A MODEL FOR THE COSMOLOGICAL EVOLUTION OF RADIO SOURCES

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The existing schemes to express the evolution of radio sources are either too simple to fit all the data (multi-frequency counts, identifications, spectra etc.) or have too many parameters and little predictive value. They do not also fit the identification statistics at different flux-densities (Swarup, Subrahmanya & Kapahi 1982, in 'Astrophysical Cosmology', Proc. Vatican Study Week) and the counts from recent deep surveys (van der Laan 1982, in 'Astrophysical Cosmology'). Here, we report a preliminary attempt to derive a model that retains the simplicity of a small number of parameters and ease of refinement when new data are added.

Following Peacock & Gull (1981, MNRAS **196**, 611), we consider two spectral populations - 'flat' and 'steep' - taking $\alpha = 0$ for the former and a P-α correlation for the latter. For both types, evolution is introduced only for $P_{0.4} > 10^{24.5}$ W/Hz/sr ($H_0 = 50$ km/s/Mpc) and is expressed as $\exp[\beta(P)(1-t/t_0)]$, where $\beta \propto \log P$ with slopes β_1, β_2 and β_3 in the $\log P_{0.4}$ ranges 24.5-26, 26-27 and 27-28 respectively, and $1.5\beta_1+\beta_2+\beta_3$ for $\log P \geq 28$. The luminosity ranges were chosen considering that the correlation between radio and optical luminosities is important only for $\log P \lesssim 24.5$ (Auriemma et al. 1977, A&A **57**, 41) and quasars generally have $\log P \gtrsim 26$.

In our method, the radio luminosity function (RLF) is first determined for 'flat' sources using flat-spectrum counts at 2.7 and 5 GHz and the observed luminosity distribution(LD) for the $S_{2.7} \geq 1.5$ Jy sample of Peacock & Wall (1981, MNRAS **194**, 331). An initial set of parameters is then found for 'steep' sources to fit the total counts at 0.4 GHz and LD for $S_{0.4} \geq 10$ Jy, which is well determined in the log P range 24.5 to 28. Observational estimates of local luminosity function (LLF) are available for lower luminosities (Fig. 1) but, for very low luminosities (spirals and irregulars), LLF is very uncertain.

After determining the LLF and an initial RLF, the parameters are refined to simultaneously fit (i) total counts at 0.4, 1.4, 2.7 and 5 GHz; (ii) spectrally separated counts at 2.7 and 5 GHz; and

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(iii) percentage identification - flux density relation for galaxies on the PSS prints (predicted using the bivariate luminosity function as in Swarup, Subrahmanya & Venkatakrishna 1982, A&A 107, 190). We could obtain satisfactory models for $q_0 = 0$ and 0.5 both with and without a cutoff in z, although the fit was considerably poorer for $q_0 = 0$ in the absence of a redshift cutoff. The predicted counts are compared with observations in Fig. 2 for the model with $q_0 = 0.5$ and $z_c = 3.5$ with the following parameters:

'Flat': $\beta_1=4.0$, $\beta_2=1.5$, $\beta_3=0.0$, $\alpha = 0$
'Steep': $\beta_1=3.8$, $\beta_2=4.5$, $\beta_3=4.0$, $\alpha = 0.7$ for $\log P \leq 24.5$ and $0.7+0.08(\log P-24.5)$ otherwise.

The fit with all the data is remarkably good in spite of the limited number of parameters.

Our results show that it is necessary to assume evolution for both flat and steep spectrum sources, although evolution for 'flat' sources could be somewhat milder. The recently observed flattening of the normalised counts at $S_{1.4} \lesssim 1$ mJy is well fitted by the adopted LLF at $\log P \leq 22$, which implies that most of the sources at these flux levels are local ($z < 0.1$). Should the redshifts turn out to be larger, evolution with epoch would be indicated for a source population of low luminosities.

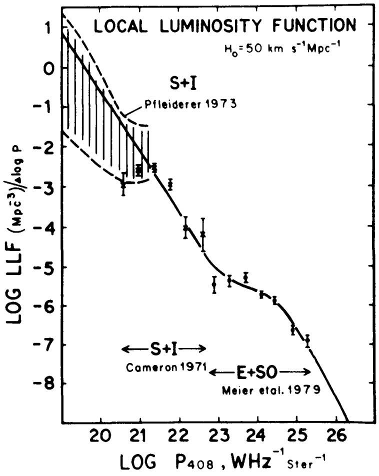

Figure 1.

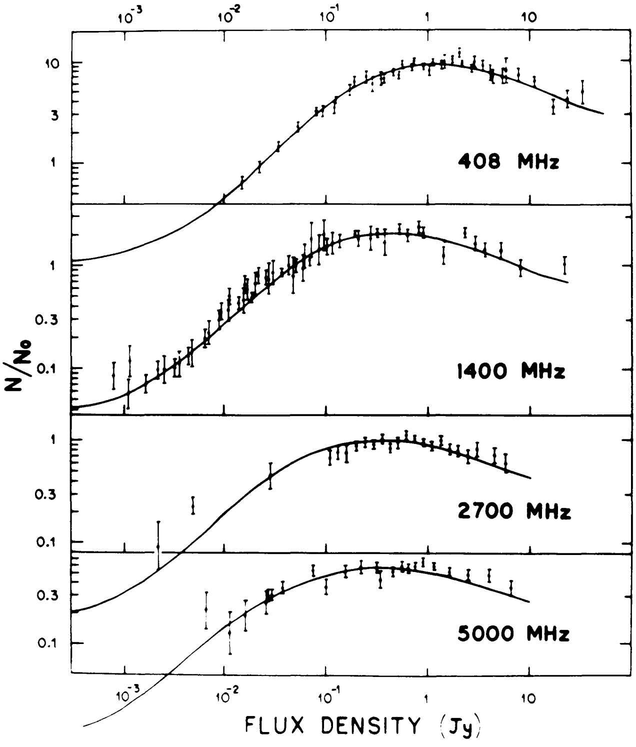

Figure 2. Source counts.