little Dipper") has a Bayer designation of "Alpha Ursae Minoris", while the second brightest is "Beta Ursae Minoris", and so on.

When astronomers began to study these stars in greater detail with telescopes, they found that some actually consisted of two or more stars extremely close together. The components were then differentiated by numbers following the Greek letter (in superscript). Thus, stars designated "Theta1 Orionis" and "Theta2 Orionis" became known.

As fainter stars became catalogued, the Greek alphabet of 24 letters soon became insufficient. Astronomers then used a different system known as Flamsteed numbers to designate stars.

1.22 Belt

A belt is a dark band in the clouds on giant planets such as Jupiter.

See also: zone

1.23 Binary Star

A binary, or double star is a system in which two stars orbit one another. In an eclipsing binary, one star periodically goes behind the other, causing the amount of light we see to fluctuate.

There can be more than two stars orbiting each other. Such cases are called "multiple" star systems.

Sometimes stars appear to lie in approximately the same direction but are located at different distances from the observer. In such cases, they are not truly associated with one another and are considered "optical doubles".

See also: Variable stars.

1.24 Black Hole

If a star is more than 40 times the mass of our Sun while on the main sequence, it will undergo a supernova explosion when it runs out of nuclear fuel. If the remnant still has a mass more than 3.2 times that of our Sun, its gravitational field will be so strong that even neutrons in physical contact with each other will not be able to resist further collapse. The object will compress down to a mathematical point of no volume whatsoever.

As one approaches a black hole, the escape velocity becomes greater and greater. Eventually, the escape velocity becomes greater than the velocity of light (at a distance known as the "event horizon" or "Schwarzchild radius"). Even light cannot escape from the intense gravitational field. If an object passes beyond the event horizon, it can be considered to have effectively left our universe, since it can never return. The Schwarzchild radius of a black hole can be approximated by:

r=3*M

where M is the mass of the black hole in solar masses, and r is the radius in kilometres.

So if even light cannot escape a black hole, how do we know it is there? There are two methods which are currently used:

1. We sometimes find a star which appears to be orbiting an unseen companion. Through the use of Kepler's 3rd law, we can measure the orbital period and determine the sum of the masses. By making an appropriate guess as to the mass of the visible star, we can determine the mass of its companion - and from this, deduce whether the object is a black hole.

2. In binary star systems, we sometimes see a lot of X-rays emitted. It is thought that these X-rays can be produced by matter being pulled off the surface of the visible companion. As it approaches the black hole, it forms an "accretion disk" and heats up so that it produces a wide spectrum of electromagnetic radiation. To make rapidly varying X-rays (as are observed), the unseen companion must be small and massive - the ideal candidate for a black hole.

Scientists believe that they have detected black holes in a number of galaxies. In addition, studies of the star known as SAO 69181 (among others) have seemed to indicate good evidence for a black hole within our own galaxy.

See also: white dwarf, neutron star, Stellar Remnants, Stephen Hawking.

1.25 Blink Comparator

A blink comparator is a special device which helps astronomers find differences between two photographic plates. While looking through a microscope-like optical system, a person's view is changed quickly back and forth between the two plates. If the plates are aligned so that the same portion of the sky is visible through the instrument, the observer periodically sees the region of sky as it appears on one plate, and then the other.

If the plates are exposed at different times and an object moves or changes brightness between exposures, it will appear to "blink" on and off as the two images are alternated. Thus, it is easy to distinguish such an object against a field of stars.

Blink comparators have been successfully used to detect asteroids and comets. Perhaps the most famous example of use for a blink comparator was when Clyde Tombaugh used the device to discover Pluto.

1.26 Celestial Equator

The celestial equator is the imaginary great circle that lies above the Earth's equator on the celestial sphere. It defines the 0 degree line of declination.

See also: Reference Markers, celestial poles.

1.27 Celestial Poles

The celestial poles are the points in the sky where the Earth's axis, extended into space, intersects with the celestial sphere. The star Polaris happens to currently lie near the north celestial pole.

See also: Reference Markers, celestial equator.

1.28 Celestial Sphere

The celestial sphere is the imaginary sphere surrounding the Earth, to which the stars, planets, and other astronomical objects are attached.

1.29 Centaurs

Centaurs are a class of cometary objects orbiting between Jupiter and Neptune. They are believed to have originated from the Kuiper Belt.

Currently, only 4 centaurs are known - 2060 Chiron, 5145 Pholus, 1993 HA 2, and 1994 TA.

1.30 Chromosphere

This is a level of the solar atmosphere immediately above the Photosphere, and extending about 2500 km. At approximately 500 km above the Photosphere, the temperature is only 3000-3500 degrees C. However for some reason not yet fully understood, the temperature then rapidly increases to 1,000,000 degrees C at its outer reaches. It is felt that the heating is due partially to a dramatic density decrease (the density can be a low as 100 trillion times less dense than that of water), as well as mechanical energy added to the Chromosphere from the Convection Zone. Granulation can overshoot hundreds of kilometers into the Chromosphere. Due to the decreased density, higher particle velocities are possible, resulting in a higher energy.

For more information, see The Sun - Structure and Nuclear Processes.

1.31 Globular Cluster

A globular cluster is a roughly spherical grouping of stars of common origin, held together by their own gravity. It is found that globular clusters within the Milky Way occur in a more or less spherical region, the center of which is the same as that of the Milky Way. Other galaxies often have their own collection of globular clusters.

Compared with one another, globulars are nearly identical in appearance, except for brightness and size. Usually, at least 100,000 stars belong to a globular cluster.

Globular clusters usually consist of ancient stars, with ages of the order of ten billion years typically being observed.

The nearest globular cluster is the Omega Centauri cluster, while the most spectacular in the northern hemisphere is M13.

See also: Cluster, Open Cluster.

1.32 Open Cluster

An open cluster is an irregular, usually loose grouping of stars of common origin, held together by their own gravity. They are thought to be much younger than Globular Clusters.

Open clusters are sometimes called "galactic clusters".

See also: Cluster

1.33 Comet

A comet is an object in our solar system between 100 metres and 100 km in diameter, composed of dust and ice. Many astronomers believe it to resemble a "dirty snowball". A typical comet travels through the solar system in a highly elliptical orbit, at a random inclination to the ecliptic. When a comet approaches the Sun, it grows a "tail" of dust and gas.

There is currently no strict definition classifying an object as a planet, satellite, asteroid, comet, or meteoroid. As a result, sometimes an object’s designation is subject to debate.

For more information, see the descriptive chapter on Comets.

1.34 Conjunction

Conjunction is the alignment of two bodies so that they appear to be at their closest approach to one another, as viewed from the Earth. If astronomers speak of the conjunction of a single body, the second object is assumed to be the Sun.

See also: conjunction, inferior, conjunction, superior, opposition

1.35 Inferior Conjunction

Inferior Conjunction is the conjunction in which a planet whose orbit is inside of the Earth passes between the Earth and the Sun. At this point, the object is closer to the Earth than during its superior conjunction.

1.36 Superior Conjunction

Superior Conjunction is the conjunction in which a planet whose orbit is inside of the Earth passes on the far side of the Sun with respect to the Earth. At this point, the object is further from the Earth than during its inferior conjunction.

1.37 Constellation

From ancient times to the present, astronomers have divided the sky up into different regions called constellations. At present, there are 88 such regions.

Often a mythical figure or object was imagined to inhabit each such region. These figures were derived by connecting lines between the stars in various imaginative ways. In more recent times, strict boundaries have been defined to simplify the determination of which constellation an object may find itself in.

See also: asterism, Constellation Boundaries.

1.38 Contact

A "contact" is a stage during an lunar or solar eclipse, an occultation, or a transit when the edges of the apparent disks of astronomical bodies seem to touch. During a solar eclipse, first contact is when the advancing edge of the Sun first touches the Moon, and second contact is when the advancing edge touches the other side of the Moon. Third contact is when the trailing edge of the Sun touches the trailing edge of the moon, and fourth contact is when the Sun and Moon separate from each other, ending the eclipse.

1.39 Convection

Heated fluids, because of their lower density, rise while cooled fluids fall. A fluid heated from below will rise in a column until it cools. At that point, it will move aside and fall to be re-heated, continuing the process. Fluid trapped in this cycle is said to be part of a "convection cell".

Convection can be observed to occur in a wide variety of physical processes - from a hot pan of water, to forming thunderheads, to the Convection Zone of the Sun.

1.40 Convection Zone

The Convection Zone of the Sun is the layer in which energy is transmitted to the outer layers chiefly by the process of convection. It is located between the Radiative Zone and Photosphere.

Convection within the Sun leads to granulation in the appearance of the solar disk.

For more information, see The Sun - Structure and Nuclear Processes.

1.41 Core

The core of a solar system object is the innermost region of the object. In the core of the Sun, nuclear fusion occurs.

1.42 Corona

View Picture

The outermost atmosphere of the Sun is known as the "Corona". Since it is substantially less bright than the Photosphere, it can only be observed when the surface of the Sun is blocked out during a total solar eclipse.

The Corona is dominated by intense magnetic fields, around which the gas accumulates to create its beautiful and delicate structure. The temperature is even higher than that in the Chromosphere, climbing to some 3,000,000 degrees C. However, if an astronaut were to visit the corona and were somehow shielded from the direct rays of the Sun, he or she wouldn't roast to death - in fact, a spacesuit heating system would be required. This is because there simply isn't a lot of gas in the corona. In fact, the atmospheric pressure within the corona rivals laboratory work in creating an almost perfect vacuum.

For more information, see The Sun - Structure and Nuclear Processes.

1.43 Cosmology

Cosmology is the study of the nature, origin, and evolution of the universe.

See also: Chapter on Cosmology.

1.44 Crescent

"Crescent" is a name given to the appearance of a solar system object when it appears less than half illuminated.

See also: gibbous, Phases of the Moon.

1.45 Declination

Declination is the angle of an object north (positive) or south (negative) of the celestial equator. It is usually measured in degrees, minutes, and seconds, and is used in the Equatorial Coordinate System.

See also: Right Ascension

1.46 Deep Sky

"Deep Sky" objects are those objects visible in the night sky which are not stars or objects in our solar system. Instead, they include galaxies, nebulae, and clusters.

They are given the name "deep sky" since they are typically located much further away than visible stars.

Three important catalogues of deep sky objects are in common use - the Messier, NGC, and IC catalogues.

1.47 Diurnal

Diurnal means something which takes place either once a day, or over the course of a day. For example, the Sun’s diurnal motion is the amount that the Sun moved in a day.

See also: annual

1.48 Doppler Shift

It is commonly observed that when an automobile is approaching you with its horn blaring, the sound is higher in pitch than when it is receding. This is because sound waves "pile up" in front of the moving object, resulting in a higher apparent frequency to a stationary observer.

The same effect occurs with light and radio waves. Light is shifted to a higher frequency (more blue in color) as an object approaches, and to a lower frequency (more red in color) as the object recedes (though since light travels much faster than sound, the object must travel faster to produce a noticeable effect). This shift in frequency is known as a "Doppler Shift", after the German physicist Christian Doppler who first described the effect in 1842. Most galaxies are moving away from us, and thus are said to have a "red shift" in their spectrae. By measuring the amount of this shift, we are able to calculate the velocity at which they are receding. Edwin Hubble used this fact to discover a great deal about the nature of our universe. See the chapters entitled Our Expanding Universe, Steps to the Hubble Constant, or Velocities of Stars for further details.

1.49 Earthshine

Earthshine is sunlight reflected off the Earth and lighting the otherwise dark portion of the Moon.

1.50 Eclipse, Annular

The Moon does not revolve around the Earth in a perfectly circular orbit. Sometimes, it is located further from the Earth than at other times, and as a result appears slightly smaller. If the Moon is too far from the Earth during a solar eclipse to completely cover the disk of the Sun, a "ring" of sunlight may be seen around the Moon at the moment of maximum eclipse. When this occurs, the eclipse is said to be annular.

1.51 Eclipse, Lunar

When the Earth lies directly between the Moon and the Sun, it casts its shadow upon the Moon. When this occurs, a lunar eclipse is said to occur, and unlike a solar eclipse, the event is visible to everyone on the night side of the Earth.

A "set" of lunar eclipses usually occurs with a period of 6585.32 days, a period known as the Saros.

See also: Eclipse Details: Lunar eclipse.

1.52 Eclipse, Partial

Any given solar eclipse only has the potential to appear total from a narrow swath across the Earth. All other observers will not see the Moon completely cover the disk of the Sun, and the eclipse is said to be partial from those locations.

1.53 Eclipse, Solar

When the Moon moves so as to appear to lie directly between the Sun and an observer on Earth, it casts its shadow on the observer. A solar eclipse is then said to occur.

Several different classifications of solar eclipses exist:

Total Eclipse
Annular Eclipse
Partial Eclipse
A "set" of solar eclipses usually occurs with a period of 6585.32 days, a period known as the Saros.

See also: Eclipse, Lunar, contact, Solar Eclipses.

1.54 Eclipse, Total

When the Moon casts its shadow on the Earth during a solar eclipse, it does so along a very narrow path. Only observers within this path have the potential to see the Moon completely cover the disk of the Sun. This phenomenon is known as a total solar eclipse.

All observers outside of the path will only be able to observe a partial eclipse.

1.55 Ecliptic

The ecliptic is the path that the Sun appears to take across the background of stars throughout the year. From a different perspective, the ecliptic is the plane of the orbit of the Earth around the Sun.

See also: Motion of the Sun

1.56 Ecliptic Coordinates

The Ecliptic Coordinate System is similar to the Equatorial Coordinate System, except its fundamental reference plane is the ecliptic instead of the Earth's equator.

Positional specifications are made by specifying Ecliptic Latitude and Ecliptic Longitude.

See also: Horizon, Equatorial, and Galactic Coordinate Systems.

1.57 Ecliptic Latitude

The ecliptic latitude is the number of degrees an object is located northward, and perpendicular to the ecliptic. It is used in the Ecliptic Coordinate System.

1.58 Ecliptic Longitude

The ecliptic longitude is the number of degrees an object is located east of the vernal equinox as measured along the ecliptic. It is used in the Ecliptic Coordinate System.

1.59 Eccentricity

The eccentricity is a parameter that specifies the shape of an ellipse, parabola, or hyperbola.

Eccentricity	Shape
0	Circle
0-1	Ellipse
1	Parabola
>1	Hyperbola

For elliptical orbits, an eccentricity of 0 is almost circular. As the eccentricity increases towards 1, the orbit becomes more and more flattened.

Orbits just slightly elliptical have a small, but nonzero eccentricity. They are often said to be ‘slightly eccentric’.

1.60 Ejecta Blanket

An ejecta blanket consists of chunks of rock, usually extending from one side of a crater, that were ejected when the crater was formed.

1.61 Elongation

Elongation (sometimes called "solar elongation") is the angular distance between the Sun and an object. If the object appears to the west of the Sun, it is often said to have a "morning elongation", since it appears in the morning sky. Likewise, if an object appears to the east of the Sun, it can be said to have an "evening elongation".

Greatest elongation of an object orbiting between the Earth and Sun occurs when it is at its maximum angular distance from the Sun. At this time, the object can be observed in as dark a sky as is possible, and thus should be easiest to see.

1.62 Ephemeris

An ephemeris is a tabulation of the positions of a celestial object for a series of dates or times.

1.63 Ephemeris Time (ET)

Ephemeris Time (ET) is the timescale used prior to 1984 used to calculate ephemerides of solar system objects. In 1984, ET was replaced with dynamical time.

1.64 Epoch

An epoch is an arbitrarily fixed instant in time. We often talk of a set of orbital elements at a particular "epoch" - this is the time for which the elements are valid.

Since effects such as precession cause the orientation of the Earth to change slightly with respect to time, any coordinate system is only strictly valid for a particular epoch. Prior to 1984, coordinate systems were generally specified as being with respect to the beginning of a particular Besselian year. After 1984, coordinate systems were referred to the epoch of the beginning of a particular Julian year. To avoid confusion, "standard epochs" are often specified with a ‘B’ or ‘J’ before the year to specify a Besselian or Julian epoch, respectively. Thus, some standard epochs are "B1950.0" and "J2000.0".

1.65 Escape velocity

Escape velocity is the velocity at which an object leaving the surface of a body will just be able to escape the body’s gravitational pull. An object leaving with less than escape velocity will fall back to the surface, while one leaving faster than escape velocity will never fall back.

1.66 Equation of Time

Local apparent solar time is defined so that noon is the moment when the Sun appears at its highest altitude from a given observing location. Because the Earth does not move at the same velocity in its orbit throughout the year, the moment when this occurs is not precisely the same from day to day.

Mean solar time, on the other hand, is defined so that noon occurs at the moment when the Sun would appear at its highest altitude if the Earth moved about the Sun at a uniform rate. It can be determined by averaging several observations of local apparent solar time over the course of a year.

The Equation of Time is simply defined as the local apparent solar time minus the mean solar time. It always lies between -20 and 20 minutes.

See also: analemma.

1.67 Equatorial Coordinates

When referring to objects in the sky, it is helpful to use a set of coordinates to specify their locations. The equatorial coordinate system is the most widely used by astronomers. In it, the plane of the Earth's equator is assumed to extend out infinitely into space. The region it intersects is said to lie along the celestial equator.

In this coordinate system, positional specifications are made by Right Ascension and Declination, analogous to longitude and latitude respectively.

See also: Horizon, Ecliptic, and Galactic Coordinate Systems.

1.68 Fireball

A fireball is an extremely bright meteor. Usually, it has an apparent magnitude brighter than -5. On some rare occasions, fireballs have been reported as bright as magnitude -20.

1.69 Fission

Fission is a nuclear process whereby great amounts of energy are released by breaking a heavy atomic nucleus (such as uranium) into smaller pieces.

See also: fusion

1.70 Flamsteed number

For years, astronomers used the Bayer designation when referring to stars. However, the 24 letters of the Greek alphabet were insufficient to designate all the stars which were visible in a particular constellation.

In order to accommodate these fainter stars, John Flamsteed came up with another method. Like Bayer, he first subdivided stars into their respective constellations. However, instead of using Greek letters, he used numbers to designate each star. As well, instead of numbering the stars in order of increasing brightness, he did so in order of increasing right ascension. He published a star catalogue containing these designations in 1725.

The Flamsteed designation for a particular star consists of Flamsteed's number, followed by the "genitive" form of the constellation name. Thus, stars such as "23 Orionis" became defined.

Of course, stars fainter than those which Flamsteed observed have since been discovered. These stars are typically designated by a few letters specifying the catalogue in which they are listed, followed by the number of the object in that catalogue. A typical star designation from the "Smithsonian Astrophysical Observatory" catalogue is "SAO 226891".

1.71 Solar Flares

Usually associated with sunspots, flares are huge eruptions taking place on the Sun. They are observed as an increase in brightness of areas of hydrogen and often give rise to intense bursts of electromagnetic radiation. These bursts can affect the ionosphere of the Earth, resulting in a disruption of telecommunications. Flares also eject streams of charged particles which affect the Earth's magnetic field and cause geomagnetic "storms". These storms can affect compass needles and have been known to cause vast power outages. In the more northern or southern hemispheres, the flares often create the spectacular aurorae.

In addition to varying in intensity, flares can vary in duration from a few minutes to several hours or longer.

For more information, see Solar Activity.

1.72 Fusion

Fusion is a nuclear process whereby great amounts of energy are released by combining two or more light atomic nuclei (such as hydrogen) into a larger nucleus.

View proton-proton fusion reaction occurring in our Sun

See also: fission

1.73 Galactic Coordinates

The Galactic Coordinate System is similar to the Equatorial Coordinate System, except its fundamental reference plane is that of our Milky Way instead of the Earth's equator.

Positional specifications are made by specifying Galactic Latitude and Galactic Longitude.

See also: Horizon, Equatorial, and Ecliptic Coordinate Systems.

1.74 Galactic Latitude

```
The galactic latitude is the number of degrees an object is located northward,
and perpendicular to the plane of our Milky Way.  It is used in the
Galactic Coordinate System.
```

1.75 Galactic Longitude

```
The galactic longitude is the number of degrees an object is located east of a
point on the plane of our Milky Way 33 degrees distant from the ascending node
of this plane and the Earth's equator of B1950.0, measured along this plane.
It is used in the Galactic Coordinate System.
```

1.76 Galaxy

```
Stars in the Universe do not usually exist alone.  They are typically found in
great concentrations called "galaxies", along with dust and gas.  Our Sun is
located in the Milky Way galaxy.

Edwin Hubble developed a system of classifying galaxies that is still in use
today.  Details of this scheme follow.  Note that the letter 'p' may be
appended to the designation of any type of galaxy.  If this is done, it
signifies that there are some peculiarities to the galaxy, such as distorted
structures or other unusual features.


 Spirals
 -------
 Spiral Galaxies consist of a spiral structure originating from the nucleus, or
central mass of the galaxy.  They are subdivided into four categories:

 a - The nucleus of the galaxy is predominant.
 b - The nucleus and spiral arms are equally dominant.
 c - The spiral arms of the galaxy are predominant.
 d - The nucleus is extremely small, while the spiral arms begin
     to appear more like an irregular mass.
A spiral galaxy is denoted by the letter 'S' followed by the letter for the
appropriate subcategory.  Thus, our Milky Way can be said to be a galaxy of
type 'Sc'.

Spiral galaxies usually exhibit more rotational motion than random motion, and
contain some gas and dust between the stars.  New star formation is often
observed to occur in the spiral arms.

 View picture of M104, an Sa Galaxy
 View picture of Andromeda Galaxy, of type Sb
 View picture of M74, an Sc Galaxy


 Barred Spirals
 --------------
 Barred spiral galaxies are similar to spirals, except that the spiral arms
```

seem to originate from the ends of a more or less straight 'bar' going through the nucleus of the galaxy. They are subdivided into the same categories ('a' through 'd') as normal spiral galaxies.

A barred spiral is denoted by the letters 'SB' followed by the letter for the appropriate subcategory. This allows for designations like 'SBb' for galaxies such as M109.

View picture of M109, an SBb Galaxy

Ellipticals

Elliptical galaxies do not exhibit a spiral pattern. They are simply an elliptical 'ball' of stars, with a condensation near the center. Star motion within the galaxies is quite random, so their elliptical appearance is not due to rotational flattening. There is very little dust and gas between the stars, and as a result there is no new star formation or hot, bright, massive stars. Most ellipticals are small and faint, and dwarf ellipticals may be the most common type of galaxy known.

Elliptical galaxies are given designations of E0 (perfectly round) to E7 (highly elliptical). In addition, a special class known as S0 is applied to those galaxies which resemble ellipticals, but are beginning to show a central or plane or disc around the condensation. This is a transitionary phase between the ellipticals and spirals.

View picture of M87, an E0 p Galaxy
View picture of M86, an E3 Galaxy

Irregulars

As with any classification system, there are always objects which do not fit into precise categories. Galaxies like this are known simply as irregulars, denoted by the letter 'I' or the abbreviation 'Irr'. They tend to lack any symmetry or defined shape.

Some irregular galaxies contain a lot of dust and gas, making new star formation possible. Most galaxies of this type are quite faint.

View picture of M82, an Irr p Galaxy

See also: Seyfert galaxy, Introduction to Galaxies.

1.77 Seyfert Galaxy

A Seyfert Galaxy is an interesting class of galaxy which shows a bright nucleus with a strong emission-line spectrum. Astronomers do not yet know the precise reasons why, but these galaxies are also strong sources of radio energy. Some people believe that these emissions may originate from quasars within the galaxy.

1.78 Gas Giant Planet

Jupiter, Saturn, Uranus, and Neptune are large planets composed mostly of a combination of various gases, with no defined surface. As a result, they are often called "gas giant" planets.

See also: terrestrial planet

1.79 Gegenschein, or Counterglow

The gegenschein is the portion of zodiacal light directly opposite the Sun in the sky. In this region, sunlight is illuminating meteoritic material almost face-on (full phase) from our vantage point on the Earth, and thus the light appears brighter than elsewhere along the ecliptic.

The gegenschein is easiest to see in September or October, but even then it is extremely dim and requires a dark sky and well-adapted eyes. It appears as a faint, nebulous patch of light about 20 degrees in diameter.

1.80 Geocentric

Geocentric is a reference to the center of the Earth. A fictitious observer at a geocentric position would be located at the center of the Earth. Similarly, geocentric coordinates are those which use the center of the Earth as their origin, and the geocentric or Ptolemaic theory of the universe describes the Earth as being at the center.

See also: heliocentric, topocentric

1.81 Gibbous

"Gibbous" is a name given to the appearance of a solar system object when it appears more than half illuminated.

See also: crescent, Phases of the Moon.

1.82 Graben

A graben is a long and narrow region between two faults that has subsided. Grabens have been detected on several planets and moons in our solar system.

1.83 Granulation

View Picture

Due to convective currents in the Convection Zone of the Sun, a great number of rising columns of hot gas can be observed at the surface of the Photosphere. These columns can be observed to give a "granular" appearance to the Sun.

For more information, see The Sun - Structure and Nuclear Processes or Solar Activity.

1.84 Heliocentric

Heliocentric is a reference to the center of the Sun. A fictitious observer at a heliocentric position would be located at the center of the Sun. Similarly, heliocentric coordinates are those which use the center of the Sun as their origin, and the heliocentric or Copernican theory of the universe describes the Sun as being at the center.

See also: geocentric, topocentric

1.85 Heliographic

Heliographic coordinates are the latitude and longitude system used when referring to objects on the Sun.

1.86 Heliopause

As you travel further from the Sun, the solar wind becomes weaker and weaker. It is expected that at a certain distance, the solar wind will be overcome by the ‘stellar wind’ originating from nearby stars. This imaginary boundary is termed the ‘heliopause’, and most astronomers consider it to define the limits of our solar system.

Though scientists do not know exactly where this boundary is located (and expect it to fluctuate with time), they are anxiously studying data returned from four interplanetary probes - Pioneer 10, Pioneer 11, Voyager 1, and Voyager 2. Currently travelling out of our solar system at immense velocities, it is hoped that at least one will survive long enough to tell us that the heliopause has been reached.

1.87 Horizon Coordinate System

The horizon coordinate system specifies the position of celestial objects by measuring their altitude and azimuth.

See also: Equatorial, Ecliptic, and Galactic Coordinate Systems.

1.88 Hour Angle

The hour angle of an object is the sidereal time that has elapsed since the object was on the observer's meridian. It is equal to the difference between the right ascension of the object and that of the observer's current meridian.

1.89 Hubble's Law

This is a observation by Dr. E. Hubble stating that the further away a galaxy is from us, the faster it is receding. The law indicates that the universe is currently expanding, and that it all started at a moment known as the "Big Bang".

1.90 Hydrogen Alpha line

This is the strongest spectral line of hydrogen in the visible part of the spectrum, appearing a deep red in color. Observations at this wavelength help to determine the distribution of hydrogen in the universe.

1.91 IAU (International Astronomical Union)

The IAU, or International Astronomical Union, is a group charged with the organization and distribution of astronomical information. The IAU develops naming conventions for objects, and acts as a sort of "central registry" for newly discovered objects (if you discover a comet, let the IAU know or you won't get credit for it!). They also perform a service to the astronomical community, distributing "IAU Circulars" notifying everyone of new discoveries.

1.92 IC Objects

As astronomers developed larger telescopes, they continued to discover deep sky objects that did not appear in the Messier or NGC catalogues. So, an extension of the NGC catalogue was made. It became known as the IC, or Index Catalogue list of deep sky objects, and in 1895 and 1980 publications, 5386 galaxies, nebulae, and clusters were added.

IC objects are usually identified by the letters 'IC' followed by a number from 1 to 5386.

1.93 Inclination

Inclination is the angle which one plane makes with another. We often talk about the inclination of an orbit to the ecliptic.

1.94 Julian Date

Since astronomers often deal with intervals of time, the traditional calendar approach to dates proves cumbersome (with differing numbers of days per month, leap years, etc.) To simplify the situation, they use the concept of a "Julian date".

The Julian date is simply the number of days (of 24 hours) which have elapsed since noon on January 1, 4713 BC. It is important to remember that astronomers chose the beginning of a Julian date to occur at noon, instead of the conventional midnight, so that the date does not change during the middle of a night's observing. As a result, midnight on March 22, 1995 is equivalent to JD 2449798.5, and noon on the same day is JD 2449799.0. "The Digital Universe" allows you to specify dates in whatever format you choose, doing the conversions for you.

To determine the amount of time between two instants, simply subtract their Julian dates from each other. This is substantially easier than having to keep track of leap years and various other calendar details.

Two related concepts to the Julian date are often used. The Modified Julian date (MJD) is the Julian date minus 2400000.5, and is sometimes used as a type of "shorthand" when dealing with events in recent history or in the near future. The Julian day number is simply the integral part of the Julian date.

1.95 Kelvin

Kelvin is a measurement of temperature. There are 100 degrees Kelvin between the freezing and boiling points of water at sea level (as in the Celsius scale). However, rather than the zero point being the freezing point of water (as is the case with Celsius), zero degrees Kelvin is absolute zero. As a result, it is quite easy to convert between Kelvin and Celsius measurements. Just use the following formulae:

```
Kelvin  = Celsius + 273
Celsius = Kelvin  - 273
```

1.96 Kuiper Belt

The Kuiper (pronounced KOY-pur) Belt is a belt of comets orbiting the Sun, just past the orbit of Neptune, up to a distance of about 50 AU. It is believed by many that the Kuiper Belt is the source of short period comets, travelling around the Sun in less than 200 years.

As of November 1994, 18 Kuiper Belt objects were known. Their characteristics are summarized in the following table:

Object	a	e	i	Mag	Diam (km)	Discovery	Discoverers
1992 QB1	43.9	0.070	2.2	22.8	280	Aug 1992	Jewitt & Luu
1993 FW	43.9	0.047	7.7	22.8	290	Mar 1993	Jewitt & Luu
1993 RO	39.3	0.198	3.7	23.2	140	Sep 1993	Jewitt & Luu

1993 RP	39.3	0.114	2.6	24.5	100	Sep 1993	Jewitt & Luu
1993 SB	39.4	0.321	1.9	22.7	190	Sep 1993	Williams et al.
1993 SC	39.5	0.185	5.2	21.7	320	Sep 1993	Williams et al.
1994 ES2	45.3	0.012	1.0	24.3	160	Mar 1994	Jewitt & Luu
1994 EV3	43.1	0.043	1.6	23.3	270	Mar 1994	Jewitt & Luu
1994 GV9	42.2	0.000	0.1	23.1	260	Apr 1994	Jewitt & Luu
1994 JQ1	43.3	0.000	3.8	22.4	380	May 1994	Irwin et al.
1994 JR1	39.4	0.118	3.8	22.9	240	May 1994	Irwin et al.
1994 JS	39.4	0.081	14.6	22.4	260	May 1994	Luu & Jewitt
1994 JV	39.5	0.125	16.5	22.4	250	May 1994	Jewitt & Luu
1994 TB	31.7	0.000	10.2	21.5	260	Oct 1994	Jewitt & Chen
1994 TG	42.3	0.000	6.8	23.0	230	Oct 1994	Chen et al.
1994 TG2	41.5	0.000	3.9	24.0	140	Oct 1994	Hainaut
1994 TH	40.9	0.000	16.1	23.0	220	Oct 1994	Jewitt et al.
1994 VK8	43.5	0.000	1.4	22.5	270	Nov 1994	Fitzwilliams et al.

```
 a =     semimajor axis in AU
 e =     eccentricity
 i =     inclination in degrees
```

It is estimated that at least 35,000 objects with a diameter of greater than 100 km exist in the Kuiper Belt.

Spectral studies of these objects have shown them to be unusually red. The following picture shows part of the discovery frames for 1993 SC. Obtained 4.6 hours apart by the 2.5m Isaac Newton Telescope on La Palma by Alan Fitzsimmons, Iwan Williams, and Donal O'Ceallaigh on September 17th, 1994, the two frames clearly show the motion of the object. 1993 SC is believed to be located approximately 34 AU from the Sun, and have a diameter of about 300km.

View picture of 1993 SC

See also: Oort Cloud, Where do comets come from?

1.97 Leap Second

The Earth does not rotate at a perfectly uniform speed. It is generally slowing down, though doing so irregularly and unpredictably.

With the advent of atomic clocks, scientists have been able to detect and measure these changes. To keep our clocks properly synchronized with the motion of the Sun and stars across the sky, periodic adjustments have to be made to UTC.

These adjustments take the form of "leap seconds" and act to keep UTC at an integral number of seconds offset from TAI, and within 0.9 seconds of UT1. Periodically, these leap seconds are added or removed at the end of June or December, resulting in a time sequence similar to the following:

```
June 30, 23:59:58
June 30, 23:59:59
June 30, 23:59:60
July  1, 00:00:00
July  1, 00:00:01
```

Since 1972 (when the leap second program started), the following differences between UTC and TAI have been observed, the changes being due to the addition of leap seconds:

```
                   Date      TAI-UTC (seconds)
                   ----      -----------------
               1972 Jan  1          10
               1972 Jul  1          11
               1973 Jan  1          12
               1974 Jan  1          13
               1975 Jan  1          14
               1976 Jan  1          15
               1977 Jan  1          16
               1978 Jan  1          17
               1979 Jan  1          18
               1980 Jan  1          19
               1981 Jul  1          20
               1982 Jul  1          21
               1983 Jul  1          22
               1985 Jul  1          23
               1988 Jan  1          24
               1990 Jan  1          25
               1991 Jan  1          26
               1992 Jul  1          27
               1993 Jul  1          28
               1994 Jul  1          29
               1996 Jan  1          30
```

See also Time Standards

1.98 Leap Year

The Earth travels around the Sun once every 365.2421897 days. Due to the fractional number of days, no calendar which attempts to break up a year into a specific number of days will be accurate unless it also has some provision to deal with the fractional component. The simplest solution is the concept of a leap year - a year periodically introduced to bring the count of days back in synchronization with the seasons.

The first attempt at this was introduced by Julius Caesar in 46 B.C. His Julian calendar consisted of "normal" years of 365 days and "leap" years of 366 days, with a leap year occurring every 4 normal years. Over a four year period, this gave an effective year of 365.25 days, the Julian year.

However, this did not precisely equal 365.2421897 days, with an error of 0.0078103 days occurring every year. By 1582, the error had accumulated to almost 13 entire days, and people began to notice that their calendar was losing synchronization with the seasons.

To try and solve the problem, Pope Gregory XIII introduced a calendar reform and developed a calendar system known as the Gregorian calendar. He used the Julian calendar as a basis, but added the provision that a year would be a leap year if it were evenly divisible by 4, unless it was also evenly divisible by 100, unless it was also divisible by 400. Thus, the years 1800 and 1900 were not leap years, though 2000 will be. This gives an effective year length of 365.2425 days, much closer to 365.2421897 than the Julian calendar. With the Gregorian calendar, an error of 0.0003103 days is introduced every year, requiring more than 3,200 years before a single day has accumulated. Most of the western world has adopted the Gregorian calendar for its present use.

In order to bring the new Gregorian calendar back into synchronization with the seasons, Pope Gregory XIII deleted ten days, so that October 4, 1582 was followed by October 15, 1582.

"The Digital Universe" uses the Julian calendar for dates prior to October 4, 1582 and the Gregorian calendar for dates after October 15, 1582. It is aware of the missing 10 days.

1.99 Libration

Librations are variations in the orientation of the Moon's surface with respect to an observer on the Earth. On average, the Moon rotates around its axis in the same amount of time it takes to orbit about the Earth, keeping the same side facing the Earth at all times.

But since the Moon's orbit is eccentric, it speeds up and slows down slightly as it approaches and recedes from the Earth. Since the rotation remains roughly constant, the net effect is to cause the Moon to appear to wobble, as it reveals to observers a bit more than just the half of the Moon facing us.

There are two types of libration. Physical librations are due to slight variations in the rate at which the Moon rotates on its axis. These variations are extremely small. On the other hand, optical librations are the effects caused by the variation in the rate of the Moon's orbital motion. "The Digital Universe" takes both of these effects into account when producing an accurate view of the appearance of the Moon.

1.100 Light Year

One light year is the distance that light would travel through space in one year. It is equal to approximately 9,460,000,000,000 km, or 63,240 A.U..

1.101 Limb

The limb of a solar system object (such as the Sun or the Moon) is the apparent edge of its disk.

See also: Limb Darkening

1.102 Limb Darkening

View Picture

The sun's limb appears darker than at its center, due to an effect known as 'limb darkening'. Since light travelling through the Photosphere is partially absorbed by material located there, our line of sight can only see so far. When we look at the center of the Sun’s disk, we are looking through less of the Photosphere than when we observe near the limb. As a result, we see deeper into the Photosphere near the centre. The limb appears darker because our line of sight ends higher in the atmosphere, where the temperature is cooler.

1.103 Magnitude

An object’s brightness is usually described by the object being of a particular magnitude. Hipparchus, who invented the magnitude system, divided the stars which were visible to the naked eye into six different classes. The brightest stars were said to be of "First Magnitude", and those just visible under the darkest skies were said to be of "Sixth Magnitude". Between those two extremes fell everything else.

In the middle of the 19th century, this scale was defined mathematically. Measurements showed a difference of 5 magnitudes corresponded roughly to a factor of 100 in brightness. As a result, Hipparchus’ scale was redefined so that this would be exactly so. Since the scale is what mathematicians term a ‘geometric’ one, it turns out that the difference in brightness from one magnitude to the next is given by the fifth root of 100, or approximately 2.512. This can lead us to develop the following table:

Magnitude difference	Factor in brightness
1	2.512
2	6.310
3	15.85
4	39.81
5	100.0
6	251.2
7	631.0
8	1585
9	3981
10	10000
11	25120
12	63100
13	158500
14	398100
15	1000000

etc.

For example, a star of Magnitude 3 is 6.31 times brighter than a star of Magnitude 5. It is important to remember that the lower the magnitude the brighter the star, contrary to what you might expect!

In the process of making detailed measurements of stellar brightnesses, it was discovered that several stars were in fact brighter than the "First Magnitude" that Hipparchus had assigned. To accommodate those brighter stars, magnitudes of less than 1 were defined from the mathematical relationship. Consequently, there are a dozen or so stars of magnitude 0, and even a few stars with negative magnitudes (Sirius, the brightest star in the sky, has a magnitude of -1.4). The full moon has a magnitude of approximately -12.6, while the Sun has a magnitude of -26.8.

Of course, there are many stars dimmer than magnitude 6 (the dimmest which can typically be seen without optical assistance). If you were to look through a telescope with a lens or mirror 15 to 25 cm in diameter (6 to 10 inches), you would be able to see stars as dim as 10th or 12th magnitude. The largest ground-based telescopes can see stars as dim as 24th magnitude, while the Hubble Space Telescope can do better still. The dimmest star which can be observed is often referred to as the Limiting magnitude. "The Digital Universe" contains stars as dim as magnitude 9.5.

When the brightness of an object is given simply as its ‘magnitude’, it is assumed that apparent magnitude is meant.

See also: magnitude, apparent, magnitude, absolute, magnitude, B-V, Magnitude System

1.104 Absolute Magnitude

The Absolute Magnitude of an object is the magnitude that the object would appear to be at a distance of 10 parsecs.

See also: magnitude, apparent

1.105 Apparent Magnitude

The Apparent Magnitude of an object is the magnitude an object appears to an observer - often just called the magnitude.

See also: magnitude, absolute

1.106 B-V Magnitude

The B-V magnitude is often called a "color index" and is a numerical indication of an object’s color. It is obtained by measuring the magnitude of the object through a standard blue filter, as well as the visual magnitude of the object, and subtracting the two numbers.

See also: Star Colors.

1.107 Limiting Magnitude

The term ‘Limiting Magnitude’ refers to the dimmest objects which can be seen (with a given telescope, binoculars, or your eye, taking into account varying sky conditions, etc.)

1.108 Visual Magnitude

The visual magnitude is the magnitude of an object as measured through a standard yellow filter. This filter simulates the range of sensitivity of the human eye, and is thus a good measure of how bright the object appears to be to the eye.

1.109 Meridian

The meridian is the great circle passing through the celestial poles and an observer's zenith. Viewed another way, it is a line extending directly north and south across the sky lying directly overhead.

1.110 Messier Objects

This is a list of deep sky objects, compiled by Messier. He originally listed 103 such objects, but later expanded his catalogue to contain 110 entries.

Since this was the first list of deep sky objects published, its entries include the brightest such objects. Other, dimmer deep sky objects have since been published in the NGC and IC catalogues.

Messier objects are usually denoted by a 'M' followed by a number from 1 to 110.

1.111 Meteor

A meteor is a meteoroid moving through the Earth's atmosphere. As it does so, its high rate of speed creates a large amount of friction with the Earth's atmosphere. This in turn causes the meteor to heat up, and often glow white hot. If the meteor reaches the Earth's surface without being totally vaporized, it is said to be a meteorite.

Meteors are often called "shooting stars", though there is nothing about them related to a star. A typical meteor seen streaking across the sky may be more than 100 km away, and the size of a grain of sand. The intense heat ionizes the air surrounding the particle, making it easily visible.

In general, objects are classified according to the following scheme:

```
 Asteroid  - Rock in orbit about the Sun
 Meteoroid - Asteroid on a collision course with the Earth
 Meteor    - Meteoroid which has entered the Earth's atmosphere
 Meteorite - Portion of a meteor which has survived its descent to the
             surface of the Earth.
```

For more information, see the descriptive chapter on Meteors.

See also: fireball.

1.112 Meteor Shower

A meteor shower is the appearance of many meteors during a short time interval. They often occur on an annual basis, as the Earth passes through a comet's orbit.

See also: Meteor Showers

1.113 Meteorite

A meteorite is a fragment of a meteor surviving its passage through the Earth's atmosphere, and its impact with the ground.

In general, objects are classified according to the following scheme:

```
 Asteroid  - Rock in orbit about the Sun
 Meteoroid - Asteroid on a collision course with the Earth
 Meteor    - Meteoroid which has entered the Earth's atmosphere
 Meteorite - Portion of a meteor which has survived its descent to the
             surface of the Earth.
```

For more information, see the descriptive chapter on Meteors.

1.114 Meteoroid

A meteoroid is a small (typically less than 1 metre in diameter) piece of rock or metal, orbiting the Sun in our solar system. The object is usually referred to as a meteoroid when it is an asteroid on collision course with the Earth.

There is currently no strict definition classifying an object as a planet, satellite, asteroid, comet, or meteoroid. As a result, sometimes an object's designation is subject to debate.

In general, objects are classified according to the following scheme:

```
 Asteroid  - Rock in orbit about the Sun
 Meteoroid - Asteroid on a collision course with the Earth
 Meteor    - Meteoroid which has entered the Earth's atmosphere
 Meteorite - Portion of a meteor which has survived its descent to the
             surface of the Earth.
```

For more information, see the descriptive chapter on Meteors.

See also: meteor, meteorite

1.115 Milky Way

The Milky Way is the term given to the galaxy in which we are located. All of the stars in the sky that we can see with the naked eye belong to this galaxy.

For a long time, astronomers have been trying to determine the shape of the

Milky Way. This feat is made difficult because we are inside the galaxy, and can only see a limited distance before our view is blocked by nebulae. In 1990, Leo Blitz (of the University of Maryland) and David Spergel (of Princeton University) found evidence to indicate that the Milky Way has the structure of a 'barred spiral'. Irregular motions of nebulae and direct near-infrared light measurements of stars near the centre seem to indicate the existence of the bar (previous studies had suggested that the Milky Way was just a simple spiral without the bar). If the Milky Way is indeed a barred spiral galaxy, it may look somewhat like M109.

View picture of M109, an SBb Galaxy

Our Milky Way is about 120,000 light years in diameter. It has a brilliant "bulge" at its center - the nucleus. This nucleus is roughly 13,000 light years thick and 20,000 light years wide. Tens of billions of old, metal-rich stars occupy this region of our galaxy. The disk of the Milky Way is about 1300 light years thick and 60,000 light years in radius, with the Sun located about 30,000 light years from the center. Over 98% of the dust and gas in the galaxy, as well as a few hundred billion stars are found in the disk. New stars are forming from the gas and dust located within.

The Milky Way also exhibits a feature called a "stellar halo". This is a roughly spherical distribution of hundreds of millions of old, metal-poor stars, with the concentration increasing nearer to the center of the galaxy. It is about 70,000 light years in radius and may contain a small amount of hot gas. Most of the globular clusters are found in the halo, with their concentrations increasing as the center of the galaxy is approached. If we were located at the center of the Milky Way, we would see approximately the same number of globular clusters in any direction we looked.

In studying how stars orbit the center of the Milky Way, astronomers have realized that the Milky Way is much more massive than can be accounted for with visible stars and gas. They have therefore postulated that up to 90% of the mass of the Milky Way has not been detected - mass which scientists have termed "dark matter". Nobody knows what it is really composed of, though some astronomers suspect that brown dwarfs (stars which shine too dimly to be seen), black holes, neutrinos with mass, or a wide variety of other things may contribute.

View diagram of our Milky Way

In total, the Milky Way is believed to contain nearly a trillion (1,000,000,000,000) stars.

When we look up on a clear and dark night, we can often see an irregular band of faint light extending across the sky. This is the light given by literally millions of stars at a great distance, all of which are a part of the Milky Way. The stars appear to be most strongly concentrated along this band, since in that direction we are looking in the plane of the Milky Way. If we look another direction, our line of sight carries us out of our galaxy comparatively quickly. Galileo was the first person to discover that this band of light actually consisted of a great number of individual stars.

See also: Galactic Structure of the Milky Way.

1.116 Nadir

The "nadir" is the point on the celestial sphere directly below an observer. It is the point opposite the zenith.

1.117 Naked Eye

This term is often used by astronomers to refer to viewing unassisted by mechanical or optical means. In other words, 'naked eye' stars are those which can be seen without the use of a telescope or binoculars.

1.118 Nebula

A nebula is a region of gas or dust in a galaxy that can be observed optically. They are usually classified into one of three different categories:

  Emission Nebula
  Absorption Nebula
  Reflection Nebula
The plural form of 'nebula' is 'nebulae'.

See also: Planetary Nebula.

1.119 Emission Nebula

An emission nebula is a cloud of gas and dust that receives energy from a nearby star. It then, re-emits this energy and can be observed to 'glow'.

Since most nebulae consist of a great deal of hydrogen, much energy is emitted at a wavelength characteristic of the hydrogen atom (called the hydrogen-alpha line). Since this line is in the red part of the visible spectrum, emission nebulae usually have a characteristic red color.

See also: Nebula, Absorption Nebula, and Reflection Nebula.

1.120 Absorption Nebula

An absorption nebula is a cloud of dust and gas which absorbs energy from background stars without re-emitting it as visible light. They are typically seen in silhouette against a brighter background, and as such are often called "dark nebulae".

Perhaps the most famous example of such a "dark nebula" is the Horsehead Nebula in Orion.

See also: Nebula, Emission Nebula, and Reflection Nebula.

1.121 Planetary Nebula

Eventually, a star depletes the supply of fuel it uses for nuclear fusion. When this happens, the star rapidly collapses under its own gravity. As it does so, it heats up, and some of the hydrogen remaining in the outer layers may undergo sufficient heating and compression to allow fusion to occur once more. The resulting explosion hurls some of the star's matter into space, so that an expanding sphere of gas and dust surrounds the star. The cloud, often lit up by the star inside, is called a "planetary nebula". Since we look through more of the gas near the edges of the sphere, a planetary nebula often appears as a 'ring' around the originating star. The Ring Nebula is perhaps one of the most famous planetary nebulae.

See also: nebula

1.122 Reflection Nebula

A reflection nebula is simply a cloud of dust and gas which reflects the light of nearby stars, making it visible.

See also: Nebula, Emission Nebula, and Absorption Nebula.

1.123 Neutron Star

A Neutron Star is an object resulting from the collapse of a dying star. It is an extremely compressed object with densities ranging up to a billion tons per cubic centimeter. The only thing stopping the object from collapsing still further under its intense gravity is that the neutrons within the star resist being pushed still closer together (the protons and electrons in the nucleus of the star have fused to make more neutrons). Neutron stars are formed in a supernova explosion.

A neutron star will have a mass ranging between 1.4 and 3.2 times the mass of our Sun. If it is any lighter, a white dwarf will form instead, and if it is any heavier, a black hole will form.

See also: Pulsar, Stellar Remnants.

1.124 NGC Objects

Charles Messier was the first individual to compile a list of deep sky objects. But, in listing only the 110 brightest objects, the catalogue was only of marginal use to later astronomers with larger telescopes who could see thousands of deep sky objects.

To extend Messier's work for more modern usage, J. L. E. Dreyer published a new list in 1888. His NGC, or New General Catalogue included 7840 galaxies, nebulae, and clusters.

NGC objects are usually identified by the letters 'NGC' followed by a number from 1 to 7840.

See also: Messier catalogue, IC catalogue

1.125 Nova

A nova (plural=novae) is a hot dwarf star which dramatically and suddenly increases in brightness. Typically, the brightness increases by 7 to 15 magnitudes over a period of just a few days. After the outburst, the star gradually fades back to its pre-nova levels over the course of a few years.

Often, stars which were too dim to be previously seen become visible, resulting in a temporary 'new' star. This is why the star is called a 'nova' - Latin for new.

Some examples of novae, with their year of appearance, include GK Persei (1901), V603 Aquilae (1918), and DQ Herculis (1934).

See also: Recurrent Novae, Supernova, variable star

1.126 Nutation

The Earth is gravitationally attracted to other objects in the solar system by different amounts at different times. The result of this is to cause the Earth's orientation in space to "wobble" slightly, with a period of about 19 years.

These forces also cause a similar effect known as precession. Precession has a much longer period, however.

You can tell "The Digital Universe" to include the effects of nutation by clicking on the appropriate gadget in the Display Prefs Window.

1.127 Oblate

Planets such as Jupiter are said to have an oblate, or flattened shape. Their high speed of rotation causes them to have a larger equatorial than polar diameter.

1.128 Obliquity

The "obliquity" is the angle between the equatorial and orbital planes of a solar system body. For the Earth, the obliquity of the ecliptic is the angle between the planes of the equator and the ecliptic. Equivalently, it is the tilt of the Earth's axis with respect to its orbit. It is currently about 23.45 degrees, though this value changes slightly with time.

1.129 Occultation

When an object moves so as to block the light of a star or object behind it, it is said to "occult" the star. The event is known as an "occultation".

1.130 Oort Cloud

The Oort Cloud is a theoretical "cloud" of perhaps a trillion comets, orbiting the Sun at distances of between 30,000 AU to 1 light year. Disturbances within this cloud are believed to periodically send comets into the inner solar system, where they are observed as long period comets taking thousands of years to go around the Sun.

No direct evidence of the Oort Cloud has been obtained, but many astronomers believe in its existence.

The Oort Cloud was first postulated by Jan Oort.

See also: Kuiper Belt, Where do comets come from?

1.131 Opposition

Opposition is the point in a planet's orbit when it appears opposite the Earth from the Sun. Only planets with orbits larger than that of the Earth can be observed to go through opposition. During opposition, such a planet is nearer to the Earth than during conjunction.

1.132 Orbital Elements

Orbital elements are a set of numerical parameters which uniquely identify the position and motion of an object in orbit.

1.133 Parallax

Parallax is the difference in apparent position of an object when seen from two different locations. There are two different types of parallax - Geocentric (diurnal) and Heliocentric (annual).

1.134 Geocentric, or Diurnal Parallax

The Geocentric, or Diurnal Parallax is the difference in the apparent position of an object when viewed from a topocentric as opposed to geocentric position.

See also: parallax, parallax, heliocentric

1.135 Heliocentric, or Annual Parallax

The Heliocentric, or Annual Parallax is the difference in the apparent position of an object when viewed from a geocentric as opposed to heliocentric position. As a result of the Earth's varying position in its revolution around the Sun, a nearby star appears to move around slightly with respect to further, background stars. Though small, the effect is measurable and provides an accurate way for astronomers to estimate the distance to a star.

See also: parallax, parallax, geocentric

1.136 Parsec

A parsec is the distance from which 1 Astronomical Unit appears to cover 1 second of an arc (1/3600th of a degree). 1 parsec equals approximately 3.26 Light years.

1.137 Penumbra

The word "penumbra" has two meanings in astronomy. It can be the outer region of a sunspot, lighter in color than the umbra. It also refers to the outer, fuzzy region of a shadow cast by an illuminating object with a discernible size. An observer in the penumbra of a shadow will see the light source partially obscured by the occulting object.

See also: Eclipse, Lunar and Eclipse, Solar.

1.138 Perigee

The perigee is the nearest point to the Earth in an object's orbit around it.

See also: apogee, perihelion, aphelion

1.139 Perihelion

The perihelion is the nearest point to the Sun in an object's orbit around it.

See also: aphelion, perigee, apogee

1.140 Perturbation

When one body orbits another with no external influences, the orbit takes the form of a circle, ellipse, parabola, or hyperbola and can be defined in a strict mathematical sense. However, when more than two bodies are involved, no such exact definition is possible, as the orbit is significantly more complex.

Since many systems consist of several lighter objects orbiting around one massive one (as is the case with our solar system), orbital solutions are often approximated by neglecting the effects of the lighter objects on each other. When this is done, the problem is simplified to that of a single object orbiting another with no external influences.

However, for more accurate calculations, the effects of these lighter bodies on one another must be taken into account. The forces that the light bodies exert on each other to cause deviations from the ideal two-body solution are termed perturbations.

1.141 Phase Angle

The phase angle of a body in the solar system is the angle measured at its center between the Sun and the observer on Earth. When the angle is 0 degrees, the Sun is located either directly behind the observer or between the observer and the solar system body. As a result, the phase of the object will appear "full".

Likewise, if the phase angle is 180 degrees, the Sun is located on the opposite side of the body as the Earth. As a result, the phase of the object will appear "new", and we will not be able to see the daylit side of the object.

1.142 Photosphere

The photosphere is the region of the Sun which we can directly see. It is a thin layer, perhaps only 100 km in depth, that produces the radiation transmitted into space, since at its distance from the center of the Sun photons are more likely to escape than be re-absorbed. The Photosphere is considered to be the innermost layer of the Sun’s atmosphere.

It is located between the Convection Zone and Chromosphere.

For more information, see The Sun - Structure and Nuclear Processes.

1.143 Position Angle

Position angle is the angular direction measured counterclockwise from north. Astronomers often talk of a star at a particular distance and position angle from another, or of the position angle of the polar axis of a planet.

1.144 Precession

While rotating about its axis, the Earth exhibits a very slow ‘wobble’, much like that of a top which is beginning to fall down. This wobble is caused by the Sun, Moon, and other planets pulling unequally upon the equatorial bulge of the Earth (the distance around the Earth along its equator is somewhat greater than the distance around the Earth passing through its poles). Over a 25,700 year period, precession causes the the orientation of the Earth’s axis to change, tracing out a large ‘circle’. An effect of this is that although the star Polaris is currently near the North Celestial pole, in approximately 13,000 years the ‘pole star’ will be replaced by Vega.

These unequal forces also cause a similar effect with a shorter period, known as nutation.

Precession was first discovered by Hipparchus.

You can tell "The Digital Universe" to include the effects of precession by selecting the appropriate gadget in the Display Prefs Window.

1.145 Prominences and Filaments

View Picture 1 - Prominence on solar limb
View Picture 2 - Filaments on solar disk, seen in H-alpha light

Gas suspended above the solar Photosphere by the Sun’s magnetic field is termed a "prominence" if the gas is visible at the limb of the Sun, and a "filament" if the gas seen against the solar disk as a background. Since filaments are not as bright as the rest of the Sun, they appear as dark, snakelike features.

Viewing prominences requires a H-alpha filter with a bandwidth of 3 or 4 angstroms. A filter passing a band of less than 1 angstrom is required to see filaments on the solar disk.

1.146 Proper Motion

Though the stars appear to be fixed objects in the sky, their positions do vary slightly with time. Much of this motion is caused by effects like precession, and are thus just an apparent motion caused by the Earth’s orientation changing slightly. But, the stars are in orbit about the center of the Milky Way and do have a true motion with respect to our Sun. The appearance of this movement from the Earth is termed "proper motion", and over a long period of time causes constellations to distort from their familiar shapes.

You can tell "The Digital Universe" to include the effects of proper motion by selecting the appropriate gadget in the Display Prefs Window.

1.147 Pulsar

If a neutron star has a strong magnetic field (a billion to a trillion times stronger than that of our Sun), this field will cause particles and energy from the star to be emitted in a "beam" from the magnetic north and south poles. If the magnetic axis does not line up with the rotation axis of the star, the beam will sweep out a path in space, much as a lighthouse does.

If the Earth happens to be in the line of sight of the beams during part of the star’s rotation, it appears to "pulse" on and off as the beam sweeps past. Such an object is then termed a "pulsar".

Neutron stars spin extremely quickly, and as a result, typical periods for pulsars range from 4 to 0.001 seconds.

The period of a pulsar is extremely, but not entirely, regular. As a pulsar continues to emit radiation, it loses some of its energy of rotation. As a result, its rotation slows down over a long period of time.

In addition, a typical neutron star periodically shrinks by about 1 mm in diameter. When this happens, the spin rate suddenly increases to conserve angular momentum.

See also: Neutron Star, Stellar Remnants.

1.148 Quadrature

A quadrature is a configuration in which two celestial bodies have ecliptic longitudes which differ from 90 degrees as viewed from a third body. Often, quadratures are tabulated with respect to the Sun as viewed from the center of the Earth.

1.149 Quasar

When astronomers began measuring the spectrae of stars, they noticed a few dim stars which seemed to have a very high red shift. This indicated that the star was moving away from us at a great rate of speed. Assuming that the universe was expanding from an event known as "The Big Bang", this speed implied that the objects were extremely far away. For them to appear as a star, even a dim one, meant that they must be unimaginably bright - brighter than entire galaxies, though they are believed to be a single object.

When strong radio emissions were detected from these objects, they became known as "quasi-stellar radio sources", since they were strong radio sources which appeared as a star. The name eventually became shortened to "quasar".

Quasars are the brightest, and most distant objects known in the universe, located up to 10 billion light years away.

1.150 Radiant

The radiant is the point in the sky from which meteors appear to originate. It is only because of our perspective on the moving Earth that they seem to come from this position.

Different meteor showers appear to come from different radiants.

1.151 Radiative Zone

The Radiative Zone of the Sun is the layer in which energy generated in the core is transmitted to the outer layers by a "radiative" process. In this layer, energetic photons originating in the core are absorbed and re-emitted at slightly less energy, in a long process towards the surface of the Sun.

It is located between the core and Convection Zone

For more information, see The Sun - Structure and Nuclear Processes.

1.152 Reflecting Telescope

A reflecting telescope is one which uses a mirror in its first stage.

See also: Refracting Telescope, Telescopes.

1.153 Refracting Telescope

A refracting telescope is one which uses a lens in its first stage.

See also: Reflecting Telescope, Telescopes.

1.154 Refraction

Generally, light travels in a straight line. However, when it passes from one medium into another of different density, it abruptly bends at the boundary. This effect, known as refraction, is what enables lenses in a telescope to bend light to a focal point.

Our atmosphere also causes an effect known as refraction. As light from a star or other object on its way to our eye encounters more and more dense air along its journey, the light is slowly bent from a straight path. The result of this is that objects are always a bit lower in the sky than they appear. At higher altitudes the effect is negligible, but near the horizon the effect can amount to a half a degree or more. The higher the pressure or lower the temperature, the stronger the effect.

"The Digital Universe" allows you to specify whether or not you want to include the effect of atmospheric refraction in its calculations. By selecting Display preferences from the "Project" Menu, you will bring up the

Display preferences window which will enable you to toggle this effect on or off.

1.155 Retrograde

The normal direction of the rotation or revolution of a body in the solar system is counterclockwise when viewed from above the object’s north pole. However, a few exceptions exist to this rule - and those exceptions are said to experience "retrograde" rotation or revolution.

1.156 Revolution

Revolution is the orbiting of a planet or other object around the Sun or other central body.

See also: Rotation

1.157 Right Ascension

Right Ascension is the angle of an object around the celestial equator, measured in hours, minutes, and seconds eastward from the vernal equinox. It is used in the Equatorial Coordinate System.

See also: Declination.

1.158 Rotation

Rotation is the spinning of a planet or other object on its axis.

See also: Revolution

1.159 Differential Rotation

Solid bodies (such as the Earth) rotate as a unit - an object located near the equator takes the same amount of time to rotate around the planet as one near the pole. On the other hand, objects which are not solid (such as the Sun, Jupiter, Saturn, Uranus, and Neptune) do not rotate as a unit. In most cases, regions near the equator rotate more quickly than those near the poles. This effect is known as Differential Rotation.

1.160 Saros

The Saros is a Babylonian lunar cycle of 6585.32 days, a period slightly longer than 18 years. At the end of this period, the Sun and Moon return to almost the same locations (as viewed from the Earth) that they occupied at the beginning of the period. As a result, solar and lunar eclipses recur approximately as before, but visible to longitudes approximately 120 degrees to the west.

1.161 Selenographic

Of, or having to do with the Moon. Selenographic coordinates on the Moon are the latitude and longitude equivalents of Earth’s geographic coordinates.

1.162 Semidiameter

The semidiameter is the apparent angular radius of an object.

1.163 Semimajor Axis

The semimajor axis is half the length of the longest distance across an ellipse. It is a standard measurement used in describing an elliptical orbit.

1.164 Sidereal

Of, or having to do with, the stars. Sidereal time is time reckoned by the apparent motion of the stars rather than the Sun. Similarly, a sidereal period of rotation is the amount of time a body takes to revolve around its axis, relative to the stars.

See also: Solar and sidereal day

1.165 Solstice

Solstices are the times in which the Sun reaches its northernmost and southernmost declinations. In the northern hemisphere, the northernmost solar declination is termed the summer solstice, and the southernmost declination is termed the winter solstice. In the southern hemisphere, the opposite is true.

1.166 Spectrum

When an object is hot, it emits electromagnetic radiation at a certain set of characteristic wavelengths. The complete set of all possible wavelengths make up the "electromagnetic spectrum" which can be summarized by the following table:

Wavelength (Å)	Frequency (Hz)	"Type" of EM radiation
>1000000	<3e12	Radio waves
1000000-7600	3.9e14-3.0e12	Infrared light
7600-3900	7.7e14-3.9e14	Visible light
3900-100	3.0e16-7.7e14	Ultraviolet light
1-100	3.0e18-3.0e16	X-rays
<1	>3e18	Gamma rays

When these frequencies fall within a particular narrow range, our eye perceives the radiation as light - the color of which is dependent upon the exact frequency. This "visible" range has a wavelength falling between 3900 angstroms (violet) to 7600 angstroms (red).

An object such as the Sun emits light from a wide variety of frequencies, so that our eyes see almost all possible colors at once. The result is what we term "white" light. By using a prism or diffraction grating, however, we can break this light back up into its constituent colors - creating a spectrum. (A rainbow does exactly this, and that is why it appears to be made up of its characteristic colors).

Each element in the periodic table emits light at a certain set of frequencies. By analyzing the frequencies apparent in the spectrum of an object (known as studying its spectral lines), it is possible to deduce its chemical composition. Additionally, by measuring the slight frequency shifts in the spectrum over that observed in the laboratory, we are able to use the doppler effect to deduce its velocity relative to us.

See also: Spectral classification, Electromagnetic Radiation

1.167 Spectral Classification

Stars exhibit significant variety in their composition and temperature. They are classified according to their spectra and temperature into the following categories:

O -	Color:	Blue
	B-V Magnitude:	<-0.2
	Surface Temperature:	25000-40000 K
	Spectral lines:	Strong lines of ionized helium, nitrogen, oxygen, and metals; hydrogen lines weak
	Examples:	Zeta Orionis, Lambda Orionis, Zeta Puppis, 15 Monocerotis.
	Comments:	-Large masses -High luminosities
B -	Color:	Blue to White
	B-V Magnitude:	-0.2-0.0

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    Surface Temperature: 11000-25000 K
    Spectral lines:      Lines of neutral helium prominent (especially
                         in B2 stars); hydrogen lines stronger than
                         in type O.
    Examples:            Rigel, Spica, Regulus, Alpha Eridani
    Comments:            -Large masses
                         -High luminosities
                         -Sometimes called "Orion stars".

A - Color:               White
    B-V Magnitude:       0.0-0.3
    Surface Temperature: 7500-11000 K
    Spectral lines:      Strong lines of hydrogen, ionized calcium,
                         and other ionized metals; weak helium lines
    Examples:            Sirius, Deneb, Vega, Altair
    Comments:            -Often called "Sirian" or "hydrogen" stars.
                         -Luminosities range from 50 to 100 times that
                          of the Sun.

F - Color:               White to Yellow
    B-V Magnitude:       0.3-0.6
    Surface Temperature: 6000-7500 K
    Spectral lines:      Hydrogen lines weaker than in type A; ionized
                         calcium strong; lines of neutral metals
                         becoming prominent
    Examples:            Canopus, Procyon, Polaris, Alpha Persei.

G - Color:               Yellow
    B-V Magnitude:       0.6-1.1
    Surface Temperature: 5000-6000 K
    Spectral lines:      Numerous strong lines of ionized calcium and
                         other ionized and neutral metals; hydrogen lines
                         weaker than in type F
    Examples:            The Sun, Capella, Alpha Centauri.
    Comments:            -"Solar type" stars.

K - Color:               Orange
    B-V Magnitude:       1.1-1.5
    Surface Temperature: 3500-5000 K
    Spectral lines:      Complex, with numerous strong lines of neutral
                         metals; faint hydrogen lines; hydrocarbon bands
                         appear
    Examples:            Arcturus, Pollux, Aldebaran, Alpha Ursae Majoris.
    Comments:            -"Arcturian" stars.

M - Color:               Red
    B-V Magnitude:       1.5-1.7
    Surface Temperature: 2500-3500 K
    Spectral lines:      Numerous strong lines of neutral metals;
                         strong molecular bands (primarily Titanium oxide);
                         Spectral classification "Me" stars show bright
                         hydrogen lines.
    Examples:            Antares, Betelgeuse, Mira

N - Color:               Deep Red
    B-V Magnitude:       >1.7
    Surface Temperature: 2500 K
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     Spectral lines:      Banded spectra showing carbon compounds.
     Examples:            S Cephei, R Leporis, Y Canum Venaticorum
     Comments:            -Usually variable stars

 R - Color:               Orange to Red
     B-V Magnitude:       1.1-1.7
     Surface Temperature: 3500 K
     Spectral lines:      Similar to type N, with weaker carbon bands.
     Examples:            S Camelopardi, RU Virginis
     Comments:            May form connecting link between classes G and N.

 S - Color:               Red
     B-V Magnitude:       1.5-1.7
     Surface Temperature: 2500-3500 K
     Spectral lines:      Numerous strong lines of neutral metals;
                          strong molecular bands (primarily Zirconium oxide);
                          Hydrogen emission lines.
     Examples:            R Cygni
     Comments:            -Basically like type M stars, with Zicronium oxide
                          replacing Titanium oxide
                          -Usually variable stars.

 W - Color:               Blue
     B-V Magnitude:       <-0.2
     Surface Temperature: >50000 K
     Spectral lines:      Strong lines of ionized helium, nitrogen,
                          oxygen, and metals; hydrogen lines weak;
                          show broad emission features caused by expanding
                          gas shell.
     Examples:            Gamma Velorum
     Comments:            -Wolf-Rayet Stars
                          -Extremely turbulent atmospheres
A number is often attached after the letter to indicate a further subdivision
within each spectral type.  For example, a G2 star is hotter than a G3 star.

Prefixes and suffixes are often used to further refine the description of the
star.  For example:

 -prefix 'd':  ordinary dwarf star
 -prefix 'g':  giant star
 -prefix 'D':  white dwarf star (degenerate star)
 -suffix 'e':  emission spectrum; bright lines replace certain absorption
               lines
 -suffix 'p':  spectral peculiarities
Thus, "dM2" or "A5p" are valid spectral designations.

Additionally, Roman numerals after the spectral type often indicate the star's
"MK luminosity class", according to the following scheme:

 -Ia  Very luminous supergiant
 -Ib  Less luminous supergiant
 -II  Bright giant
 -III Normal Giant
 -IV  Subgiant
 -V   Main sequence star, Normal dwarf (like our Sun)
 -VI  Subdwarf
Thus, the complete spectral classification for our Sun is G2-V.
```

See also: B-V Magnitude, Spectral Types, H-R Diagram.

1.168 Spicule

Spicules are structures present in the Chromosphere of the Sun. These streams of gas shoot up from the Photosphere and can be 800 kilometers thick, up to 15,000 kilometers high, and last for up to 15 minutes.

For more information, see Solar Activity.

1.169 Sunspot

View Picture 1 (close-up view of a sunspot group)
View Picture 2 (full disk of Sun with sunspots)

The surface of the Sun is not uniformly bright. In regions of intense magnetic fields, "spots" seem to appear. These spots seem much darker than surrounding areas of the Sun. Despite their dark appearance, sunspots are actually still quite bright. It is only their proximity to the much brighter Sun that makes them seem dark.

The life of a sunspot can range from a few hours to several months. Those sunspots which last longer can often be observed for several solar rotations, and can be used to provide a rough verification of the differential rotation of the Sun with different latitudes.

See also: umbra, penumbra

For more information, see Solar Activity.

1.170 Supernova

A supernova (plural=supernovae) is the explosion of a star much more massive than our own Sun. Its brightness suddenly becomes 20 magnitudes greater than its previous state, shining with the brilliance of several hundred million stars. The original star is destroyed in the explosion.

Typical examples of supernovae include the Nova of 1572 in Cassiopeia, and the Nova of 1604 in Ophiuchus.

Supernovae are rare occurrences, and are only visible in our Milky Way every few hundred years, on average. But when astronomers look at other galaxies they have a better chance of finding supernovae, owing simply to the vast number of stars in galaxies.

In 1987, a supernova erupted in a nearby galaxy called the Large Magellanic Cloud, about 160,000 light years from the Earth. It was detected by Canadian astronomer Ian Sheldon, and designated SN1987A.

The following pair of photographs show the region in which the supernova occurred, both before and a few days after the explosion. The star which went supernova was identified from previous data to be a B3 supergiant.

View picture of SN1987A

See also: Nova, variable star.

1.171 Synodic

The term "synodic" means related to the alignment of three bodies, usually the Earth, Sun, and a third body such as the Moon or a planet.

For example, we often talk of the "synodic period" of planets, which is defined as the mean interval of time between successive conjunctions of planets, as viewed from the Sun.

1.172 System I

The large, gas giants in the solar system (Jupiter, Saturn, Uranus, and Neptune) do not rotate at a uniform rate - they experience differential rotation. As a result, no features on the planets can be said to be fixed in place. This creates a problem when defining where the zero meridian of longitude will be located on the object.

As a result, several systems are adopted. In addition to defining a zero meridian of longitude, the speed of rotation (length of the day) typically varies with the system chosen.

System I longitudes (only defined for Jupiter and Saturn) are based on the mean atmospheric rotation in the equatorial region of the planet.

1.173 System II

The large, gas giants in the solar system (Jupiter, Saturn, Uranus, and Neptune) do not rotate at a uniform rate - they experience differential rotation. As a result, no features on the planets can be said to be fixed in place. This creates a problem when defining where the zero meridian of longitude will be located on the object.

As a result, several systems are adopted. In addition to defining a zero meridian of longitude, the speed of rotation (length of the day) typically varies with the system chosen.

System II longitudes (only defined for Jupiter) are based on the mean atmospheric rotation north of the south component of the north equatorial belt, and south of the north component of the south equatorial belt.

1.174 System III

The large, gas giants in the solar system (Jupiter, Saturn, Uranus, and Neptune) do not rotate at a uniform rate - they experience differential rotation. As a result, no features on the planets can be said to be fixed in place. This creates a problem when defining where the zero meridian of longitude will be located on the object.

As a result, several systems are adopted. In addition to defining a zero meridian of longitude, the speed of rotation (length of the day) typically varies with the system chosen.

System III longitudes are based on the mean rotation measured by observing fluctuations in radio frequency emissions from the planet.

1.175 Syzygy

In a general sense, the word "syzygy" refers to any alignment of celestial bodies. Usually, however, it is used to refer to an opposition or conjunction.

1.176 Terminator

The terminator is the edge of the lighted region of the Moon or a planet. It is the line between day and night on the object.

1.177 Terrestrial Planet

Mercury, Venus, The Earth, Mars, and Pluto have solid, rocky surfaces. Being similar to the Earth in structure, they are classed as "terrestrial planets".

See also: gas giant planet

1.178 Topocentric

Topocentric is a reference to the user's actual position on the surface of the Earth. Since astronomical calculations usually use the center of the Earth or Sun as the origin in their coordinate systems, a correction has to be made for the slightly different view obtained from a user's true position.

Accurate topocentric calculations (such as are used in "The Digital Universe") consider the fact that the Earth is not a perfect sphere, but is in fact slightly 'bulged' at the equator. You can define your position in latitude and longitude as well as your altitude above sea level, by selecting Environment Prefs from the "Project" menu.

See also: heliocentric, geocentric

1.179 Transit

An object is said to transit another when it appears to lie against the disk of the background object. For example, when Mercury or Venus transit the Sun, they may appear as a tiny black dot on the Sun. Similarly, a moon can be observed to transit the planet it orbits around.

The next transit of Venus across the Sun will occur on June 8, 2004, but will only be visible in the sky from certain locations on Earth. Only those places experiencing day during the event will be able to witness the phenomenon. You can use "The Digital Universe" to determine if this transit will be visible from your location.

An additional meaning for "transit" is the passage of an object across an observer's meridian.

1.180 Twilight

Twilight occurs for a period of time preceding sunrise and following sunset, during which the sky is partially illuminated. There are several different stages of twilight, defined mathematically by the angular distance of the Sun's center below the ideal horizon:

```
      Name                   Angular distance below the horizon
      ----                   ----------------------------------
      Civil twilight         50 arcminutes to 6 degrees
      Nautical twilight       6 to 12 degrees
      Astronomical twilight  12 to 18 degrees
```

When the Sun is more than 18 degrees below the horizon, it no longer illuminates the sky to any significant degree.

1.181 Umbra

The word "umbra" has two meanings in astronomy. It can be the central region of a sunspot, darker than the penumbra. It also refers to the inner, dark region of a shadow. An observer in the umbra of a shadow would see the light source totally obscured by the occulting object.

See also: Eclipse, Lunar, Eclipse, Solar.

1.182 Variable Star

Some stars do not shine at a steady magnitude, but change in brightness. They may do so irregularly or periodically, with brightness variations varying from only a fraction of a magnitude to 10 magnitudes or more.

Variable stars are classified into a variety of categories, in one of three broad classes:

```
 Pulsating Variables
 -------------------
 These stars appears to be changing in size, periodically expanding and
contracting.  Associated with this is a change in brightness.
  Cepheids
  Long period variables
  Semi-regular variables
  Irregular variables
  Cluster, or RR Lyrae variables
  RV Tauri variables
  Beta Canis Majoris variables
  Dwarf Cepheids

 Eruptive Variables
 ------------------
 These stars change in brightness irregularly, often only once.  They usually
brighten dramatically for short periods of time.
  Novae
  Recurrent Novae
  Supernovae
  Dwarf Novae, or SS Cygni
  Flare stars
  R Corona Borealis stars
  Nova-like stars

 Eclipsing Variables
 -------------------
 These are systems in which two or more stars orbit one another, and
periodically occult each other.
  Algol systems
  Lyrid systems, or Beta Lyrae
  Dwarf Eclipsing systems
  Ellipsoidal variables


In addition to these categories, some astronomers consider a fourth class known
as "nebular variables".  Brightness changes in these stars are thought to
originate from nebulae surrounding, and periodically obscuring, the object.  In
addition, other variable stars are unique and cannot be conveniently
categorized.

Variable stars are denoted by a rather confusing scheme.  The first variable
star discovered in a constellation is named ‘R’, followed by the genitive name
of the constellation.  Thus, the first variable star discovered in Andromeda is
called ‘R Andromedae’.  The second variable star in the constellation is named
‘S’, and so on until ‘Z’ is reached.  Then, double letter identifications are
used.  The next variable is denoted ‘RR’, then ‘RS’, and so on up to ‘RZ’.
Then, they are named ‘SS’, ‘ST’, ... ‘SZ’, ‘TT’, ‘TU’, ... until ‘ZZ’. After
‘ZZ’, the double letter scheme continues with ‘AA’, ‘AB’, ... ‘AZ’, ‘BB’, ...
‘BZ’, ‘CC’, ... ‘CZ’ and so on until ‘QZ’, omitting use of the letter ’J’,
which might be confused as an ’I’.  This scheme allows up to 334 variable stars
in each constellation to be denoted.  If yet more stars are discovered, they
are named ‘V335’, ‘V336’, and so on indefinitely.  If a star originally had a
Bayer designation (Greek letter) assigned to it, it retains that designation.

The naming scheme for variable stars is definitely a clear example of a process
```

that had not been properly thought out from the beginning.

1.183 Algol Systems

Algol variable star systems are binary stars which are relatively far apart. As a result, the light curve remains quite flat between the dips representing eclipses.

Typical examples include Beta Persei, U Cephei, and U Sagittae.

See also: variable star

1.184 Beta Canis Majoris variable

These are bright stars of spectral type B1 to B3. Their magnitude fluctuations are not very large, and exhibit a period of only about 5 hours.

Typical examples include Beta Canis Majoris (from which the class is named), and Beta Cephei.

See also: variable star

1.185 Cepheids

Cepheid (pronounced SEFF-ee-id) variables are very bright giant stars, with highly regular periods ranging from 1 to 50 days. They are of spectral types F, G, or K.

Cepheid variables are important "yardsticks" with which to measure the universe. In 1912, Henrietta Leavitt discovered that their luminosity is directly proportional to the period of the variable. The shorter the period of its variability, the dimmer the star is. By measuring the period, they can therefore determine how bright the object is. If they measure the object's apparent magnitude (the brightness that the object appears from the Earth), they can then determine its distance. This relationship is known as the "period-luminosity" relationship.

Studies of the Andromeda Galaxy revealed that there were two different 'types' of Cepheids. Population I stars were bright, blue giants - about 1.5 magnitudes brighter than Population II stars, which were red and yellow. Astronomers can distinguish between the two types of Cepheids from the shape of their light curve profiles (a plot of brightness vs. time). This finding was significant, since it caused astronomers to recalibrate their 'yardstick', and come to the conclusion that the Andromeda Galaxy was 2 to 3 times further away than originally thought.

Examples of Cepheid variables are Delta Cephei (from which the Cepheids obtain their name), Eta Aquilae, and RT Aurigae.

See also: variable star

1.186 Circumpolar

An object is said to be "circumpolar" if it is close enough to one of the celestial poles that it never appears to rise or set from the latitude it is being observed at. For an observer north of the equator, an object is circumpolar if its declination is greater than (90 - the latitude). For an observer south of the equator, an object is circumpolar if its declination is less than (-90 - the latitude).

1.187 Cluster

A cluster is a grouping of stars in the sky. Most known clusters are located within the Milky Way.

Clusters are usually divided into one of two categories:

Globular Clusters
Open Clusters

1.188 Dwarf Cepheid variable

These are similar to RR Lyrae variables, but have smaller brightness fluctuations and shorter periods (usually less than 6 hours).

Typical examples include CY Aquarii and SX Phoenicis.

See also: variable star

1.189 Dwarf Eclipsing variables

These are rapidly rotating dwarf stars in a binary system. They are so near to each other that their surfaces are nearly touching, and often have periods of less than a day. They appear as variable stars due to mutual eclipses of the two components.

Typical examples include W Ursae Majoris and U Pegasi.

See also: variable star

1.190 Dwarf Novae, or SS Cygni variables

These are hot dwarf stars which suddenly brighten by up to 5 magnitudes and then return to normal brightness over a period of about a week, repeating the process with a period of a few months.

Typical examples include U Geminorum and SS Cygni (which gives the class its name).

See also: variable star

1.191 Ellipsoidal variables

These are binary star systems which do not eclipse one another (as seen from our vantage point on Earth), but instead vary in brightness due to the changing amount of surface seen. They are rapidly rotating, and thus quite ellipsoidal in shape.

A typical example is Zeta Andromedae.

See also: variable star

1.192 Flare Stars

These are faint red dwarf stars which suddenly brighten several magnitudes over a period of just a few minutes.

Typical examples include UV Ceti, DO Cephei, and Alpha Centauri C (Proxima Centauri, the nearest star to our solar system.).

See also: variable star

1.193 Irregular variables

These are stars, of any spectral type, which do not have a consistent period in their variability. Sometimes this class is merged with the
Semi-regular variables.

Typical examples include Betelgeuse and Mu Cephei.

See also: variable star

1.194 Long period variables

This are red giant stars, of spectral type M, R, N, or S. They pulsate with periods of from 75 to 700 days or more, ranging in brightness over 5-6 magnitudes. The periods are more or less regular, though they can fluctuate by several days.

Typical examples of long period variables include Omicron Ceti (Mira), Chi Cygni, R Leonis, and R Hydrae.

See also: variable star

1.195 Lyrid systems, or Beta Lyrae variable stars

These eclipsing variables are usually giant stars which are quite near to each other as they orbit. Tidal forces and rapid rotation distort the stars into ellipsoids, creating a light curve which is continuously varying with alternate maxima and double minima.

Typical examples include Beta Lyrae (after which the class derives its name), and 68 Herculis.

See also: variable star

1.196 Nova-like stars

These are a class of irregular variables, with strange spectrae showing features of both a red giant and a blue dwarf. They brighten suddenly, at unpredictable intervals.

Typical examples include R Aquarii, Z Andromedae, and BF Cygni.

See also: variable star

1.197 R Corona Borealis variables

These unusual variables behave like an ‘inverse’ nova. Normally, they remain at reasonably bright levels, but can fade by up to 8 magnitudes quite suddenly at unpredictable intervals. Over a period of several months, the star gradually regains its former brightness.

Stars of the R Corona Borealis class are typically giants of various spectral types.

A typical example includes R Corona Borealis, the star from which the class derives its name.

See also: variable star

1.198 Recurrent Nova

Recurrent novae are those novae which have shown two or more outbursts. They also exhibit smaller amplitudes, shorter maxima, and a more rapid return to normal brightness than ‘normal’ novae.

Typical examples include T Corona Borealis, RS Ophiuchi, and WZ Sagittae.

See also: variable star

1.199 Cluster, or RR Lyrae variables

These variable stars range in brightness of about one magnitude, with a typical period of less than a day. They are of spectral type A or F, and experience a rapid rise in brightness followed by a slow decline.

All RR Lyrae stars have the same average absolute magnitude of about 0.6. Astronomers can use this fact to determine the distance to such a star by measuring its apparent magnitude and comparing it to its absolute magnitude.

A typical example is the star from which the class derives its name - RR Lyrae.

See also: variable star

1.200 RV Tauri variable

These are pulsating giant stars with two or more periods of variability. If a plot of the light from the star vs. time is made (a "light curve"), we see one wave with a period of between 30 to 150 days superimposed over another, longer wave with a period of three to four years.

Typical examples include RV Tauri (from which the class is named) and R Scuti.

See also: variable star

1.201 Semi-regular variables

These are red giant stars, similar to the Long period variables, but with unpredictable variations in their period.

Typical examples include Alpha Herculis, W Cygni, and Rho Persei.

See also: variable star

1.202 Vernal Equinox

The vernal equinox is the intersection of the ecliptic and the celestial equator that the Sun passes on its way north.

See also: autumnal equinox, Motion of the Sun

1.203 White Dwarf

White dwarves are stars which have exhausted their nuclear supply of fuel and have shrunk down to a size about that of the Earth. The only thing keeping them from shrinking further is the push of electrons against adjacent atoms. Neutrons and protons still have the room to move around freely.

If the mass of a stellar core is greater than 1.4 times that of the Sun, a white dwarf will not form. Instead, compression will continue and a neutron star or black hole will develop.

The density of a white dwarf is about 1 tonne per cubic centimetre. They are formed as the outer layers of a red giant star expand outwards to make a planetary nebula.

See also: Stellar Remnants.

1.204 Anomalistic Year

An anomalistic year is the amount of time it takes for Earth to return to perihelion. In 1990, this took 365.25964 days.

See also: Besselian Year, Eclipse Year, Gaussian Year, Julian Year, Gregorian Year, and Sidereal Year.

1.205 Besselian (Tropical) Year

A Besselian, or tropical year is the period of one complete revolution in right ascension of the fictitious mean Sun.

In 1990, this unit of time was 365.2421897 days long.

See also: Anomalistic Year, Eclipse Year, Gaussian Year, Julian Year, Gregorian Year, and Sidereal Year.

1.206 Eclipse Year

An eclipse year is the amount of time it takes for the Moon to pass through its ascending node twelve times. In 1990, this took 346.62005 days.

See also: Anomalistic Year, Besselian Year, Gaussian Year, Julian Year, Gregorian Year, and Sidereal Year.

1.207 Gaussian Year

A Gaussian year is the amount of time it would take for an object in a circular orbit at a distance of precisely 1 AU to go around the Sun. It is equivalent to 365.25690 days.

See also: Anomalistic Year, Besselian Year, Eclipse Year, Julian Year, Gregorian Year, and Sidereal Year.

1.208 Gregorian Year

A Gregorian year is that used by the Gregorian calendar, 365.2425 days long.

See also: Anomalistic Year, Besselian Year, Eclipse Year, Gaussian Year, Julian Year, Sidereal Year, and leap year.

1.209 Julian Year

A Julian year is that used by the Julian calendar, 365.25 days long.

See also: Anomalistic Year, Besselian Year, Eclipse Year, Gaussian Year, Gregorian Year, Sidereal Year, and leap year.

1.210 Sidereal Year

A sidereal year is the amount of time it takes for the Earth to return to the same position in its orbit with respect to the stars. It is equivalent to approximately 365.25636 days.

See also: Anomalistic Year, Besselian Year, Eclipse Year, Gaussian Year, Gregorian Year, and Julian Year.

1.211 Zenith

The "zenith" is the point directly overhead an observer.

See also: nadir.

1.212 ZHR (Zenithal Hourly Rate)

The ZHR, or Zenithal hourly rate, is the maximum number of meteors an ideal observer would see in perfectly clear skies during the peak moment of a meteor shower if the radiant were directly overhead. Though usually a real observer will see fewer meteors than this, short-lived "meteor storms" could reach rates of several times the ZHR.

The ZHR is useful when comparing the relative intensity of different meteor showers.

See also: meteor showers

1.213 Zodiac

Traditionally, the zodiac consists of a set of 12 constellations through which the Sun, Moon, and planets pass during the course of a year. Actually, this region of sky contains many portions of additional constellations, and because of precession, the Sun is no longer in the constellations associated with the "traditional" dates at those times.

1.214 Zodiacal light

Most of the objects in the solar system orbit the Sun in more or less the same plane - a region known as the ecliptic. As a result, there is more meteoritic material and dust located there than elsewhere in the solar system.

Sunlight reflects off these particles and produces a faint band of light stretching across the sky. Generally, it is extremely dim, requiring a dark site and well-adapted eyes for observation. It appears triangular in shape with the base on the observer's horizon and the apex and different altitudes depending on conditions. It is most easily visible from locations near the Earth's equator on spring evenings and autumn mornings.

A similar patch of light occurs directly opposite the Earth from the Sun, known as the gegenschein.

1.215 Zone

A zone is a bright band in the clouds on giant planets such as Jupiter.

See also: belt

1.216 Gadgets & Requesters

A "Gadget" is a graphic box or other such object which you can click with the mouse button, enter information, or perform some other kind of activity in a graphic user interface. If the object is something which is activated by clicking the mouse pointer on it, it is often called simply a "Button". On the other hand, a "Requester" is the terminology usually used to refer to a box in which you may type or choose information.

These concepts are extremely popular with modern operating systems using a graphic user interface, and as a result, almost all computers use some form of them. Unfortunately, the terminology varies between computer platforms; the terminology described here is specific to the Amiga computer.

1.217 Hypertext

If you’ve managed to read this far, you’ve begun to get a bit of a feel for what hypertext is all about. In its simplest form, hypertext allows the reader to read information about a subject in a manner which is most intuitive to them (and not the author).

Hypertext documents have ‘links’ to other areas of documentation which the user may follow in any order they wish. Links are represented on the Amiga (with Amigaguide) by text within a button, and the reader follows a link merely by clicking the mouse button on it. To backtrack, just click on the ‘Retrace’ button at the top of an Amigaguide window.

1.218 Radio Button

Sometimes "The Digital Universe" requires the user to select between one of several different "operating modes". A common way to do this is to present the user with "radio buttons" - a list of the different modes with little buttons to the left. The user can select the mode by simply clicking in the button beside it. Only one mode can be selected at a time.