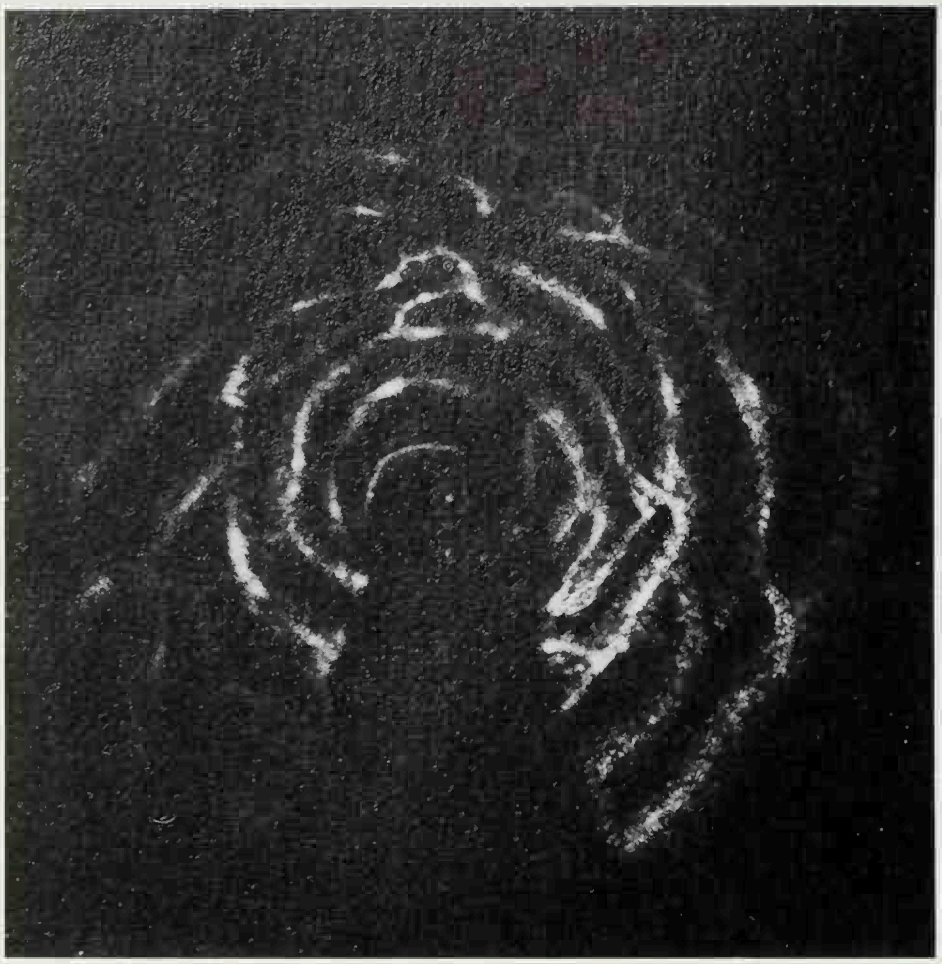

Radio surveys at a wavelength of 21 cm reveal our Galaxy to be spiral in form. The sun lies in the position circled; the region opposite it is blank because the hydrogen there does not show a Doppler shift (due to the Galaxy's uniform circular rotation) and so no information about its distribution can be obtained.

known for some time, but understanding of them has only come through research with the highly successful IUE (International Ultraviolet Explorer) satellite. This has shown the presence of very hot gas clouds with temperatures as high as 10^5 – 10^6 K at distances of at least 5 000 pc from the galactic plane; there are indications that they may extend out to about 8 000 pc on each side. It now appears that intense heating caused by supernova explosions causes 'fountains' of hot gas to rise into the outer regions of the Galaxy, and that cooler gas is flowing back towards the galactic plane. The considerable mass of gas at such distances forms the **galactic corona,** and similar coronae have been shown to exist around other galaxies.

The structure and distribution of the Galaxy's disc is revealed by a study of the hydrogen distribution. A radiotelescope pointing in a direction within 90° of the galactic centre is receiving radiation from all along a long line stretching right across the Galaxy. All the hydrogen clouds in this line of sight are orbiting the centre of the Galaxy at different radii from it, and simple geometry shows that the highest-velocity cloud is that situated where our line of sight passes closest to the galactic centre. By looking for the highest velocity in the hydrogen spectrum, we can thus find the rotational velocity of a cloud at that particular distance from the galactic centre. A different line of sight lets us measure the velocity of a cloud at a different distance from the centre; and by building up observations in this way it is possible to construct the **rotation curve** of our Galaxy. This curve simply shows how the orbital velocity of a gas cloud (or a star) in a circular orbit around the Galaxy depends on its distance from the centre.

One immediate use of the rotation curve is in determining the total mass of our Galaxy. Using Newton's law of gravitation, it is relatively easy to calculate the mass of the Sun, for example, by knowing the Earth's orbital velocity and the Earth–Sun distance. Unfortunately, the situation is rather more complicated with the Galaxy, for the Sun is not orbiting just a central compact body, it is moving in the gravitational field of all the stars in the Galaxy. The rotation curve does allow us to make a reasonable estimate, although the result depends on exactly how the mass of the Galaxy is distributed. Within the orbit of the Sun (radius 10 kpc) the Galaxy contains about 10^{11} $M_\odot$; and although it is not possible to measure directly the rotation curve outside the Sun's orbit, the matter further out is estimated to raise the Galaxy's total mass by another 50 per cent.

Armed with the Galaxy's rotation curve, the distance to any H I cloud can be calculated from its radial velocity and its angular distance from the galactic centre. The distribution of clouds so obtained clearly show the spiral arms of the Galaxy far beyond the region mapped by optical spiral arm tracers.

Present theories of spiral structure indicate that the material making up a spiral arm is just passing through it: there is a spiral gravitational pattern, or **density wave**, which bunches up stars and gas as they travel around the galactic centre. Since this gravitational pattern must affect the gas velocity by some 10 km per s, speeding it up as it enters the arm, and slowing it down on leaving, distances derived simply from radial velocities are not exact. The positions of distant spiral arms are thus not known as accurately as was once hoped, but the spiral nature of our Galaxy is established beyond doubt by the H I observations.

The galactic centre

The picture of our Galaxy which we have built up is a calm and orderly one, and until recently there was little reason to question this view. The first indications that matters might be different came to light in the late 1950s, when radioastronomers first mapped the H I distribution in the Galaxy. All the spiral arms so far discovered had been found to be smoothly rotating about the galactic centre. In particular, all hydrogen clouds along the line of sight from the Sun to the centre of the Galaxy had zero radial velocity, just as would be expected on a uniformly rotating model. But in 1957 Jan Oort, working in Holland, found two clouds of H I lying in this direction which did have significant velocities along the line of sight. In addition to their normal rotation, these clouds actually appeared to be moving outwards from the galactic centre, one towards and the other away from us. Further work established that the closer feature was an armlike extension of gas (called the **3 kpc arm**, after its estimated distance from the centre), and that the cloud on the far side of the centre was expanding outwards at 135 km per s (hence its name of the **+ 135 km per s feature**).

The following years saw great improvements in radioastronomy methods, and the consequent discovery of several smaller 'expanding' features in the direction of the galactic centre. Some even appeared