Comet Ikeya-Seki 1965 VIII, a typical Sun-grazing comet, photographed shortly after perihelion passage by Alan McClure on 1965 November 1, from Mount Pinos, California

numerous than previously thought, although there is the possibility that such close-approach comets tend to occur in groups. Both these 'colliding' comets and other Sun-grazers follow practically identical orbits and are thus probably fragments of individual objects.

A distinction may be drawn between cometary periods which are of thousands or even millions of years and those which are comparable with the planets'. The division is somewhat arbitrary, but is generally taken as being at about 200 years, and there are suggestions that planetary influences are responsible for a large number of the short-period orbits. Comets which have periods equal to, or shorter than Jupiter's have been captured from longer-period orbits by the planet, which has also caused a gap in the periods, similar to those in the planetoid belt and Saturn's rings.

Table 5·21 gives some details of typical cometary orbits.

Appearance and composition

At great distances from the Sun, comets are small, faint, indistinct objects, but as they approach, volatile materials begin to be vaporized to produce the main head or **coma**. At times this may become exceptionally large; in the Great Comet of 1811, for example, the diameter exceeded 2×10^6 km (nearly one-and-a-half times that of the Sun). The tail may begin to develop at a considerable distance, as happened with Comet Schuster 1976c, which has the greatest perihelion distance known (6·882 au, that is, beyond Jupiter) but which nevertheless had a moderate tail. Tails may not only be highly conspicuous (*left*), but also exceptionally long; that of the Great Comet of 1843 (a Sun-grazer) had a length of about $3{\cdot}2 \times 10^8$ km, considerably greater than the mean distance of Mars from the Sun. At times, a small star-like point, or **nucleus**, may be seen in the centre of the coma, and, occasionally, multiple nuclei develop. A further feature, which can only be observed from spacecraft, is a vast hydrogen halo surrounding the visible portions of the comet.

Despite their apparent size even the largest comets may have total masses of only 5×10^{16} kg (less than one-millionth of that of the Moon). Observations of recent comets confirm that the main parts are small, with diameters of the order of 10 km, and that they are concentrations of ice and dust particles – graphically described as 'dirty snowballs'. Variations in the rate at which the volatile materials are vaporized and gases released easily account for the observed changes in brightness of the head and in the structure of the tail.

Many molecules can be detected in cometary spectra, including water vapour and molecules such as hydrogen cyanide (HCN) and methyl cyanide (CH_3CN), which are also found in interstellar space (see p. 182). In the early stages of a comet's approach the light is reflected and scattered sunlight, but later the appearance of emission lines indicates that various elements have been vaporized by solar radiation. Within cometary tails there are usually two distinct components, one of which is ionized gas and its direction is controlled by the solar wind, while the other is usually comparatively featureless and consists of electrically neutral gas and dust.

The mass lost by a comet may amount to as much as 1 per cent per orbit, and short-period comets are seen to become noticeably and progressively fainter. Some even lose most of their volatile materials. This implies that even long-period comets cannot have followed their present orbits since the formation of the Solar System and that they are comparatively recent introductions.

Cometary particles are known to be responsible for many meteor showers, but the density of a cometary tail is so low that passage of the Earth through it (as happened with Comet Halley in 1910) is not likely to produce any observable effects. On very rare occasions, collision with the main body of a comet may be expected, and this is almost certainly the explanation for the brilliant fireball and immense explosion which occurred on 30 June 1908 in the Tunguska River area of Siberia. Trees were uprooted as far away