ASTRONOMY FROM A-Z

APPULSES

When a planet approaches a star closely, the event is called a planetary appulse. This is a rare happening, and the actual occultation of a star (9th magnitude or brighter) occurs even less often. The planets take up very little space in the sky; even mighty Jupiter has an angular diameter of only 50 second of arc when closest to Earth. The chance of such a tiny area shutting off the light from a bright star is indeed slight. Yet, it does happen. Venus occulted Regulus in 1959, and in the period 1959 through 1964, Saturn has twice occulted stars, once in 1960 and again in 1962. These rare occasions are of considerable astronomical interest and receive a good deal of attention.

ASTEROIDS

Asteroids, also called minor planets, are small rocky bodies moving in an elliptical orbit around the sun. An estimated 50,000 asteroids exist ranging in size from about 600 miles in diameter down to boulder size. They are too small to have atmospheres and their sun-scorched and meteorite-pounded dusty surfaces would be hostile to all life forms. Asteroids frequently collide among themselves, producing debris that occasionally falls to Earth as meteorites.

In 1772, German astronomer Johann Bode predicted an undiscovered planet would be in orbit around the sun between Mars and Jupiter. A group called the "Celestial Police" was organized to search for this body. In 1801, an independent Italian astronomer discovered the first asteroid Ceres. Within the next few years Pallas, Vesta, and Juno were discovered. These four are considerably brighter than the rest. By 1890, 300 asteroids had been found. After that time photography was used in finding and identifying the orbits of asteroids. About 2,500 now have precisely know orbits.

Asteroids are classed in three groups according to their orbits: the Apollo and Amor groups, and the Trojan asteroids. The Apollo and Amor groups have a highly elliptical orbit. At their farthest points (aphelion) they are in the main belt between Mars and Jupiter; at their closest point to the sun (perihelion) they move between the inner planets. Some asteroids have come close to Earth and chance of collision is only approximately a million to one. The Trojan asteroids move in the same orbit as Jupiter. It is also believed that some of the smaller of Jupiter's moons may be asteroids captured by Jupiter's gravity. The two moons of Mars, Phobos and Deimos are also believed to be captured asteroids. About 90% of asteroids studied have surfaces resembling either carbonaceous meteorites, normal stony, or stony-iron meteorites.

Wilhelm Olbers first suggested that the asteroids might be fragments of a disrupted planet. A few may be the remains of a short-period comet. But the general opinion now is that, at the origin of the solar system, a cloud between two and four times the Earth's distance from the sun formed an original family of perhaps 15 to 30 asteroids with diameters from 60 to 600 miles. Collisions among these led to the highly fragmented system now visible, with only Ceres, Pallas, Vesta, and possibly and handful of the original bodies surviving intact.

BINARY STARS

Binary or double stars are stars which to the naked eye appears as a single point of light, but when viewed through a telescope are found to be composed of two or more stars. The stars may be connected gravitationally (binary stars), or they may simply happen to lie nearly in the same direction. A binary star is said to be a visual binary if the components may be resolved in the telescope and their orbital motion detected by positional measurement; a spectroscopic binary if it is detected from the periodic doubling and displacement of lines in its spectrum; or a photometric binary if it is detected by the periodic variations in its magnitude (variable stars). A binary star may fall into more than one of these categories. The orbital periods range from a day or two to many centuries--the visual binaries having periods of at least two years and the other two types normally having much shorter periods.

It is estimated that more than half of the stars in our Milky Way galaxy are components of double or multiple star systems. Double and multiple stars far outnumber deep-sky objects catalogued. More than 65,000 pairs have been listed. And yet, with the exception of a few showpieces, double stars are generally ignored by serious observers.

Our own sun would be considered part of a double star system, with Jupiter as its companion. Jupiter is a star that did not quite make it as a true star because it does not have enough mass to generate nuclear reactions. It does, however, emit more energy from its own slow contraction than it receives from the sun.

Mizar was the first double star observed in 1650 by the Italian astronomer G. B. Riccioli. Systematic observation of double stars began in 1779 with the astronomer William Herschel, who discovered the first binary star, Castor, in 1804. Until the end of the 19th century, double stars were probably the most closely and carefully studied objects in the heavens, at least by amateur astronomers.

With the discovery of faint nebulae and distant galaxies and a renewed interest in planetary observation, double and multiple star observing has been virtually forgotten. Today only four or five professional observatories are actively engaged in making double star measurements. Over a long period of time, such measurements allow the orbit of one star around the other to be reduced in order to determine the star's masses.

There are three important measurements to consider in any study of double or multiple stars; magnitude (combined magnitude and the magnitude of the component stars); separation of components (measured in seconds of arc) : and the position angle (location of the fainter component, relative to the primary star, measured in degrees) . A binary's position angle can slowly change over the years as the stars orbit one another.

Observing double and multiple stars can be both profitable and pleasing. You can squint into the eyepiece for minutes on end in an effort to split an extremely close pair or ferret out a faint star from the overpowering glare of its brilliant partner. There is no need for double stars to be neglected as an observing program. Beginning astronomers, especially, should be started on observing double and multiple stars instead of the fainter, more difficult deep-sky objects.

There might be fewer drop-outs than seems to occur when the beginner gets that initial disappointment that comes when he realizes that the beautiful and colorful object shown in the astronomy book really is that faint, undefined smudge in his eyepiece.

Bibliography - "Observing Visual Double Stars", Paul Couteau, MIT press.

CONSTELLATIONS

The celestial sphere has been divided into 88 separate regions, each of which is considered to be a constellation.

The total number of constellations that exist today were not all designated at one time, but represent contributions from many years, from various distant locations. The earliest constellations derive their origin from Mesopotamia some 3,000 to 4,000 years ago. Early Greek writings indicate about 48 constellations, most of them having been named by Ptolemy. Throughout centuries many alterations and additions were made, many of which did not survive. It was not until 1982 that the International Astronomical Union established definite boundaries for the present 88 constellations. Today we are left with the majority of constellations representing mythological characters from the thoughts of early man.

The Big Dipper is considered a classical constellation. However, in the strictest sense, the Big Dipper is not a constellation, but an asterism. An asterism is a group of stars that form a commonly recognizable shape and is part of a larger constellation or constellations. In this case the Big Dipper resembles a water dipper but is part of Ursa Major, the Big Bear. Other asterisms are the Little Dipper, the Northern Cross, and the Great Square in Pegasus.

For simplicity, constellations are divided here in separate groups:

CIRCUMPOLAR:
Ursa Major, Ursa Minor, Draco, Cepheus, Cassiopeia, Camelopardalis

JANUARY:
Auriga, Perseus, Caelum, Eridanus

FEBRUARY:
Taurus, Orion, Lepus, Columba, Canis Major

MARCH:
Lynx, Gemini, Cancer, Canis Minor, Monoceros, Puppis, Pyxis

APRIL:
Leo Minor, Leo, Sextans, Hydra, Antila, Vela

MAY:
Canes Venatici, Coma Berenices, Virgo, Crater, Corvus

JUNE:
Bootes, Centaurus

JULY:
Corona Borealis, Hercules, Serpens Caput, Libra, Scorpius, Lupus, Norma

AUGUST:
Lyra, Ophiuchus, Serpens Cauda, Scutum, Sagittarius, Corona Australis, Telescopium

SEPTEMBER:
Cygnus, Vulpecula, Sagitta, Deiphinus, Aquila, Microscopium

OCTOBER:
Lacerta, Pegasus, Aquarius, Piscis, Austrinus,

NOVEMBER:
Andromeda, Pisces, Sculptor, Phoenix

DECEMBER:
Triangulum, Aries, Cetus, Fornax, Capricornus, Grus, Equuleus

ECLIPSES

An eclipse is normally defined as the passage of one astronomical body into the shadow of another; but the term is also applied to the passage of the Moon in front of the Sun (a solar eclipse), though the event is more correctly termed an occultation of the Sun by the Moon. Solar eclipses can occur only at new Moon, when the Moon comes between the Sun and Earth. The Sun is not eclipsed at each new Moon because the Moon's orbit is inclined by about 5% to the plane of the Earth's orbit. A solar eclipse can therefore happen only when the new Moon occurs near the two points where the lunar and terrestrial orbits cross (called the Nodes).

When the Moon is near its most distant position from Earth (apogee), the tip of its conical umbra (dark central shadow) falls short of the Earth's surface by up to 20,300 miles. This produces a so-called annular eclipse, in which the dark disk of the Moon is surrounded by a bright ring (annulus) of sunlight. When the Moon is at its closest (perigee), its umbra covers a strip along; the Earth's track, in the outer partial shade called the penumbra, observers over several thousand miles see a partial eclipse. Total solar eclipses last longest when the Sun is at; its greatest distance (aphelion) and therefore appears smallest (early July), and the Moon is near perigee; this circumstance produced the longest eclipse of modern times, 7 minutes 14 seconds on June 30, 1973.

Lunar eclipses occur when the Moon passes into the Earth's shadow, which it can do only at full Moon, when it is opposite the Sun in the sky. At the mean distance of the Moon, the Earth's shadow is about 5,700 miles wide. A total lunar eclipse can last for up to 100 minutes, plus a further two hours during the Moon's passage in and out of the shadow. Around this central umbra is the penumbra (diameter 10,200 miles), in which the sunlight is only partly cut off by the Earth; taking this into account, a lunar eclipse as a whole can last up to nearly six hours. Because the atmosphere refracts sunlight into the Earth's shadow, the totally eclipsed Moon usually appears a dull copper color; variations are caused by changing atmospheric transparency. Lunar eclipses are rarer than solar eclipses, but since they can be seen where-ever the Moon is above the horizon, they are about equally frequent to any given observer. There are seldom more than two lunar eclipses in a year while there may be up to five solar eclipses.

Because the motions of the Earth, Moon, and Sun have been precisely calculated, eclipses can be accurately computed far into the past or future.

GALAXIES

Almost without exception, galaxies appear to be diffuse glows of light. Very few are resolved at all. Most galaxies are in the spring sky, they form a band from Ursa Major through Canes Venaciti, Coma Bernices, and Virgo. There is an area just east of Beta Leonis called the "Realm of Galaxies". Many nights can be spent in this area alone just identifying galaxies visible in a six inch or eight inch telescope in the country. Galaxies almost outnumber all other types of objects combined. Galaxies are divided in the following categories:

1) ELLIPTICAL (E) -- are featureless and smooth, perceptibly brighter in the center than at the edges. Nearly round examples of this class are designated EO, with numbers increasing as the ellipse flattens. Thus E7 is assigned to elliptical galaxies so spread out they are lenticular or lens shaped.

2) NORMAL SPIRAL (S) -- are made up of bright nuclei with spiral arms developing at a tangent from opposite points on the nucleus. Young spirals (Sa) have arms which are close in to the nucleus, middleaged (Sb) spirals have more extended arms, and the oldest type (Sc) have widespread arms.

3) BARRED SPIRAL (SB) -- look somewhat like the normal type except that the spiral arms extend from opposite ends of a band of glowing material which extends across the nucleus.

4) IRREGULAR (I) -- follow none of the patterns mentioned above. There are two types, resolvable and unresolved. The former show some detail in the form of granulations, bright patches, dark areas, and the like. The latter are smooth textured and featureless.

GRAZES

When a star appears to slide along the moon's limb near the poles (a grazing occultation), its light flashes as it passes behind lunar mountains and reappears in valleys. The occultation or grazes of planetary satellites asteroids, and radio sources by the moon gives precise information about their sizes and position. When observing and recording information on a graze the following data should be listed in your log:

(1) Designation of the star, asteroid, etc. (use a catalog number, map designation, or the system given in the graze prediction)

(2) Date and UT of the graze. Accurate timing of disappearance and reappearance of a star.

(3) Longitude, Latitude, and elevation of your observing point.

(4) Stellar magnitude, whether the graze occurred at the dark or bright limb, and whether observed at immersion or emersion.

(5) Seeing conditions.

(6) Instrument detail: type and aperture of telescope, magnification used, etc.

METEOROIDS, METEORS, and METEORITES

Meteoroids are chunks of matter in space ranging in size from tiny particles to boxcar size. When one of the smaller particles, the size of a grain of sand or smaller, darts into our atmosphere and is heated to incandescence, we see a streak in the sky called a meteor or "shooting star". Part of the light may come from the glowing meteoroid, but most of it comes from the ionized air particles with which it has collided. At the height above the earth where meteors appear, 40 to 80 miles, the atmosphere is very thin and is easily ionized into a glowing streak. Bolides are particles large enough to produce a brilliant flash and leave a trail that lasts for some few seconds. Sometimes these are accompanied by an explosion which sounds like thunder. Finally, if a large chunk gets all the way through the atmosphere and strikes the earth, the object is called a meteorite.

Because meteors are caused by debris left from the passage of a comet, the tiny particles are moving in an orbit just as the parent comet was and with approximately the same speed. On any dark night, an observer can expect to see half a dozen meteors, but the total number that might be seen in any 24 hour period from all points on the earth reaches an unbelievable figure of approximately 90 million. Most of these are sporadic meteors in the sense that they don't come from any particular point in the sky. Radiant meteors all seem to come from a specific sky area and are seen when the earth intersects with the path of a comet. When the paths of these meteors are traced backward, they all intersect in a small area called a radiant.

"Meteor showers" are on the nights the earth travels through the comet debris, when the six or eight meteors a night become closer to 60 per hour. Some showers in the past have recorded 1,000 per hour.

Meteor showers are usually named for the constellation in which the radiant lies, but sometimes may take on the name of the parent comet. The meteors which originate in Draco in June are called the Draconids. In October there is another shower from the same constellation; these are named for the parent comet and are called

Giacobinids. Some meteor showers are very brief, lasting only a single night, but many extend over a period of several days or even weeks.

Although sand-sized grains of matter burn-up in the atmosphere, pieces larger than this may get through without destruction. These fall to earth as meteorites. There seems to be no upper limit to their size. The object that created the Barringer Crater in Arizona (4,100 ft. across,600 ft. deep) was estimated to weigh anywhere between 12,000 to 63,000 tons. Even this is small compared to the Chubb Crater in Ungava which is three miles in diameter.

Meteorites fall roughly into three categories:

(1) Aerolites - the stony meteorites. These are rarely very large and are made up of earthy materials, silicates, and compounds of magnesium with tiny particles of nickel-iron alloys called chrondules imbedded in them.

(2) Siderites - the metallic meteorites. Composed of 80-90 percent iron, 5-15 percent nickel, with occasional small amounts of cobalt1 the siderites pepper the Earth in all sizes. The great craters in Africa, Canada, United States, Russia, and Australia were all created by siderites, yet they can also be as small as an ounce or two.

(3) Siderolites - the 'iron-stone' meteorites. Much rarer than the other types, the siderolites are spongy arrangements of iron ores in which the spaces are filled with minerals. They have a mottled often pitted appearance.

Tiny particles called micro-meteorites can also penetrate our atmosphere without damage. These are falling continuously on us at an estimated rate of 10,000 tons daily. This amounts to about 4 ozs. per square mile per year.

Most meteoroids are connected with comet debris but the larger ones are presumed to be minor asteroids. It is believed that a planet much like Earth existed in an orbit between Mars and Jupiter. It either exploded or had a collision with another heavenly body thereby sending debris in every direction. This theory could account for meteorite showers, the pockmarked surfaces of Mars and our Moon, the great craters in the Earth's surface, and even for micrometeor dust.

OBSERVING METEORS

Meteors are naked-eye objects, but you need a dark and open area as far away from city lights as possible.

(1) Meteors will appear all over the sky but try to check for a common "radiant" point.

(2) In a good shower meteors will range in magnitude from dim streaks to bright flashes. Try to compare their brightness to close stars with known magnitudes.

(3) Count the number of meteors in prearranged time periods. Remember most showers peak around or after midnight.

(4) Bolides should be checked as carefully as possible for brightness, color change, length of path in degrees, altitude above the horizon, persistence of the trail, and time of occurrence.

ANNUAL METEOR SHOWERS

Name	Dates	Rate	Associated Comet
Quadranids	Jan. 3	40/hr	
Lyrids	Apr. 15	15/hr	1861 I Thatcher

Eta Aquarids	May 5	20/hr	Halley
Draconids	Jun. 28	12/hr	Pons-Winnecke
Delta Aquarids	Jul. 28	20/hr	
Perseids	Aug. 12	50/hr	1862 III Swift-Tuttle
Orionids	Oct. 21	20/hr	Halley
Taurids	Nov. 6	15/hr	Encke
Andromedids	Nov. 14	10/hr	Biela
Leonids	Nov. 17	15/hr	Temple
Geminids	Dec. 12	60/hr	
Ursids	Dec. 22	15/hr	Tuttle
Giacobinds	Oct. 9	10/hr	Giacobini-Zinner

OCCULATI ONS

An occultation is the passage of Earth's moon between the Earth and a major astronomical object, such as a planet, star, or star group.

Timing occultations comes under the heading of useful fun for amateurs. Enough accurate reports on a given occultation provide a real addition to astronomical knowledge, since this is one of the most convenient and accurate methods of determining the moon's position. One might think that centuries of lunar observation would have evolved an accurate table for determining where the moon may be found for any instant of time, yet differences between its calculated and observed positions still exist.

For timing occultations, telescopes of any size or type may be used. The only other required equipment is an accurate timepiece, since the instant of immersion and emersion must be determined to the nearest second. The observer must also know the latitude and longitude of his observing site and its height above sea level. To set your timepiece accurately, tune in a short-wave radio to one of the standard time signals.

The data in your logbook should include:

(1) Designation of the star (use a catalog number, map designation, to the system given in the occultation prediction guide).

(2) Date and UT of occultation of one second accuracy.

(3) Longitude, latitude, and elevation of your observing point.

(4) Stellar magnitude, whether the occultation occurred at the dark or bright limb, and whether observed at immersion or emersion.

(5) Seeing conditions.

(6) Instrument details: type and aperture of telescope, magnification used, etc.

PULSARS

Pulsars are a radio source that emits short pulses of radiation at very regular intervals, typically of about a second. The radiation is produced by a very small and dense neutron star, which rotates and "flashes" a beam of radio waves like the beam of a lighthouse.

Pulsars were discovered accidentally in 1967 by Bell and Hewish, who were investigating the scintillation (twinkling) of distant radio sources. The regular pulses seemed so artificial that they were first called "The Little Green Men" signals. The hypotheses that a rotation neutron star could be producing the impulses was confirmed 1968 when a pulsar was discovered in the Crab Nebula (the debris of a star that exploded in 1054).

The radiation at all wavelengths is produced by electrons moving in the neutron star's magnetic field, which is a trillion times as strong as the Earth's field. This SYNCHROTRON RADIATION travels outward in a beam, causing the pulsar to flash as it rotates.

Over 100 pulsars have now been discovered and their periods range from 1/30 of a second to about 3 seconds.

The electrons in space between the pulsar and the Earth slow down the radiation, so the different wavelengths from each pulse arrive at different times. The measured delay between wavelengths reveals the distance of the pulsar. Most pulsars lie in the disk of our galaxy, where the stars and gas are concentrated, and are at distances of 300 to 30,000 light-years from the Sun.

Although their time keeping is almost as good as that of atomic clocks, many are slowing down at a rate of about a billionth of a second per day as they radiate away their energy. This provides a key to the pulsar's age. The Crab pulsar is found to be about 1,000 years old, in good agreement with the date of the supernova outburst. Most pulsars, however, are millions of years old.

RADIO ASTRONOMY

Radio Astronomy is the study of radio emissions of celestial objects by measurement and analysis of the electromagnetic radiation they emit in the wavelength ranging from l mm to 30 m. Because radio astronomy signals are weak it is necessary to use large collecting surfaces.

Much of the progress made in our understanding of the universe has been due to discoveries made using radio astronomy.

Radio astronomy started in 1932, with Karl Jansky's investigations of the cause of the crackling sounds heard in short-wave transmissions. He discovered that the interference was at a maximum when the aerial pointed to a region in the sky in the constellation of Sagittarius.

Ten years later Grote Reber located further radio sources in Cassiopeia and Cygnus. He also found that our own Sun was source of radio waves.

Today, radio astronomers study an entire range of celestial objects, including stars, planets, galaxies, quasars, pulsars and x-ray sources.

Radio telescopes have been used to map the skies and determine the positions and intensities of individual sources of radio emissions. Knowing the position, astronomers can refer to optical photographs of the sky. Most radio sources have remained unidentified; that is, no optical object has been seen in the location of the radio source, concluding that these source are at such great distances that they cannot be seen optically.

Radio astronomy seems to provide a more complete sampling of objects in the universe than does optical astronomy. As such, it may be a tool for investigating cosmological questions, such as questions about the origin of the universe.

The following are the strongest radio sources:

M31-Adromeda Galaxy
NGC 1275-Galaxy in Perseus
Taurus A-in Crab Nebula in Taurus
Puppis A-peculiar nebulosity in Puppis
Virgo A-Elliptical Galaxy M87

SOLAR SYSTEM DATA

	Diameter (miles)	Distance from Sun (millions of miles)	Time to Orbit	Time to Rotate
Mercury	3100	36	88 days	59 days
Venus	7700	67	225 days	244 days
Earth	7920	93	365 days	24 hrs
Mars	4200	141	687 days	24 hrs 24 mins
Jupiter	88640	483	11.9 years	9 hrs 50 mins
Saturn	74500	886	29.5 years	10 hrs 39 mins
Uranus	32000	1782	84 years	23 hrs
Neptune	31000	2793	165 yeas	15 hrs 48 mins
Pluto	1500	3670	248 years	6 days 7 hrs