

The A-Z of Astronomy

Patrick Moore was born in 1923, and read his first book on astronomy six years later. When still of school age he was elected to the British Astronomical Association, and concentrated on observations of the Moon. During the war he flew as a navigator in the Royal Air Force; subsequently he set up his private observatory in Sussex and now lives in Selsey. Between 1965 and 1968 he was Director of the Armagh Planetarium in Northern Ireland.

Every month since April 1957 Patrick Moore has presented the BBC Television programme *The Sky at Night*, and he is also a frequent broadcaster on radio. He is Director of the British Astronomical Association Lunar Section and the Association's Goodacre Medallist. His hobbies include cricket, music and chess. He was awarded the OBE in 1968.

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Patrick Moore

Diagrams by Cyril Deakins

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Foreword

A complete dictionary of astronomy would be a very large volume indeed. In this brief 'A–Z', I have made no attempt to be complete, and I am well aware that many terms of importance have been left out; however, I hope that the result will be useful for quick reference.

In the text, an asterisk indicates that the term so marked is described under its own separate heading.

The Planetarium, Armagh, 1966

Foreword to the Revised Edition

"Much has happened in the world of astronomy since this book was first published, so I have taken the opportunity to bring the text up to date. I am most grateful to Michael Foxall and to Hilary Rubinstein for all their help and encouragement.

Selsey, 1975

PATRICK MOORE

A

Aberration of Starlight. The apparent displacement of a star from its true position in the sky, due to the fact that light has a definite velocity (186,000 miles per second) and does not move infinitely fast. A good analogy is to picture a man walking along in a rainstorm, holding up an umbrella to shield himself. To keep dry, he will have to slant the umbrella forward, as shown in the diagram (Fig. 1); in other words, the raindrops will seem to be coming at an angle, instead of straight down. In the case of starlight, the aberration effect is due to the movement of the Earth, which is travelling round the Sun at an average velocity of $18\frac{1}{2}$ miles per second; thus the starlight seems to come 'at an angle'. The apparent positions of stars may be affected by up to 20.5 *seconds of arc.



Fig. 1. Aberration

Absolute Magnitude. The *magnitude that a star would seem to have if it were observed from a distance of 10 *parsecs, or 32.6 *light-years. (See *Magnitude*.)

Absorption of Light in Space. It was formerly thought that space must be completely empty. This is now known to be wrong; there is a vast amount of thinly-spread interstellar matter, so that the light coming from distant objects is partially absorbed.

Achromatic Lens. A lens corrected for chromatic aberration, so that 'false colour' is reduced.

Adams, John Couch (1819–1892). Great English mathematical astronomer, chiefly remembered for his correct prediction of the position of Neptune – though the actual discovery of Neptune was made on the basis of similar calculations by the French astronomer *Le Verrier.

Adams, Walter S. (1876–1936). American astronomer; Director of *Mount Wilson Observatory from 1923 to 1946. His main work was in stellar spectroscopy.

Aerolite. A stony *meteorite.

Airglow. The faint luminosity of the night sky, due mainly to processes going on in the Earth's upper atmosphere.

Airy Disk. The apparent size of a star-disk produced by a perfect optical system —since the star can never be focused perfectly, 84% of the light will concentrate into a single disk, and 16% into a system of surrounding rings.

Airy, Sir George Biddell (1801–1892). The seventh Astronomer Royal, who was appointed to the post in 1835 and retired in 1881. He was a great administrator, though somewhat autocratic! He made many notable contributions to astronomy, and was responsible for raising Greenwich Observatory to its present position of eminence.

Aitken, Robert (1864–1949). A great American observer of double stars, and one-time Director of the *Lick Observatory.

Albedo. The reflecting power of a planet or other non-luminous body; the ratio of the amount of light reflected from the body, to the amount of light which falls on to the body from an outside source. A perfect reflector would have an albedo of 100%.

Alcyone. The brightest star in the *Pleiades.

Algol. The prototype *eclipsing binary.

Alpha Centauri. The nearest of the bright *stars; distance 4.3 light-years. It is a fine binary, but too far south to be seen from

Europe. Its faint companion, Proxima, is slightly closer to us (4.2 light-years).

Altazimuth Mount. A type of telescope mount upon which the instrument may swing freely in any direction (Fig. 2). Small telescopes are often mounted in this way, but a larger telescope is better fitted with an *equatorial mount.

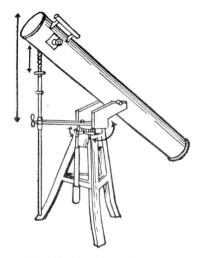


Fig. 2. Altazimuth mount

Altitude. The angular distance of a celestial body above the horizon. At the overhead point or *zenith, the altitude is 90° ; at the horizon, the altitude is 0° .

Amalthea. The innermost satellite of Jupiter; it is the closest to the planet of the Jovian satellite family, but has a diameter of only about 150 miles. It was discovered by Barnard in 1892.

Ananke. The twelfth satellite of Jupiter.

Andromeda Galaxy. One of the nearest of the external starsystems or *galaxies. It is dimly visible to the naked eye; photographs with large telescopes show it to be spiral in structure. It lies at a distance of 2·2 million *light-years, and is considerably larger than the Galaxy in which we are situated. The galaxy is officially known as M.31, since it was the 31st object in a famous catalogue drawn up by the French astronomer Charles Messier in 1781.

Ångström Unit. The unit for measuring the wavelength of light, X-rays and other electromagnetic vibrations. It is equal to one hundred-millionth part of a centimetre. The wavelength of visible light ranges between about 3900 Ångströms (violet) and 7500 Ångströms (red). The unit is named after the last-century Swedish physicist Anders Ångström; the official abbreviation is Å, though often written simply as A.

Antoniadi, Eugene M. (1870–1944). Greek-born astronomer who spent most of his life in France, and became the most distinguished planetary observer of his time. He was particularly noted for his studies of Mercury and Mars, carried out mainly with the 33-inch refractor at the Observatory of *Meudon.

Antares. The leading *star in Scorpio; a Red Giant over 250,000,000 miles in diameter. Its name means 'the Rival of Mars'. It has a small greenish companion which is a radio source.

Apennines. The most conspicuous mountain range on the *Moon. It borders the Mare *Imbrium.

Aphelion. The position in the *orbit of a planet or other body when furthest from the Sun. For instance, the Earth is at its furthest point, or aphelion, in early July, when its distance from the Sun is $94\frac{1}{2}$ million miles; at its closest to the Sun, in early January (*perihelion) the distance is only $91\frac{1}{2}$ million miles. Similarly, *apogee* refers to a body moving round the Earth; the Moon is at apogee when at its greatest distance from us.

Areography. The physical study of *Mars (from Greek, Ares).

Ariel. The first *satellite of Uranus.

Aristarchus (BC 310–250). Born at Samos. Greek astronomer, who believed the Earth to be in motion round the Sun, and who made a noble attempt to measure the distances of the Moon and Sun.

Armagh Observatory. The leading observatory in Northern Ireland, founded in 1790.

Armillary Sphere. An old type of instrument which may be described as a 'skeleton' of the celestial sphere.

Artificial Satellite. A man-made vehicle put into a path or *orbit round the Earth. It is launched by rocket power; once it has been put into a stable orbit it will not come down unless it spends any part of its time within the resisting part of the *atmosphere, in which case it will be affected by friction against the airparticles and will gradually have its orbit changed until it reenters the lower atmosphere and is destroyed. Of course, an artificial satellite may be brought down deliberately in a controlled descent, as has happened with many of the Russian vehicles – and, needless to say, with all man-carrying satellites!

The first artificial satellite, Sputnik I, was launched by the Russians on 1957 October 4: this may be said to mark the real beginning of the Space Age. Many more have followed, most of which have been launched by the Americans or the Russians, though a few have come from Britain, Italy, China, Japan and France. The first US satellite, Explorer I of 1958, was of special importance, since its instruments detected the zones of intense radiation round the Earth now known as the *Van Allen zones.

Artificial satellites have been put to many uses. They have been invaluable sources of information about Earth's resources, and they are also used daily as communications relays for both radio and television. Instruments carried in satellites have studied phenomena such as *cosmic rays, *meteoroids, *ultraviolet and *X-radiations from space, and so on. Meteorological satellites have led to a great advance in our knowledge of the weather systems, and have also done great service in giving advance warnings of potentially dangerous storms developing out at sea. Many lives have been saved in this way.

Some of the artificial satellites have been very bright – notably the two Echo balloon vehicles of the 1960s. Most, however, are considerably fainter, and look like slowly moving stars.

Ascending Node. This is described under the heading *Nodes.

Ashen Light. When the planet *Venus appears as a crescent, the 'night' side sometimes appears dimly luminous. This is known as the Ashen Light. Its cause is not certainly known; some authorities believe it to be a sheer contrast effect, but more probably it is a genuine phenomenon. There is no comparison with the *earthshine seen on our Moon, since Venus has no satellite.

Asteroids. An alternative name for the *Minor Planets.

Astræa. The fifth *asteroid, discovered by Hencke in 1845. It is considerably smaller than the first four members of the swarm.

Astrograph. A telescope designed specifically for astronomical photography.

Astrolabe. An instrument used by ancient astronomers to measure the *altitudes of bodies in the sky. An astrolabe consisted of a circular disk marked off in *degrees along its rim; the star or planet was sighted by means of a movable arm, with the astrolabe held suspended in a vertical position, and the altitude read off upon the scale.

Astrology. The so-called 'science' which attempts to link human destinies and characters with the positions of the planets against the starry background. It is still widely practised in some countries, notably India; but it has no scientific foundation whatsoever, and has long since been completely discredited. It should never be confused with true *astronomy.

Astronautics. The science of space research, using either unmanned vehicles or manned space-ships. It is a modern development, since it is only since the end of the war that rockets have become powerful scientific tools instead of mere toys; but since 1957 it has become of fundamental importance, and has provided information which could not possibly have been obtained in any other way.

Astronomical Unit. The distance between the Earth and the Sun; in round figures, 93,000,000 miles. The mean distance from the Earth to the Sun has now been found to be slightly less than this (92,957,209 miles or 149,598,500 km) but the astronomical unit is still conventionally kept as 93,000,000 miles.

Astronomy. The science dealing with the bodies in the sky. It began in prehistoric times, when our remote ancestors gazed up at the stars and formed them into fanciful *constellations; but its real development began with the Greeks, who drew up excellent star catalogues, measured the size of the Earth, and studied the movements of the Sun, Moon and planets. Unfortunately, most of them made the mistake of supposing that the Earth must lie in the centre of the whole universe.

*Ptolemy, last of the great astronomers of ancient times, died about AD 180, and for some centuries after this little progress

was made. A revival came with the Arabs of a thousand years ago, and at last interest in astronomy was re-kindled in Europe. In 1546 Copernicus, a Polish churchman, published a book in which he rejected the Greek theories of the universe, and claimed that the Earth is nothing more than a planet moving round the Sun. Arguments about this vitally important problem went on for more than a century, but the work of great scientists such as Galileo and Kepler, followed by Sir Isaac Newton's researches into the effects of *gravitation, finally settled the matter in favour of Copernicus.

Telescopes were invented in the early 17th century, and were used astronomically by Galileo in the winter of 1609–10. Though Galileo was probably not the first telescopic astronomer, he was certainly the most skilful, and he made a series of spectacular discoveries; for instance he observed the satellites of Jupiter, the phases of Venus and the countless stars in the Milky Way. With the construction of more powerful telescopes, progress in astronomy became rapid, and during the 18th and 19th centuries came the development of astronomical *photography and the *spectroscope: More recent still are *radio astronomy and *rocket astronomy.

Modern astronomy is, of course, basically mathematical, and the professional astronomer does very little direct observation at the eye-end of a telescope. Amateurs still carry out useful work with relatively modest equipment, but any student wishing to make a career as a professional astronomer must make sure that he (or she) is a first-class mathematician.

Astrophysics. The branch of modern astronomy which may be defined as 'the physics and chemistry of the stars'. Further details will be found under the headings *Stars* and *Spectroscope*.

Atmosphere. The gaseous mantle surrounding a planet or other body. The Earth's atmosphere is made up of several layers; the bottom seven miles or so is known as the *troposphere, above which come more rarefied layers such as the *stratosphere, *ionosphere and finally the *exosphere, which has no hard and sharp boundary, but which simply 'tails off' into space (Fig. 3). The atmosphere may be said to extend upward for at least 2000 miles above the ground, though most of the mass of the atmosphere is concentrated in the bottom four or five miles.

The Earth, with an *escape velocity of 7 miles per second, has been able to retain a dense atmosphere. Bodies with lower escape velocities, such as Mars (3 miles per second) have thinner

atmospheres, while the Moon (escape velocity 1½ miles per second) has virtually no atmosphere at all. On the other hand, the giant planet Jupiter (escape velocity 37 miles per second) has been able to hold down even hydrogen, lightest of all the gases, so that its atmosphere is made up largely of hydrogen and hydrogen compounds.

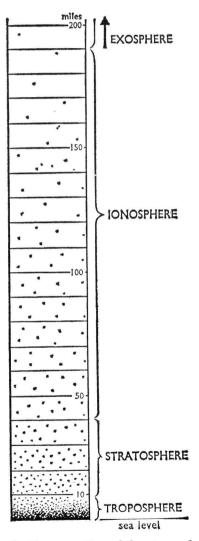


Fig. 3. Cross-section of the atmosphere

Atom. The smallest unit of a chemical *element which retains its own particular character. Each atom may be said to consist of a central nucleus, around which move particles known as *electrons; the nucleus has a positive electrical charge and the electrons have negative charges, the two balancing each other and making the complete atom electrically neutral. Modern atomic theory is highly complicated, and it is quite misleading to suppose that an atom is a miniature Solar System, made up of solid lumps, but it is almost impossible to give a useful description in non-technical language.

Atoms may link up to form atom-groups or *molecules; thus a molecule of water is made up of two hydrogen atoms combined with one oxygen atom, so that its chemical formula is the familiar H_2O .

Aurora. Auroræ are the lovely Northern Lights (Aurora Borealis) and Southern Lights (Aurora Australis). They occur in the Earth's upper atmosphere, and are due to charged particles sent out by the Sun, which penetrate the outer air and produce the beautiful glows. The process is not yet completely understood, and is connected with the zones of trapped particles in the *Van Allen Zones. At any rate, auroræ are linked with events taking place in the Sun; a brilliant solar *flare, which emits charged particles, is likely to be followed by a display of aurora about 24 hours later.

Because the particles are magnetic, they tend to move toward the Earth's magnetic poles. Consequently, auroræ are best seen in the polar regions. In North Norway, Iceland and even North Scotland, auroræ are common during the winter; in South England, brilliant displays are rare, and in low latitudes auroræ are almost (though not quite) unknown. Obviously, auroræ are commonest when the Sun is at its most active. The next solar maximum is not due until about 1980.

Azimuth. The angular bearing of an object in the sky, measured from north (0°) through east (90°), south (180°) and west (270°) back to north (360° or 0°). Due to the Earth's rotation, the azimuths and *altitudes of all celestial bodies change constantly.

B

Baade, Walter (1893–1960). A German-born astronomer who spent most of his life in the United States. He made many notable contributions to stellar astronomy, and discovered the error in the *Cepheid scale which led to a doubling of the estimated distances of the *galaxies.

Baily's Beads. Brilliant points seen along the edge of the Moon's dark disk at a total solar *eclipse, just before and just after actual totality. They are caused by the Sun's light shining through valleys on the limb of the Moon, between mountainous regions.

Baily, Francis (1774–1844). English amateur astronomer, best remembered for his observations of *Baily's Beads at the total solar eclipses of 1836 and 1842.

Balloon Astronomy. From the Earth's surface, some types of astronomical observations cannot be carried out, because we are looking at the sky through a dense layer of atmosphere. For instance, it proved to be impossible to detect water-vapour in the atmosphere of the planets Mars or Venus, because the light from these bodies had to pass through our own atmosphere – which contains considerable water-vapour, and masks the traces of water-vapour in the atmospheres of other worlds.

One solution is to send up instruments in balloons to heights of 85,000 feet or so, above most of the Earth's air. Several very successful ascents have been made during the last few years, and there can be no doubt that balloon astronomy has an important future. Though it is naturally limited in scope, it has two great advantages over *rocket astronomy: balloons are easy to control, and are also easy to recover intact, together with their instruments and all their scientific records. Moreover, they are cheap!

Barnard, Edward Emerson (1857–1923). American astronomer, noted for his observations of planets and for his comet discoveries. In 1892 he discovered *Amalthea, the fifth satellite of Jupiter.