are irregular in shape, the refractive varies as they rotate, and thus the spin rate has been calculated in more than 50 examples.

On the surface of planet Earth different materials are found to possess a wide range of albedo. For example, snow is 4.0 to 0.8 and clouds are similar, 0.4 to 0.8. (Europe, one of Jupiter's moons, displays an albedo comparable to snow.) The total albedo of the Earth averages about 0.39 but is a constantly changing variable because of clouds, soil moisture, vegetation, oceans (sea state), sea ice, snow, glaciers and so on (Fairbridge, 1967). Although clouds are constantly changing, the mean cloudiness of the Earth is almost stable at about 50%. Thus snow cover, sea ice and vegetation are the three biggest variable factors in terrestrial albedo. The surface of water, the Sun near zenith, has an albedo of about 0.02, i.e. 98% incident radiation is absorbed, but at a low angle of incidence it can be 0.8-0.9. Forest is usually around 0.04 to 0.1, and green fields up to 0.15.

Albedo is thus easily changed on planet Earth by anthropogenic activity. Generally, such changes are inadvertent, but Block (1964, noted in Fairbridge, 1967, p. 17) cited examples in China and Peru where drought conditions were relieved by spreading coal dust on glacier surfaces, thereby reducing rapid melting. In public relations, volcanic ash showers over ice caps could trigger brief glaciation events. On the planet Mars the large orbital eccentricity favors a regular build-up and decay of snow-white polar caps (CO2 ice), thus creating a fluctuating albedo and the consequent planetary climate state. Mercury, because of its highly eccentric and inclined orbit, displays a correspondingly variable albedo.

Rhodes W. Fairbridge

Bibliography

Cross references
Atmospheric Science
Marc: remote sensing
Opposition effect

ALFVÉN, HANNES OLOF GÖSTA (1900-1995), AND ALFVÉN WAVE

Distinguished Swedish astronomer and specialist in plasma physics, Alfvén earned his PhD at the University of Uppsala in 1934 and was awarded the Nobel Prize for physics in 1970. He was long associated with the Royal Institute of Technology in Stockholm, as professor of electronics, then electronics and later (1963-1973) of plasma physics. Key publications by Alfvén include his Cosmical Electrodynamics (1944), On the Origin of the Solar System (1950), Atom, Man and the Universe (1969) and Cosmic Plasma (1981), jointly with Gustaf Arrhenius, are the fundamental works of the Solar System, which was issued by NASA as a special publication (No. SP-345, 1976).

Alfvén waves

At very low frequencies a plasma may be considered a low-density, perfectly conducting fluid. In the presence of a static magnetic field, physical displacement of the charged particles can launch magneto-hydrodynamic waves. Mechanical motion of the particles sets up an electromagnetic wave and current; the currents, in turn, interact with the magnetic field, modifying the motion of the particles. When the background magnetic field strength B0 is large and the medium μ in low, the characteristic velocity of these waves V = B0/√(4πnμ0) is large enough that significant energy transport can occur. Alfvén originally proposed that such waves might move energy from the Sun's interior to the photosphere and be partly responsible for tides. Alfvén waves may also be found in the solar wind and in planetary magnetospheres.

Simultaneous solution of Maxwell's equations and the continuity equation for a perfectly conducting medium yields a vector expression involving only the small amplitude velocity perturbations of the plasma particles. There are four solutions for B. One solution describes a compressional wave that can travel both along and across the magnetic field. This wave is called the fast magnetoacoustic mode because it is the fastest of the four modes. In this wave the magnetic and density compression are in phase. The second mode is a transverse perturbation of the magnetic field that travels the field but compresses neither the field nor the plasma density. It is mostly called the Alfvénian cyclotron mode, but it is often referred to as the intermediate mode or shear Alfven wave. The third mode is the slow mode with oscillation in which the density and the field compression are generally out of phase. In general it is the slowest of the three propagating modes. The fourth mode is referred to as the energy wave in MHD and the mirror mode in kinetic analysis. This wave exhibits total pressure balance across the magnetic field and does not propagate.

Interaction of the transverse wave with the magnetic field may be likened to oscillations on an elastic string. The curvature in the magnetic field provides a restoring force. Figure 1A illustrates a fast magnetoacoustic wave moving perpendicularly to the field and an Alfvén wave moving along it. In the former case both the magnetic field and the charged particles become compressed. In the latter the field oscillates and the wave moves parallel to the field but neither the field nor the particles are compressed. If the medium is not perfectly conducting, the oscillations will be damped. In media such as solar plasma, field strength are large and densities low, yielding high Alfvén velocities with relatively little damping. If a disturbance propagates through a plasma at greater than the velocity of any of the three propagating waves, a collisionless shock may be formed. Whereas conventional acoustic shocks transfer energy largely through collisions of particles at the shock front, in the plasma in which shocks occur associated with Alfvén waves occur, the density of the medium is very low and collisions are unimportant. Instead it is the electric and magnetic fields of the 'collisionless' shock that provide the dissipation required.

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Bibliography

Cross references
Plasma
Plasma wave
Solar wind
AMOR OBJECT

AMOR objects are a subset of near-Earth asteroids (see Near-Earth objects), distinguished from the Apollo objects (p.) and Aten objects (A.) by characteristic orbital elements. Amor objects have orbital semi-major axes greater than that of Earth (i.e. somewhat greater than 1 astronomical unit). The first member of this class, asteroid Amor, discovered in 1902 by E. Delporte. The best known member

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