LETTERS TO THE EDITOR

ASTRONOMY

Relation between the Red-shifts of Quasi-stellar Objects and their Radio Magnitudes

In a previous letter[1] we showed that in a sample of thirty identified quasi-stellar objects no sensible correlation exists between red-shifts z and radio fluxes S, though a log N–log S plot of these same objects gives a slope compatible with the usual radio source counts. We therefore stated: "Thus if we adopt the usual distance–volume interpretation of the result $NS^{3/2} \approx$ constant, we must conclude that the red-shifts have nothing to do with the distance". A number of authors have criticized this conclusion[2–4], not on the basis of our actual statement, but apparently on what the authors have read into our letter on their own account. Thus Longair[2] begins: "Hoyle and Burbidge have recently examined the red-shifts of a number of quasi-stellar radio sources, and have plotted their radio flux densities (S) against red-shift (z); they conclude that the results are inconsistent with a cosmological interpretation of these red-shifts".

Next, Sciama and Rees[3] say: "A similar diagram was constructed by Hoyle and Burbidge, who claimed that the absence of a clear correlation between small S and large z shows that red-shift has nothing to do with distance. We shall see that this claim is not necessarily correct".

Finally, Roeder and Mitchell[4] begin: "Hoyle and Burbidge have recently expressed the opinion that the red-shifts found in the spectra of the quasi-stellar objects are not related to distances".

Obviously, all three quotations misrepresent us. We said that *if* the usual distance–volume interpretation is assumed, the red-shifts have nothing to do with distance. Our statement can be inverted to the form: if the red-shifts are related to distance in the usual cosmological sense, then the distance–volume interpretation of $NS^{3/2} \approx$ constant must be abandoned for the sources in our particular sample. Consider the sources in a shell between r and $r + dr$. Provided these sources have an intrinsic scatter in their radio emission they will exhibit a log N – log S curve. If all such shells have the same log N – log S curve, then summation of all shells will give a curve related to intrinsic scatter, not to distance. This is the point made by Bolton[5]. It must be noticed, however, that in order that all shells give the same log N – log S curve it is necessary for the average emission to vary in a special way from one shell to another. This, indeed, is the suggestion of Longair[2] and of Roeder and Mitchell[4]. It requires the average emission to be a function of r and hence of the epoch. Such an interpretation is evidently in disagreement with the strict steady-state theory[3].

While one can certainly express a personal preference for this latter form of argument, it is overstating the case to claim support from it for one cosmology or another. It appears to us that all these discussions are predicated on the cosmological interpretation of the red-shifts of the quasi-stellar objects, in the sense that this interpretation is taken as axiomatic. Conclusions following from it are accepted, essentially whatever they may be, because a non-cosmological interpretation is taken to be out of the question. In fact, the issue is an open one. The difficulties of the problem, both observational and theoretical, lie in deciding between the cosmological and the "local" interpretation, not in seeing the implications of either one of them by itself. Throughout our work on this subject[6,7] we have been concerned to cover both sides of the problem, rather than to concentrate on one half. By doing so we have been able to place limitations on the kind of model required in the cosmological case, as well as in the "local" case. This may be seen, for example, in the model devised to explain the radio variations in 3*C* 273*B* (ref. 6), and in our discussion on the limitations placed on possible models by the inverse Compton effect[7].

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Inverse Compton Effect in Quasi-stellar Sources

Hoyle, Burbidge and Sargent[1] have discussed a model of the quasi-stellar source, 3*C* 273*B*, in which the optical emission is synchrotron radiation from relativistic electrons moving in a magnetic field. Some of the synchrotron photons will interact again with the relativistic electrons through the inverse Compton effect and their energy will be increased. In the model chosen by Hoyle *et al.*, the electrons lose about 10^5 times as much energy in the Compton process as in the synchrotron process. The authors consider that this result is anomalous because the photons which take part in the Compton process have themselves come from the synchrotron process; they point out that the photons can undergo successive Compton collisions and that this could apparently lead to a divergence in the energy radiated by the source. Consequently, Hoyle *et al.* have rejected this particular model of 3*C* 273*B*.

The purpose of this report is to show that the Compton losses can be greater than the synchrotron losses and that there need be no divergence in the power radiated. This model of a quasi-stellar source does, however, impose restrictions on the source of the relativistic electrons.

Consider a spherical object of radius R in which there are n relativistic electrons per cm^3, each with energy E. Let k be the energy of a photon before, and k' be its energy after, a Compton collision with a relativistic electron. When

$$kE < (mc^2)^2 \quad (1)$$

(which is the condition that, in the rest-frame of the electron, the interaction appears as Thomson scattering) the energy of the photon will be increased by a factor g, where[2]

$$g = \frac{k'}{k} \sim \frac{4}{3}\left(\frac{E}{mc^2}\right)^2 \quad (2)$$