production rate of comet Bennett (1970II) from observations of its dust tail, and their results were found to be in excellent agreement with those derived from ultraviolet observations[13]. Again, in these cases the icy conglomerate model has given rise to predictions which have been later confirmed.

Such large production rates are seemingly incompatible with the notion that the gas is produced by desorption from dust grains. For example, if the solar wind is the source of the desorbed gas it is difficult to account quantitatively for the production rates of hydrogen[14] and, more importantly, for the roughly equally strong production of OH (ref. 13), as well as for the existence of such parent molecules as HCN, CH_3CN, and H_2O which have been directly detected by radio techniques[15–17]. It should be noted in this respect that ice-coated grains cannot survive a close perihelion passage; indeed, even a single large nucleus must lose a layer of ice at least a metre thick due to sublimation during the perihelion passage with $r_{min}=0.5$ a.u. The questions raised by these modern observations seem to us to constitute a serious, if not impossible, difficulty for the dust swarm hypothesis.

It is certainly not the case that the icy nucleus model is inconsistent with observations of the contraction of cometary comas as the comets approach the Sun. The apparent contraction is a very obvious consequence of the fact that the increase in gas production and in excitation of the coma of a comet approaching the Sun is counterbalanced by a decrease in the lifetime of the molecules and radicals due to dissociation and/or ionisation. For example, a very rough analysis indicates that, because the intensity of solar ultraviolet and of the solar wind flux both vary as $1/r^2$, the characteristic scale of the coma should vary approximately as r^n, where n is about 2 (ref. 18). The observations are consistent with such a variation[19–21] and are not easily explained by the swarm hypothesis. It is also interesting to note that, although a dust swarm contracts in terms of its lateral dimensions, its length actually increases with decreasing heliocentric distance. However, as pointed out by Delsemme[21], isophotes of monochromatic brightness profiles corresponding to neutral radicals are always nearly circular, barring rare cataclysmic events. It is difficult to understand how such results could be explained by desorption of gas from an elongated swarm.

The progress which has been made during the past decade has been associated with an increasing interest in the physics of comets and in particular their origin, composition and ultimate fate. Their possible significance as 'building blocks' for the Solar System is now widely acknowledged and has stimulated efforts to perform *in situ* measurements from a space probe. A rendezvous mission, even if it involves a fast flyby, should be capable of providing most of the information we need to settle existing arguments and should also give us quite new insights into the nature of comets. Let us hope we do not have to wait too long for the realisation of such a mission, which is certainly feasible and possibly relatively inexpensive.

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Quasar luminosity

from F. Graham Smith

OBSERVATIONAL cosmology, although by now a very respectable subject, is still short of hard evidence about the way in which the Universe is evolving. A particular difficulty is that evolution affects the constituent bodies as well as the smoothed densities of matter and energy, so that we cannot easily test cosmological models by simple comparisons of distant and nearby galaxies. This is the main difficulty with tests involving counting populations of galaxies at different distances: a change in population at larger distances might be an indication of youth rather than a measure of the general expansion of the Universe.

Counts of distant quasars do in fact show very large evolutionary effects. A recent comparison between counts of bright and faint quasars (Green & Schmidt *Astrophys. J. Lett.* **220**, L1; 1978) shows a population increasing with distance, in all directions, as distance to the power 1.6. This could be due to an evolution in the average luminosity of quasars, or it could be due to a general cosmological evolution of density. In either case it is further evidence against any hypothesis that quasars are 'local' objects. There is, however, a serious problem in allowing for the evolution in luminosity if this observation is to be used for discriminating between closed and open models of the Universe.

A second test of cosmological models is obtained from a comparison of the redshift and the luminosity of quasars. This is particularly useful if measurements can be made at large distances, that is, at large redshifts. Unfortunately the luminosity is then very difficult to measure directly, as the normally observed part of the spectrum is shifted out of the visible range. A very promising method for inferring luminosity from the intensity of emission lines has now been developed by Baldwin, Burke, Gaskell and Wampler (see page 431, this issue of *Nature*) which may remove the difficulty. They show that the luminosity of certain quasar emission lines increases as the third power of the continuum luminosity. They use the C IV line with rest wavelength 1,549 Å for redshifts between 1.1 and 2.5, and they show that the Mg II line at 2,800 Å can be used in the same way for quasars with lower redshifts. In this way, and with few assumptions, they can construct a 'Hubble diagram' for quasars covering most of the available range of redshifts.

The results favour a high value of the deceleration parameter q_0, which excludes low-density models of the Universe. This agrees with previous but less reliable work on the relation between redshift and luminosity, and also with the evidence on populations. But there are still some important provisos; it is conceivable that the luminosity is itself affected by the local mean density of the Universe, or that it varies with cosmological epoch for some other reason. These provisos may be overcome eventually when the physics of quasars become better understood.

This new approach, in which the luminosity of a quasar can be measured from the intensity of emission lines, is important for the tentative support it gives for a closed Universe; it also shows that ground-based optical observations have a new and powerful way into critical cosmological questions.

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