weigh between 1 kg and 31 tons[7]. K. Esbensen and colleagues[8,9] at the Technical University of Denmark found surprisingly large differences in composition among these samples. For example, they found twofold variations in the concentrations of iridium and gold, and up to 10 per cent change in iridium concentration over 0.9 m in a 20-ton specimen. Such variations are not compatible with radial plane-front solidification of a core 10–50 km in radius. Esbensen and colleagues favour dendritic growth or growth from blocks that were detached from the outer edge of the core and accumulated nearer the centre.

Through the application of metallurgical, geochemical and analytical techniques, and the concerted efforts of meteorite hunters and curators across the world, we are beginning to learn much about the nature and formation of metallic cores of asteroids. Such studies, when augmented by field studies of asteroids, should lead to a greater understanding of the more inaccessible planetary cores. □

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Astronomy

Do we live in an elliptical galaxy?

from M. G. Edmunds

It is perhaps surprising, at a time when a great deal of astronomical research is directed to probing the most distant parts of the observable Universe, that fundamental details of the structure of our own Galaxy should remain uncertain. We know quite a lot about its most conspicuous part — the thin disc of stars, gas and dust in which active star formation is occurring, and which contains our own Sun — but the faint 'spheroid' of old stars which surrounds the disc is less well understood. Two recent, and conflicting, studies of the number of stars in this spheroid highlight the uncertainty; and together with new information on the dynamical properties of the spheroids of other galaxies, they show that we can no longer ignore the possibility that the spheroid may be a major (or even dominant) component of the Galaxy.

Since the ages and distribution of stars in the spheroid may be very like that of an elliptical galaxy, it is possible to speculate that our Galaxy is simply an elliptical which happens to have been born with, or acquired — perhaps very early on — a disc of gas in which classic spiral structure subsequently developed.

The difficulty of judging the importance of the spheroidal component comes from its intrinsic faintness. It contains few (if any) of the short-lived, bright and recently formed massive stars that delineate spiral structure in the disc. Furthermore, although the local density of spheroid mass near the Sun is very much less than that of disc stars, the total numbers of stars could be comparable when summed over the much larger volume occupied by the spheroid.

Stars can now be counted on photographic plates by measuring machines with computer-controlled scanning light beams, with a vast increase in speed and objectivity over earlier manual and ocular methods. G. Gilmore and N. Reid[1] have used these new techniques, linked with fairly extensive calibration of stellar types and distances from infrared photometry, to push the determination of the relative numbers of stars of different intrinsic brightness to about 100 times fainter than previous reliable determinations. Then, by counting the relative numbers of stars of different observed brightness and colour towards the South Galactic Pole (that is, up through and out of the plane of the Galaxy), they determine the distribution in space of the stars[2]. They identify not only the well known thin galactic disc, but also what they claim is a 'thick' disc extending above the plane some four times further than the thin disc. This thick disc may represent a somewhat flattened spheroid distribution, although (as I shall argue in detail elsewhere) the resultant mass of such a spheroid could be large — indeed it could be between one-third and three times the mass of the disc. Such a thick disc or spheroid (and the two models cannot be distinguished on the basis of the present star counts) would then have to be accepted as a critical component in the formation and evolution of the Galaxy.

Examples of dominating spheroids are known in other spiral galaxies. A recent series of papers by P. C. van der Kruit and I. Searle shows a range from fairly negligible spheroids right up to cases (see, for example, ref.3) in which the visible spheroid has at least as much mass as the disc, and probably more. It has become customary to distinguish between 'spheroid', which means the visible stars which are not part of the disc, and the 'halo' which means the almost spherical distribution of dark (or almost non-luminous) matter which is invoked to explain the behaviour of rotation velocity as a function of radius in our own and other spiral galaxies. While the rotation curves seem to have forced us to accept a dominance of the halo mass, the contribution of spheroids has, until recently, remained uncertain.

A somewhat different picture from that of Gilmore and Reid has been painted by J. N. Bahcall *et al.*[4]. Their model is developed by fitting together their interpretation of star count data (which does not include the recent work of Gilmore and Reid) with data on stars near the Sun which show the high-velocity kinematics required for them to spend most of their lives outside the disc, and the kinematic data on the overall rotation of the Galaxy. Adding a concentrated mass component at the centre of the Galaxy, the relative masses they deduce for disc/spheroid/centre/dark halo are 5.6: 0.27: 1.1: 56. In other words, a dominant dark halo, but a visible spheroid which is rather negligible compared with the disc. Gilmore and Reid can say nothing about the dark halo (except that its mass is not in the form of nuclear-energy-generating stars), but the reason for the disagreement on the importance of the visible halo is not obvious. It may lie in the different relationships between intrinsic brightness and numbers assumed for the spheroid stars by the two groups, but the true picture may only surface in later debate.

Further interesting evidence of the relationship between spiral and elliptical galaxies has come from the comparison of the kinematics of stars in the spheroidal components of spirals with the kinematics of stars in ellipticals. A few years ago much excitement was generated by the realization that bright massive elliptical galaxies were not flattened into their elliptical shape by rotational forces. The result was a flurry of theoretical work on the dynamics of such systems, and it was subsequently observationally demonstrated that, in contrast, the spheroidal components of spiral galaxies did rotate fast enough to provide their observed flattenings. This argued for a fundamental difference between ellipticals and spheroidal components. But the spheroids of spirals are typically considerably less luminous than the large elliptical galaxies that had been observed, and a recent paper by Davies *et al.*[5] has shown that ellipticals of comparable luminosity to the spheroids of spirals do rotate in the same way. Thus it is the bright massive ellipticals which are in some way unusual, and the spheroids of spirals appear very similar to the ellipticals of comparable brightness.

The true nature of the dark halo matter in our own and other galaxies remains an embarrassing problem, but the recent research indicates that the study of what we can see — the spheroid stars in our Galaxy — may be more rewarding than has often been realized. The spheroid may be the closest elliptical galaxy that we can study. □

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