longitudes on the planet and also with Io's position in its orbit.

Quite apart from the aurorae detected by Voyager 1, both Voyagers recorded lightning discharges on the planet, as well as picking up the accompanying radio emissions.

The rings

One of the most surprising discoveries made by Voyager was the existence of a system of rings around Jupiter. These are quite unlike the extensive rings of Saturn, which accounts for the fact that they had not been discovered previously, although they have since been detected from the Earth. They are very tenuous – Pioneer II even passed through them at the time of its Jupiter encounter in 1974 without suffering any damage – and the total thickness is probably less than 1 km. The main rings are quite narrow and occur in two bands, the outer, brighter one lying between about 52 200 and 53 000 km from the top of the atmosphere. The fainter inner belt is about 5 000 km wide and extends down to about 47 000 km. However there is also a very tenuous population of particles which extends all the way down to the cloud tops. All the particles are very dark, and they are thought to be very small rocky grains. Their origin is unknown, but they must be continually renewed, perhaps from the small satellites found to be orbiting just outside the rings, as their orbits must slowly decay and bring them down into the atmosphere.

Satellites

The two small satellites orbiting at the edge of the rings were not the only objects discovered by Voyager. One other small body (since named Thebe) is certain, and there are at least another three suspected objects. But the four large satellites, which prior to the Voyager missions were poorly known, having only the vaguest discernible markings, have now been revealed as distinctive objects in their own right. It has long been known that they were the size of small planets, but what was surprising was the fact that they are all different.

It was certainly not expected that the innermost, Io, would prove to be the most volcanically active body in the Solar System, with as many as eight vents active at any one time. Despite the fact that Io should undergo more intense meteoritic bombardment than any of the other satellites, due to the 'focusing' effect of Jupiter's gravitational field, not one impact crater can be found on any of the images returned by the Voyager cameras. This in itself would be enough to show that the surface is very young and must be geologically active, but this was confirmed by the detection of the volcanic plumes rising to between 70 and 280 km above the surface. Further examination showed the volcanic vents themselves and extensive lava flows. However, the ejected material and the 'lava' is quite unlike that of the volcanoes on Earth, as it consists of molten sulphur and sulphur dioxide. It is largely the former material which is responsible for the striking red and orange colour of the satellite, with the extensive white areas of the surface being comprised of sulphur dioxide snow.

The exceptionally high ejection velocities from the volcanoes (in some cases probably exceeding 1 000 m per s – several times greater than any found on Earth), together with the intense bombardment of the surface by energetic particles trapped in Jupiter's magnetosphere, are thought to contribute to the loss of material into space. Considerable quantities of both neutral and ionized sodium (Na), and ionized sulphur, potassium (K) and oxygen have been found in Io's torus around the planet.

A small body such as Io, which is only slightly larger than the Moon, should have long ago lost the

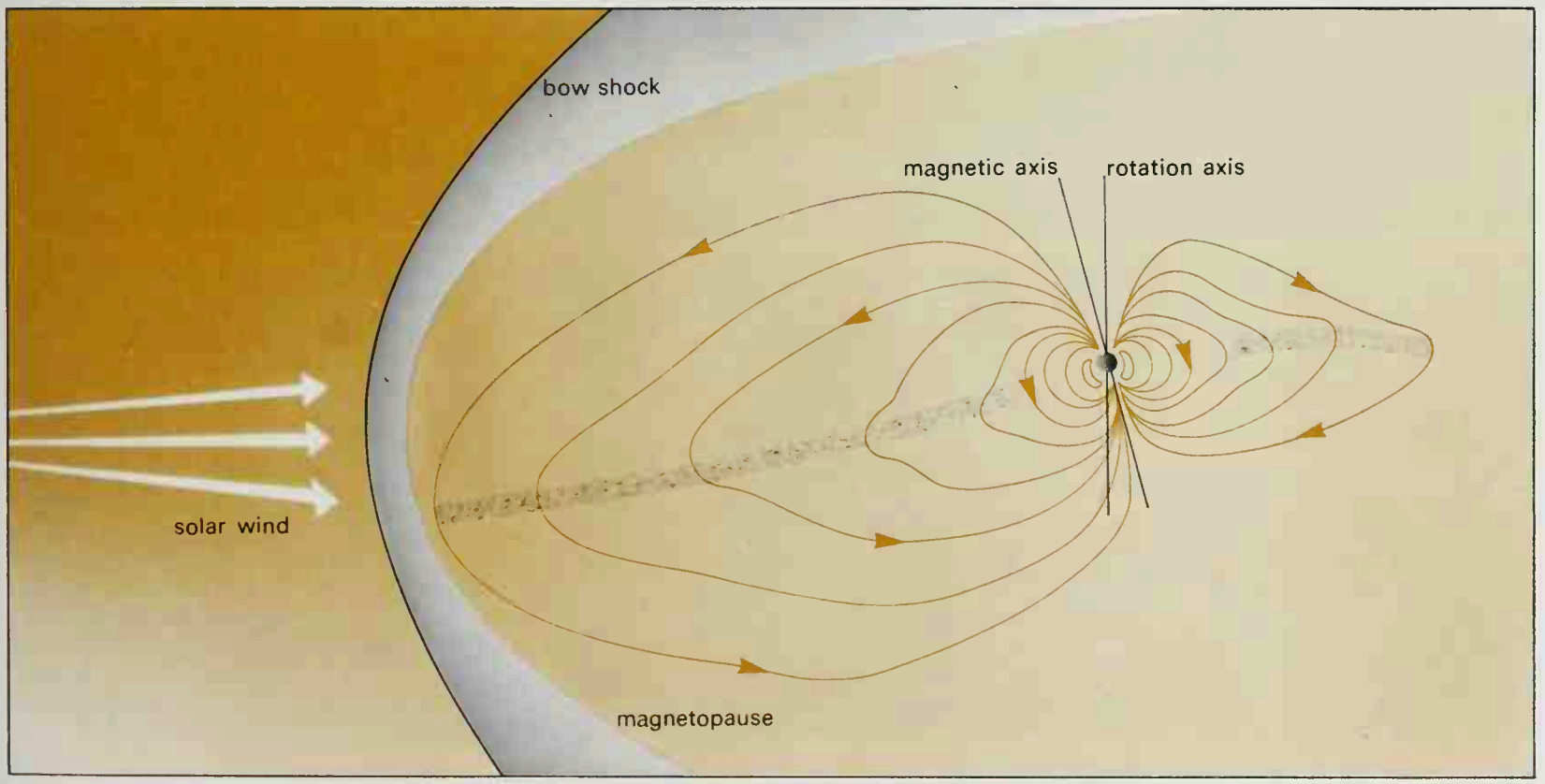

Fig. 5·17 Jupiter's magnetosphere, showing the sheet of trapped particles (stippled). This diagram is approximately to scale for a 'quiet' state of the solar wind.