Seyfert galaxies and QSOs

from John Gribbin

NEW observations of H-β or Lyman-α fluxes of a sample of 57 Seyfert galaxies and QSOs suggest strongly that QSOs are indeed distant, bright Seyfert galaxies too remote for the faint outer structure of the galaxies to be observed. As well as confirming the now increasingly accepted view that the redshifts of QSOs are cosmological distance indicators, the suggestion that QSOs are high-redshift Seyferts provides a new use of these objects as cosmological probes, and suggests some limits on the so-called "deceleration parameter" of our Universe.

The possibility of a link between active galaxies such as Seyferts and QSOs has long been recognised in a qualitative sense, two touted possibilities being that explosions on the scale of a QSO may occur in the nuclei of all spiral galaxies from time to time, or that such violent activity may mark a step in the evolution of a proto-galaxy, after which it settles down into a quiet spiral with no further comparable activity. Supporters of such ideas have had powerful circumstantial evidence to hand in the observation that class I Seyferts and QSOs cannot be distinguished from their spectra alone. Both have broad Balmer emission lines, narrow forbidden lines and power-law spectra, the difference being that Seyferts are seen as active nuclei surrounded by visible galactic material, while QSOs have higher redshifts and no surrounding galaxies are seen. Because of the confusion effects from bright nuclei, surrounding galactic disks could not, however, be observed at redshift greater than 0.1—so any Seyfert of class I with $z>0.1$ would be identified automatically as a QSO.

Weedman has now developed from this observation a quantitative measure of the similarity between the two kinds of object (*Astrophys. J.*, **208,** 30–36; 1976). Earlier studies along these lines had compared the fluxes from the two in a specified part of the observed spectrum; as Weedman points out, this is not the best approach because the redshift effect means that different parts of the emitted spectra are shifted into the chosen observational window. Instead, he has made measurements of the emission of his sample of Seyferts and QSOs in the hydrogen lines, H-β or Lyman-α. The H-β lines were measured wherever possible, but at large redshift these are shifted out of the visible range and for those objects L-α can be measured instead, the relative strength of the two lines (based on model calculations by K. Davidson, *Astrophys. J.*, **171,** 213; 1972) then giving an estimate of the strength of the invisible H-β.

The results show clearly a continuous smooth distribution of luminosity in line with the cosmological interpretation of the redshifts of these objects. The range covered, equivalent to 11.5 magnitudes, is large, but as Weedman points out still less than the luminosity range of main sequence stars. Accepting this as confirmation that QSOs are simply bright class I Seyferts, this immediately provides a new probe of the Universe extending over a wide range of redshifts, and Weedman points out some preliminary conclusions from this which set limits on some cosmological parameters. In particular, the luminosities of high redshift QSOs (which are now regarded as high-redshift Seyferts) are relatively faint, suggesting that either there is some limit to the brightness of these objects or that the deceleration parameter of the Universe, q_0, is negative. This tentative first conclusion is, however, less important than the fact that at last it seems possible that QSOs can be used with confidence as genuine cosmological probes to define the structure of our Universe on the large scale, and to rule out some of the large family of possible models now applied to the Universe. The problem of the energy source of QSOs remains, of course (even if there is some upper limit), but here too it seems that this problem can now be approached from a new and promising direction by investigating the more easily studied and nearer members of the family, the Seyfert galaxies.

a short growing season. Pearsall (*Mountains and Moorlands*, 49, Collins, 1956) described his observations on the heath rush (*Juncus squarrosus*) and showed how the length of the flowering stalk, the number of flowers per inflorescence and the number of viable seeds produced per capsule are all inversely related to altitude. The production of viable seed for this species is uncommon at altitudes over 820 m. It is also reported, however, that the heath rush produced seed on the summit of Ben Wyvis (1,036 m) in the unusually warm summer of 1947.

Among lowland plants, some occur only in those parts of the country experiencing high summer temperatures. For example, the round-headed rampion (*Phyteuma tenerum*) occurs mainly within the 16.6 °C July average isotherm. Such species may also be expected to extend their range under current conditions.

Other species may find high summer temperatures detrimental, particularly species of arctic alpine distribution. Dahl (*Oikos*, **3,** 22; 1951) observed that arctic alpine species grown in lowland gardens suffered most during hot summers. He has also demonstrated that many of these species have distributional patterns in which their limits coincide with low summer temperatures. Similar observations have been made recently for certain arctic alpines in Newfoundland (Damman, *Can. J. Bot.*, **54,** 1561; 1976), for example, the bog bilberry (*Vaccinium uliginosum*) is found only in areas having an average temperature in the growing season below 15 °C. It is known that dark respiration rates of many arctic alpine species are higher than their lowland counterparts (Billings and Mooney, *Biol. Rev.*, **43,** 481; 1968) and since respiration is stimulated by high temperatures, the plant could experience difficulty in maintaining a positive carbon balance during a hot summer.

One species which does appear to be suffering in upland Britain this year is the bilberry (*Vaccinium myrtillus*). This is a species which dominates some open moorlands in the uplands of western Britain, yet is found only under a woodland canopy in the east and in continental Europe. Microclimatic factors, possibly involving temperature and humidity may therefore be critical for its survival. This summer the open populations of the west are showing evident signs of stress when unprotected by a tree cover. It is possible that its reduced vigour will allow such species as the heather (*Calluna vulgaris*) to spread at its expense.

Our freak summer offers valuable opportunities to increase our understanding of many plant species and one can only hope that any ensuing changes in vegetation will not remain unrecorded. This may be an appropriate time to mobilise that large and willing labour force, the amateur botanists, to undertake a census of selected plant species on the model of the British Trust for Ornithology's common bird census. Perhaps the Botanical Society of the British Isles is the appropriate organisation to initiate such a census which could begin to provide an answer to the question how responsive and fluid is our flora? □