Table 5·21 Cometary orbits

name and designation*		perihelion distance (au)	eccentricity	period† (yr)	inclination
Gt. March Comet	1811 I	1.035412	0.995124	—	106.9397°
Gt. Comet (Flaugerges)	1843 I	0.005527	0.999914	513	144.3484°
P/Halley	1910 II	0.587211	0.967298	76.1	162.2160°
Stearns	1927 IV	3.683902	0.998179	—	87.6574°
P/Temple-Tuttle	1965 IV	0.981730	0.904396	32.9	162.7092°
P/Perrine-Mrkos	1968 VIII	1.272212	0.642630	6.72	17.7619°
Bennett	1970 II	0.537606	0.996193	—	90.0437°
P/Encke	1974 —	0.338125	0.847450	3.30	11.9820°
West	1975n	0.196630	0.999955	—	43.0710°
Schuster	1976c	6.882188	1.0‡	—	112.0176°

* Periodic comet designations are those of the last (or a recent) return. P/ before a comet's name denotes that this is a short-period comet, i.e. one whose period is less than 200 years. Apparitions of P/Halley can be traced back to 86 BC, and P/Halley and P/Encke have been well observed since 1682 and 1786 respectively.

† Periods are not given where they exceed 1000 years. ‡ Assumed parabolic orbit.

as 40 km, and the pressure waves recorded as far off as the British Isles, while vast quantities of meteoric dust remained suspended in the upper atmosphere for months. Yet no major fragments have ever been found, only microscopic iron and silicate particles having been recovered from the soil. These results are consistent with an encounter with the head of a small comet largely composed of ice and small solid particles.

Meteors and meteorites

At the end of the eighteenth century it was finally recognized that meteors (the so-called 'shooting stars') were produced by small bodies burning up in the Earth's atmosphere, and that meteorites were remnants which had survived to reach the Earth's surface. These terms have continued to be used and recently **meteoroid** has become widely employed for particles in space, while **fireballs** are meteors brighter than magnitude – 5.

Visual observations can give useful information about the number and direction of meteors, but increasing reliance is now placed upon photographic and radar methods of detection. Although the mass of a meteor is about 0·1–1g, in passing through the atmosphere it forms a trail of ionized gas which is an efficient radar reflector and may be detected during the day, giving valuable information about meteor rates which would otherwise be unobtainable. All three types of observation can give information about the height at which meteors occur (80–50 km), while radar and photographic techniques enable the velocity of some meteors to be obtained. From information about the direction and speed of meteoroids, their orbits may be established, and in every case these have proved to be elliptical, showing that they originate in the Solar System.

Meteor showers

Meteors are noticeably more frequent at certain times of the year, when they form meteor showers. These objects have tracks which appear to diverge from a single small area of the sky, known as the **radiant**, but this is an optical effect; they are actually travelling along parallel paths. The showers are usually named from stars close to the radiant position, or the constellation in which this is situated, as with the κ Cygnids and the Perseids. Examination of the orbits of showers shows that they are similar to those of short-period comets; the Bielids, for instance, following the path of the lost Comet P/Biela. The shower meteoroids are composed of cometary debris spread out along the parent cometary orbits and the showers occur when the Earth passes through the meteoroid streams. However, planetary perturbations can cause rapid changes in these orbits, causing sudden alterations in the number of meteors encountered by the Earth. Moreover, variations in meteor rates occur due to differences in density in various parts of the streams, while meteor storms may be observed if the Earth intercepts a compact cluster of particles recently derived from the parent comet. Such an event happened on 17 November 1966 when the Leonid rate became as high as 150 000 per hour, due to a dense cloud derived from Comet P/Tempel-Tuttle 1866 I about 100 years earlier.

Sporadic meteors and micrometeorites

Non-shower meteors occur at all times of the year with a rate of about eight per hour, and are known as **sporadics**. Very occasionally their analysis has revealed a hitherto unknown radiant and shower, but the majority are clearly the widely dispersed debris of extinct comets. A similar origin is responsible for the minute particles known as **micrometeorites**, which are so small that they do not burn up when they encounter the Earth's atmosphere. Their deposition rate over long periods of time may be studied by examination of cores from ocean sediments and polar ice caps.

Vast numbers of such tiny particles exist in interplanetary space, reflecting sunlight and producing the **zodiacal light**, which is a diffuse, weakly luminous area of sky, appearing ellipse-shaped and centred on the Sun. It is only visible under favourable conditions in the evening after the end of twilight, or in the morning before the dawn. As the ellipse lies along the ecliptic its visibility varies greatly with the seasons and the observer's geographical latitude. On occasions, a luminous area known as the **gegen-**