with the constellations. In fact, we now know that the stars of a constellation are not physically connected, constellation patterns being purely fortuitous arrangements observed from Earth; observed from far out in space they would look entirely different. We recognize **open clusters**, like the Pleiades or the one in Scorpius, which may contain as few as 15 or 20 members, or as many as 2 000, and **globular clusters**. Visible only with a telescope, the globulars are spherically shaped concentrated collections of hundreds of thousands or even millions of stars. They contain no dust or gas, both of which may be present in an open cluster.

All these occupants of space – planets, stars, open clusters, globular clusters, the wisps of dust and gas between the stars and the vast nebulae – are all part of a giant star island, known as the Galaxy. Shaped like a pair of dishes placed rim to rim with a bulge at the centre (Fig. 1·2), it has a diameter of some 30 000 pc (30 kpc, about 98 000 light-years), and at its centre its thickness is around 41 kpc (13 000 light-years).

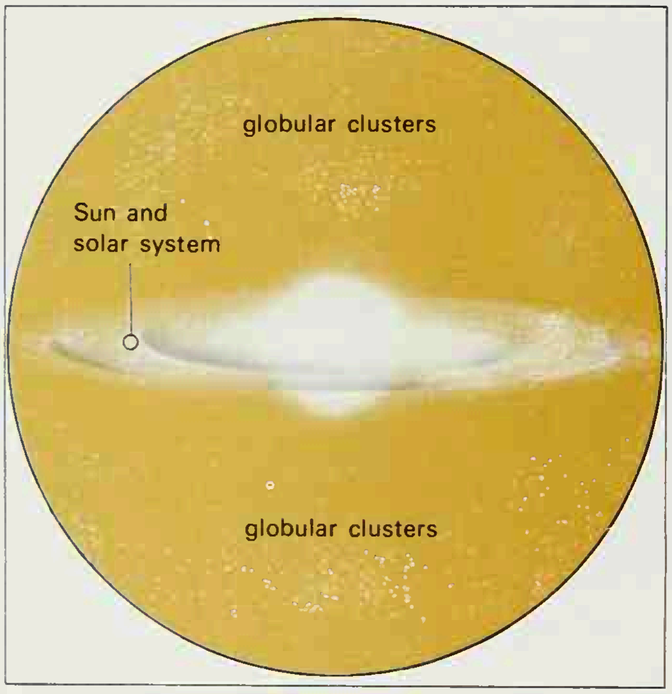

Fig. 1·2
An artist's impression of our Galaxy surrounded by a halo of globular clusters, and showing the position of the Sun and the solar system.

The Sun, with its planetary system, is situated rather more than 10 kpc from the centre of the Galaxy, a little nearer to the edge than we are to the centre. When we look towards the rim or the centre we are seeing the denser regions of the central plane, the regions we call the Milky Way. The star associations, open clusters and nebulae lie mainly in the plane of the Galaxy, but not so the globular clusters. These lie around the Galaxy, forming a kind of spherical halo, also about 30 kpc in diameter. The main part of the Galaxy is not only disc-shaped: observed from outside it would look like a giant catherine wheel or pin-wheel, with the Sun lying in one of its spiral arms.

In spite of the fact that the Galaxy contains some 100 000 stars, to say nothing of the gas and dust in it, it is nowhere near the whole of the universe; it is only a minute unit among literally millions of other galaxies. Some of these galaxies are spirals like our own, others have no spiral arms but seem to be merely giant conglomerations of stars having little or no dust and gas. There are still others which are irregular, like the two Magellanic Clouds which can be seen from the southern hemisphere, and also a number that are small but intensely active, emitting atomic particles, radio waves and other radiation. All are moving outwards into space, so that it seems as if the entire universe is expanding, probably having once begun as a tiny compact mass of material which exploded out into space ten or twenty thousand million years ago.

To obtain the kind of picture of the universe we now have has meant centuries of painstaking observation and measurement, and the precise expression of the results of this work in numbers. This obsession of astronomy with numbers is vital if the science is not to be one of pure speculation, as a simple question such as whether or not the stars are fixed in space will show. In 1718 Edmond Halley (of Halley's comet fame) compared his observations of three stars with observations made in Greek times. He found discrepancies too gross to be put down to observing errors, and was forced to conclude that these stars had actually moved in space. What was true of his three stars has been found to be true of all stars.

Today we refer to the motion of an individual star as its **proper motion**, which is defined as its motion across the sky. It is measured in arc seconds because the movement is very small; Barnard's star, which has the greatest proper motion of any star, moves only 10·3 arc sec. per year. Proper motion, however, does not specify the entire motion of a star; there is still the question of a star's movement towards or away from us. Such **radial motion** cannot be observed directly because stars are too far away to show any noticeable change in size when they approach or recede. The spectroscope, a device unknown in Halley's time, has to be used to determine this.

To reach his conclusions Halley had to measure star positions carefully; he also had to express them in numerical form, just as the Greeks had done. The way they did so was very similar to that used today, and is the method we shall adopt in the text of this

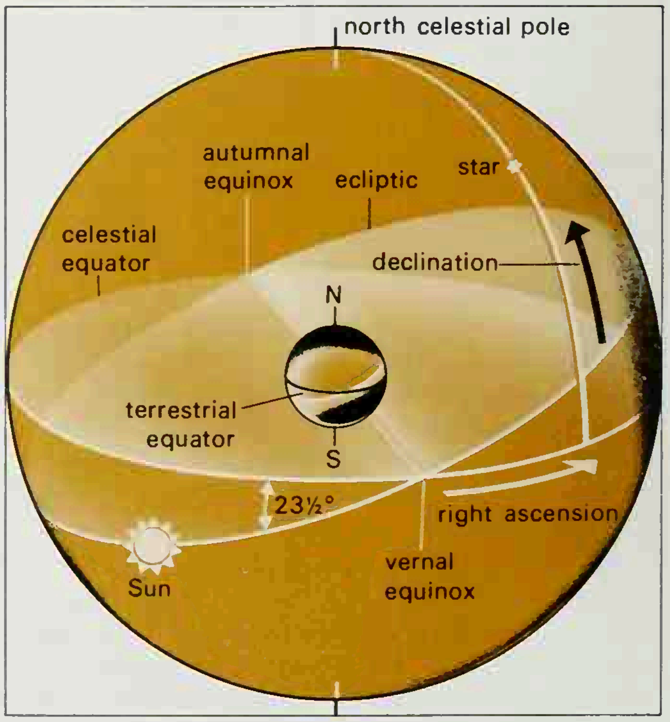

Fig. 1·3, far right: Celestial co-ordinates from which the positions of celestial objects can be specified precisely.