EXTENDED STRUCTURE IN HIGH-REDSHIFT RADIO SOURCES

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We have compared measurements of several hundred 3C and 4C radio sources at large redshifts to investigate how radio-source structure changes over a factor of 5-10 in luminosity. Our results show that for $z \gtrsim 0.6$:

(i) most sources (both 3C and 4C) have hotspots about 3.5 kpc in size ($H_0 = 50$ km s^{-1} Mpc^{-1}, $\Omega = 1$);
(ii) lower-luminosity sources (bottom of 4C) have less-extended outer lobes.

Our observations were made at 81.5 MHz with the Cambridge 3.6-hectare Array using the method of interplanetary scintillation (IPS: Readhead, Kemp & Hewish 1978). The 3C sources were all measured individually to determine the angular diameter, θ, in the range 0.2 to 2 arcsec, and 'compactness', R, which is the fraction of the total flux density originating in the compact feature. The fainter sources in the range 2-3 Jy at 81.5 MHz were too weak to show up individually on the records but contributed to an IPS background. We applied the method of background-deflection analysis (P(D)) to determine weighted average values of θ and R for these sources (Duffett-Smith, Purvis & Hewish 1980). Wall, Pearson & Longair (1980) have shown that sources in this range of flux density occur mainly at redshifts between 0.6 and 2. We were thus able to compare the mean IPS properties of these sources with the properties of the high-redshift members of the 3C167-sample to investigate how radio source structure varies with luminosity.

The results show clearly that the fainter sample has larger average values of both θ and R implying that the less-luminous sources are more compact on average than their 3C counterparts but which yet have a larger average angular diameter. We can typify the structure of the high-redshift members of the 167-sample by an idealised equal-double source model (Fig. 1a) in which the lobes are at least 10 arcsec apart and contain hotspots with $\theta = 0\overset{''}{.}4$ contributing 60% of the total flux density. Taking this model as the starting point, how must we modify it to reproduce the IPS background measurements (which correspond to a factor of 5-10 lower luminosity)? The most likely possibility is that

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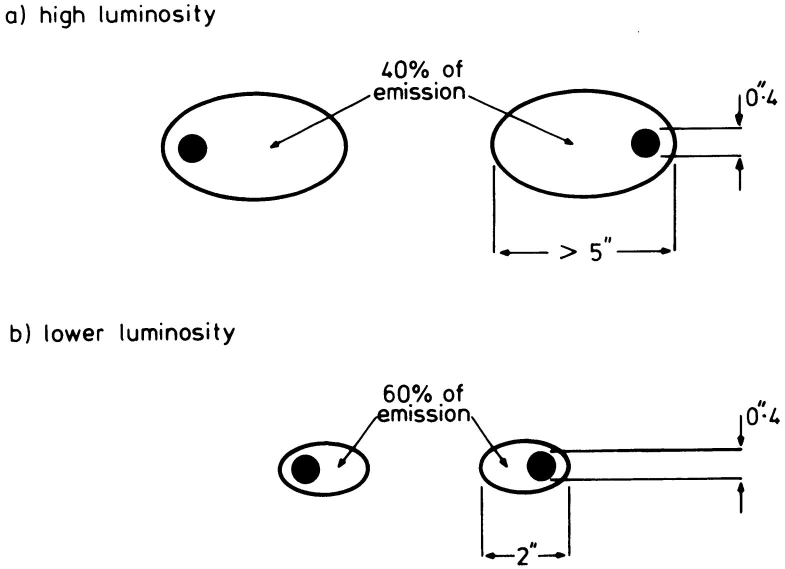

Figure 1. Schematic models of radio sources with z $\gtrsim$ 0.6.

the hotspots have about the same average linear sizes as their 3C counterparts but that the extended structure has a much smaller angular extent so that it now contributes significantly to the scintillations. (This requires its angular size to be of the order of 2 arcsec; Fig. 1b). The IPS measurements then reflect a blend between the hotspot and its surroundings giving larger values of both θ and R (Duffett-Smith 1980).

These are of course only schematic representations of a whole range of brightness distributions undoubtedly present in both samples. However, it is hard to escape the general result that outer lobes in high-redshift radio sources are smaller when the luminosity is lower. We should expect such a result if the extended structure is in pressure balance with its surrounding medium. Sources at the same redshift should have similar environments. Hence the more powerful is the source, the further its extended structure can expand until its energy density equals that of the medium around it.

References

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