Galaxies

Perhaps one of the biggest steps forward in astronomy this century came with the discovery that the system of stars in which we find ourselves — the so-called Milky Way Galaxy (Greek "galaxias" = gala-aktos, milk) — is in no way unique. The Universe is composed of billions of similar galaxies, each one of which is a separate star system in its own right made up of an enormous number of individual stars. During the nineteenth century and the first two decades of the twentieth century, however, this picture was not generally accepted.

It had long been known that many objects in the sky — even when viewed through powerful telescopes — appeared diffuse or cloudy, instead of having the point-like appearance of individual stars. But the majority view had always been that these diffuse objects were clouds, perhaps dust or gas clouds within our local system of stars. Indeed, in 1784 the Frenchman, Messier, made a catalogue of over one hundred of these diffuse objects; he called them all nebulae (the Latin for clouds). A more extensive catalogue of nebulae, the New General Catalogue, or N.G.C., was made by Dreyer * in 1887. [The Messier catalogue and New General Catalogue are still in very much use today. Many "diffuse objects" are referred to by their positions in either, or both, of these catalogues. For instance, the so-called "Great" globular cluster of stars in the constellation of Hercules is referred to either as M13 or NGC 6205].

The idea that some of these diffuse objects might be separate star systems well outside our own local system — "island universes" as they were then called — did have its advocates. But if they were to substantiate their viewpoint, they needed to measure the distance to some of these supposed extragalactic objects. Unfortunately, such measurements were difficult to obtain; none of the objects had measurable parallaxes, and there was debate over whether some of the claimed values of proper motion were more likely to have resulted from observational inaccuracies, rather than from genuine shifts of positions of the objects. [We now know that the values of proper motion were, indeed, grossly overestimated].

The matter was finally resolved in 1924 by the American astronomer, Edwin Hubble. Working with the new hundred-inch Mount Wilson reflector in California, he found that he was able to resolve individual stars in the outer regions of M31. Furthermore, he discovered several Cepheid variables among these newly-resolved stars and so proceeded to measure their periodic variation in light output. [See A.9 → 9(b)]. The matter was then no longer in doubt — M31 was clearly beyond even the largest estimated limit of our own Galaxy. Modern measurements put M31 at a distance of about 650 kpc. In addition, measurements of

* Dr. J.L.E. Dreyer, former Director of the Armagh Observatory in Ireland

the angular size of M31 show that if its distance is 650 kpc, then, its diameter must be 30 kpc. This makes it comparable in size with our own Galaxy, and enormously larger than the Orion nebula, which is a mere 5 pc in diameter.

① What is the angular size of M31?

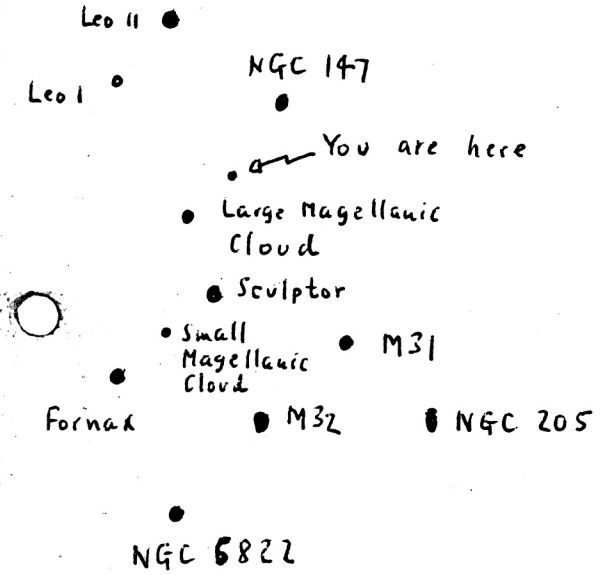
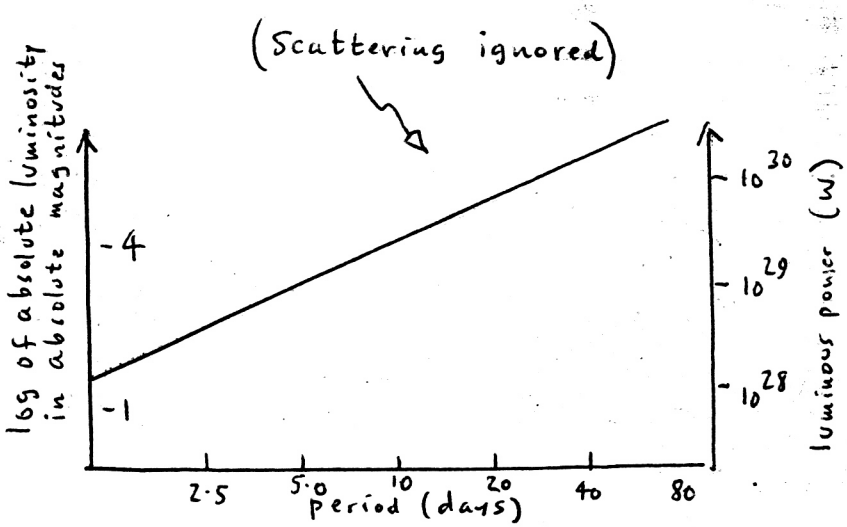


Fig. 1

The Local Group of galaxies. It is not possible, of course, to show on paper the three-dimensional distribution of galaxies in space. Here, some of our nearest-neighbour galaxies have been collapsed onto a plane, with our own Milky Way Galaxy shown at the centre. Because of this, although the distances of the galaxies relative to the Milky Way are correctly represented here, the distances between galaxies are distorted.

② Suppose an astronomer using a telescope 2m in diameter has a detector the limit of detection is 3.2×10^{-17} W. Use Fig. 2 to deduce the period of the faintest Cepheid variable that he can observe at a distance of 2×10^6 light years (1 l.y. $= 9.46 \times 10^{15}$ m)

Fig. 2



Notice that both scales are logarithmic, so the straight line implies that period $\propto$ (luminosity)^m

Hubble discovered Cepheids in other "nebulous" objects (M33 and N.G.C. 822) and showed that these, too, were beyond our Milky Way Galaxy. In the years that followed, many of the diffuse objects in the Messier and New General Catalogues were shown to be separate star systems. We now refer to all such star systems as <u>galaxies</u>, and reserve the term <u>nebulae</u> for genuine clouds of dust and gas.