Dispute over scale of Universe

Controversy continues about the scale of the expanding Universe, with the two camps separated by a factor of two. Resolution of the conflict is more urgent than the disputants acknowledge.

OF all the natural constants, Hubble's constant must be the least deserving of the name. Those not directly concerned with the measurement of the distance-scale of the Universe may be forgiven if they harbour the impression that, for the past quarter of a century, the extant value of H_0 has stubbornly refused to settle down within some bounded range of all possible values, eventually to approximate ever more closely to what might be called a true value. Instead, successive estimates of H_0 seem to have fluctuated between two extremes differing numerically by a factor of nearly two.

Behind each value, there is a different school of opinion. Sandage and Tammann, whose latest estimate of Hubble's constant appears in this issue on page 326, are among those who hold that H_0, the measure of the rate at which the expansion velocity of the Universe increases with distance, is unlikely to be very different from 50 km s^{-1} per megaparsec (abbreviated to Mpc). The opposing school, represented for example by Dr G. de Vaucouleurs of the University of Texas at Austin, considers that the value of H_0 is more likely to be twice as large, approximately 100 km s^{-1} Mpc^{-1}. In some ways, the latest contribution from Sandage and Tammann appears to be a direct response to a challenge issued by de Vaucouleurs two years ago (*Nature* **299**, 303; 1982), when he argued that a careful examination of the hydrogen-line radio-emission from receding galaxies should provide one of five crucial tests of the conflict between the two distance scales.

This long-standing issue is unlikely, however, to be settled by the appearance of just one more contribution, and neither Sandage and Tammann nor de Vaucouleurs should be blamed for that. For one thing, the problem is uncommonly difficult, as Hubble himself recognized more than half a century ago. Essentially it is that of attempting to construct a distance scale applicable to objects in the Universe so distant that yardsticks usable on smaller scales (for example within our galaxy) are not directly applicable. Instead, they must be translated into secondary yardsticks by processes never free from assumptions about the physical nature of extragalactic objects (and even the space between them).

Then, the problem seems always to become more complicated. While the uniform (in space) and constant (in time) expansion implied by the definition of the Hubble constant may be a good first approximation to the Universe in the large, only in the past fifteen years has it become plain that we perforce look out at the Universe from an exceptional place, one near enough to the Virgo cluster for the motions of most nearby galaxies (on which previous estimates of distance have largely been based) to be streaming towards its centre of gravity, and even for the motion of our own galaxy (as measured by the anisotropy of the microwave background radiation) to be influenced as well.

Inivitably, these tenuous chains of inference run into serious trouble in the most distant reaches of the Universe, where the galaxies may be physically different (witness the quasars) from those in our immediate neighbourhood. One practical consequence is that people seem for the time being to have abandoned hope (still strong less than a decade ago) of being able to determine accurately from direct observation any but the first linear approximation to the expansion of the Universe. The Hubble constant may be uncertain, but the the range of values admissible for the deceleration of the expansion — the next approximation — is so great that the argument whether the Universe is open or closed has reverted entirely to the theorists.

The article by Sandage and Tammann will find a wide hearing simply because it offers a novel test of a sensible prediction of the relationship that should exist between the intrinsic luminosity (or mass) of a galaxy and the maximum velocity of its interstellar gas, predominantly hydrogen. Crudely, the greater the mass within some distance of the centre of a galaxy, the greater will be the gravitational potential at that distance so that, other things being equal, the greater will be the velocity of freely moving material at that point.

So, according to what is known as the Tulley–Fisher relationship, it should be possible to infer, from the broadening of say the 21-centimetre hydrogen line, the spread of velocities of hydrogen clouds within the galaxy and that, by comparison with other galaxies of the same type, should yield an estimate of the intrinsic magnitude of the distant galaxy. The use of the Tulley–Fisher relationship is not of course new; two years ago, de Vaucouleurs used exactly such an argument to support his view that the Hubble constant is roughly twice that now quoted by Sandage and Tammann.

How can such discrepancies arise in the analysis of the same data? And how will they eventually be resolved? The obvious difficulty is that the process of extending the distance scale beyond nearby galaxies is far from being objective. Whatever physical principle is used to help determine the intrinsic brightness of a distant galaxy, people will eventually be driven to select, from among all galaxies for which measurements are available, a sample which can be held to be comparable with each other.

The snag, as the experience of past decades has shown, is that this process of selection can also be a source of bias, involving as it does explicit or even hidden assumptions about the physical reasons why one type of galaxy differs from another. Indeed, these chains of inference are so complicated that many of the minor controversies that arise within the ambit of the larger controversy are discovered, in the end, to have arisen because some set of apparently independent measurements is found to hang on a few or even a single one of them.

The only remedy is the old remedy — more data. In the long run, the construction of a reliable distance scale will require such a detailed study of the properties of the galaxies involved that the propriety of the comparisons made can be verified directly. The search for novel ways of comparing the intrinsic brightness of near and far galaxies should of course continue (as it will), but there should by now be enough experience, most of it disappointing, for the practitioners to know that there is no magic solution on the cards.

What, in the meantime, is to happen to the controversy between the opposing camps, each of which is convinced of the correctness of its own estimates of the distance scale? Sandage and Tammann point out that their own estimate of Hubble's constant has the virtue of suggesting an age for the Universe as a whole which is more nearly in agreement with Astrophysical estimates of the age of the objects which it contains than the shorter time-scale implied by the longer distance scale of de Vaucouleurs and others (which does not, of course, prove that it is correct). This circumstance seems to infuriate the other camp, with the consequence that the controversy is no longer seemly. The ideal would be that those concerned should acknowledge that the crying need is for a reliable distance-scale, not for a proof that one or other of the two candidates now in the field is the better.

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