RADIO-SOURCE EVOLUTION AND THE REDSHIFT CUT-OFF

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1. INVESTIGATING HIGH-REDSHIFT SPACE

The idea that there may be a cut-off in the distribution of quasars at high redshifts ($z \sim 4$) has been of some recent interest through the work of Osmer (1982). The observation of such an epoch of quasar creation is potentially of great importance in relation to theories of galaxy formation, but the evidence from optically-selected quasar samples remains uncertain: quite apart from the notorious problems in achieving quantifiable completeness in objective-prism surveys, any observed lack of high-redshift quasars may always be attributed to absorption either by a neutral IGM or by dust in intervening galaxies. Radio-selected samples, however, do not suffer from these problems, and this paper aims to review what studies of extragalactic radio sources can tell us about the numbers of objects at the highest redshifts.

The problem with radio cosmology is that complete redshift information is available only for sources of high flux density - there is thus an uncertainty in constructing the radio luminosity function (RLF) and its epoch dependence. However, the partial data which are available may be combined to yield self-consistent RLFs which explore the uncertainties allowed by the observational constraints. Initial efforts of this sort (e.g. Wall, Pearson & Longair 1980) assumed that the evolution with redshift had a form similar to $\rho \propto \exp(mt)$, where $m=0$ for weak sources and $m \sim 10$ for the most powerful sources (t is look-back time in units of the age of the Universe). This differential evolution fitted low-frequency source counts quite well, but was unsatisfactory in general, because the assumed arbitrary form was hard to extend to incorporate additional observations.

2. FREE-FORM EVOLUTION

A scheme to account for all flux-density/redshift data at all frequencies was produced by Peacock & Gull (1981). This assumed smooth RLFs (expanded as free series expansions) for flat-spectrum and steep-spectrum sources separately; different expansions consistent with the data were used to map out the features of the RLF which were well-constrained. This study demonstrated that strong differential evolution

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applied for both spectral classes. To study the behaviour of these RLFs at high redshift, Figure 1 shows the analogue of the simple exp(mt) law - cuts through the RLFs at P(2.7 GHz) = 10^{27} WHz^{-1} sr^{-1}, a typical quasar luminosity. These are plotted against t for 4 models - two different values of q_o, with and without an imposed cut-off at z=5. In each case the upper lines are for the steep-spectrum RLF, the lower for flat-spectrum.

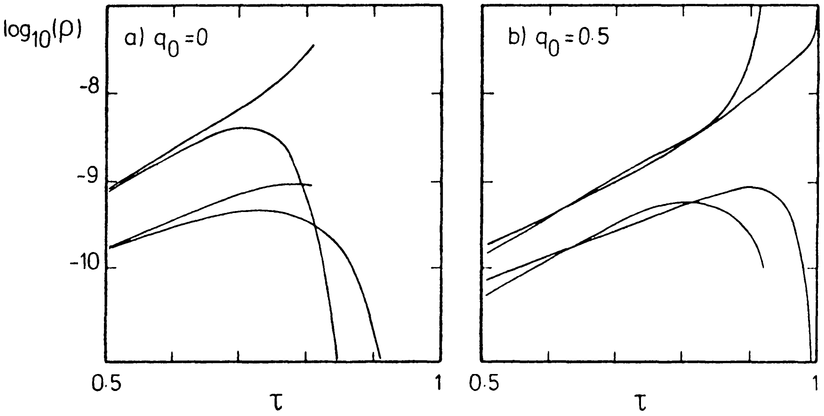

Fig. 1

We see from this that although there is no evidence for a decrease in the rate of evolution at high redshift for the steep-spectrum population in every case the flat-spectrum RLF has ceased to evolve by z ∿ 3. This result may seem uncertain due to the difference between various RLFs, but there is support for its reality from data on flat-spectrum quasars from the Parkes ±4° sample studied by Wills & Lynds (1978). In applying the V/V_m test to quasars with limiting redshifts less than and greater than 1.8, they found $<V/V_m> = 0.65$ for the nearer subset, but $<V/V_m> = 0.52$ for the more distant one - confirming the slackening of evolution at high redshift.

3. FUTURE PROSPECTS

Our knowledge of radio-source evolution is advancing on two fronts - through the gathering of new redshift data on faint sources, and through the synthesis of all new results to produce new evolving RLFs. The Peacock & Gull analysis is presently being extended and we expect on the basis of the results given here that the redshift cut-off for flat-spectrum sources will be confirmed. As yet, the high-redshift evolution of steep-spectrum sources is uncertain, but it is simply a matter of time before this is resolved.

REFERENCES

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DISCUSSION

Peterson: Do you use simple power-law spectra for the radio sources in your models?

Peacock: Yes, we do. A spread of spectral indices makes no important difference to the predictions. Also, I do not believe that spectral curvature matters unless you want to go to $z \sim 10$, which is highly uncertain anyway.

Peterson: How well can your models predict counts at $z > 3.5$ when they are based on samples with maximum redshifts of 2.6 that show evolution?

Peacock: The whole point is that a luminosity function which evolves as fast at $z \sim 3$ as at $z \sim 2$ would predict many ultrahigh redshift sources which are not observed, so that the evolution must have turned off by $z \sim 3$. Higher redshifts are more uncertain; obviously, it will be a long while before we can delineate accurately any actual turnover in the luminosity function.

Segal: The chronometric cosmology predicts that objects of spectral index α will appear relatively abundant at redshifts $\sim(1-\alpha)^{-1}$ but cut off observationally at somewhat larger redshifts. Isn't it possible that the cut-off you observe in flat-spectrum sources derives in part from this effect and in part from the general cut-off at larger redshifts predicted by the chronometric cosmology, and that physically there is in reality no evolution of these sources?

Peacock: It is clear that studies like this cannot tell you about the geometry of the universe -- it must be assumed in order to obtain an evolving luminosity function. Now, Occam's razor tells me that there is no point in working with any geometry but the simplest one which satisfies all known tests -- to me this is general relativity. I agree that this would not be so if the chronometric cosmology could explain the data without evolution -- but it cannot. If the Hubble D-Z relation is taken, low luminosity sources do not evolve, while they would evolve if the chronometric D-Z relation were taken.