A COMPARISON OF COMPACT AND EXTENDED RADIO SOURCES IN THREE WAVEBANDS +

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I shall compare the luminosities in the X-ray, optical, and radio wavebands of two types of radio source - compact flat-spectrum sources and extended double sources - and attempt to place limits on models which unify these types.

Fig. 1 shows the correlation between Hβ emission-line luminosity and X-ray luminosity (taken from Zamorani et al. 1981, Owen et al. 1981, Tananbaum et al. 1983, and Fabbiano et al. 1983) obtained by combining various radio samples. The correlation is similar to that found for Seyfert galaxies (Elvis et al. 1978, Kriss et al. 1980) and for other quasars (Blumenthal et al. 1982, Reichert et al. 1982). Under the hypothesis that all the objects with broad emission-lines form a single class of object, it is reasonable to combine all these sources on one diagram, and the correlation then shows that the compact radio sources have the same range of the ratio $L_X/L_{H\beta}$ as the extended radio sources. Since the emission-lines are neither blue-shifted, nor shifted with respect to other emission or absorption lines in the objects, the emission-lines cannot be relativistically boosted. Thus, if the nuclei of the differing classes of radio source are intrinsically the same, the correlation shows that the X-rays are not relativistically boosted by a factor greater than 3 in any one class of object. Obscuration of the Hβ emission is unlikely to be important, since (a) extended double quasars show similar optical spectra and colours to compact quasars, and (b) there is no evidence for large obscuration in either radio galaxies (Saunders and Miller, 1983) or quasars (Puetter et al. 1981) from infra-red observations.

Fig. 2 shows the correlations between flat-spectrum nuclear radio emission and X-ray emission (Owen et al. 1981, Tananbaum et al. 1983, Fabbiano et al. 1983). The total radio luminosity has been used for the compact sources. For a given X-ray luminosity these have radio emission which is a factor about 30 stronger than the radio cores of the extended sources. Since the X-ray emission is not substantially beamed, the radio cores of compact radio sources are at most boosted by a factor 30 above the cores of extended double radio sources. This is

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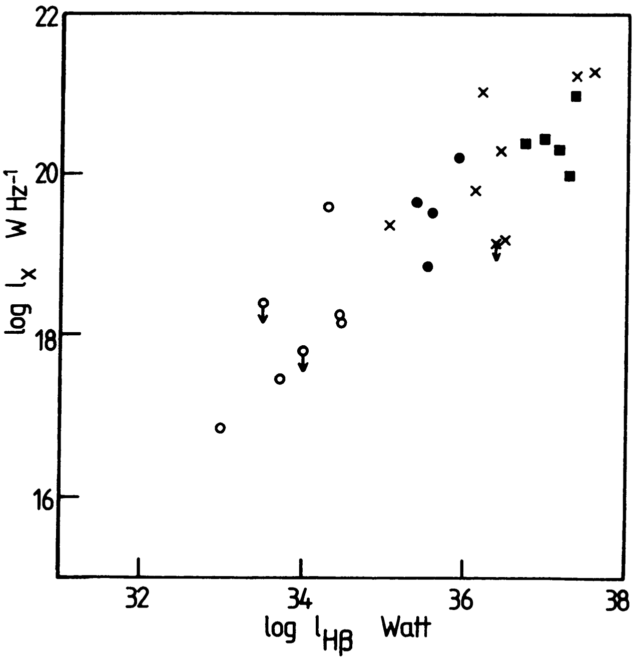

Fig. 1. The correlation between X-ray and Hβ luminosity for compact quasars (crosses), extended quasars (filled squares), extended radio galaxies with broad emission-lines (filled circles), and extended radio galaxies with narrow emission-lines only (open circles).

insufficient to turn a double source into a compact source, since a boosting factor > 300 would be required to swamp the extended emission (Perley et al. 1982). The model of Orr and Browne (1982) would require boosting factors > 1000. The radio properties are thus not consistent with models where the only difference between extended double sources and compact sources is that of relativistic boosting of the radio core luminosity.

This is illustrated also in fig. 3, which shows X-ray luminosity plotted against total radio luminosity at 6 cm, for the objects in fig. 2. All the classes of source lie on the same slope. Yet the fraction of the total radio emission in the compact sources which can be attributed to the lobes of an extended double source is typically less than 3% (Perley et al. 1982). So, for a given X-ray luminosity, any extended double-lobe structure in the compact sources is at least a factor 30 weaker than in the double sources. In fig. 3, there are only correlations for the radio galaxies and the compact sources. The comparison is unlikely to be biased by source selection, however, since the two samples of double sources used are complete to radio and optical flux density limits, and there was no selection against X-ray bright objects (Tananbaum et al. 1983, Fabbiano et al. 1983). Hence,

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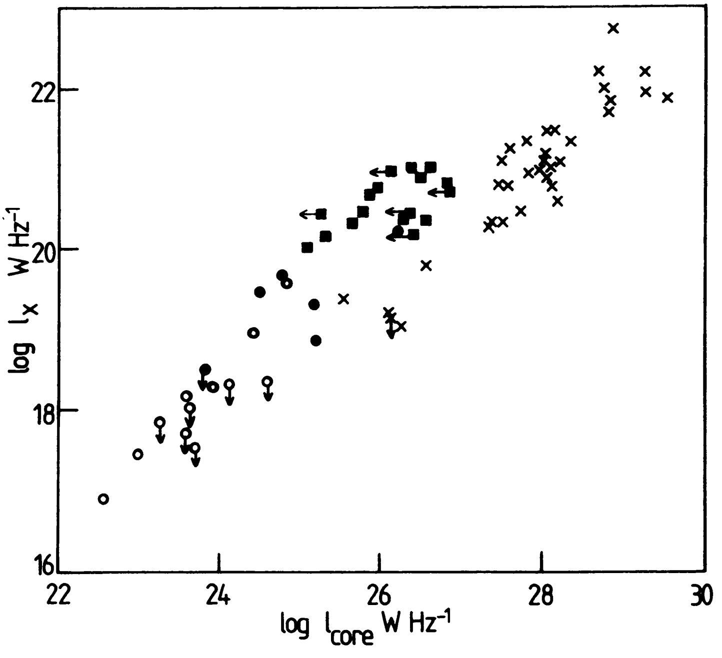

Fig. 2. The correlations between X-ray and flat-spectrum radio core luminosity.

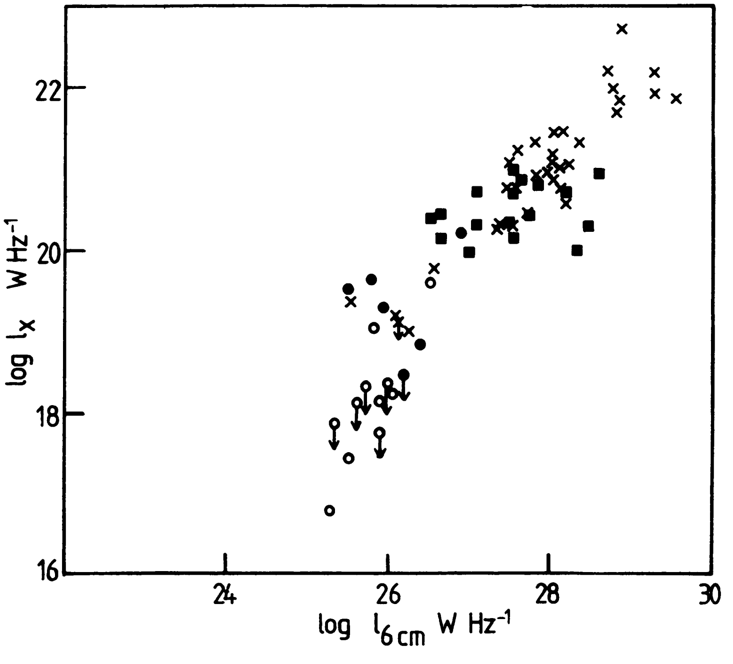

Fig. 3. The correlations between X-ray and total radio luminosity.

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in the relativistic beaming models, the unfavourably oriented counterparts of the compact sources should be X-ray and optically bright, unless they are affected by obscuration, but any double-lobe structure should be relatively weak.

Finally, the compact sources might be intrinsically weaker sources which have been gravitationally lensed. Since most compact quasars show arcsec - scale radio emission (Perley et al. 1982, Browne et al. 1982) the most promising candidates for unlensed objects are the cores of extended double radio sources. Fig. 1 shows that the X-ray and emission-line regions would each have to be lensed by similar amounts, and fig. 2 shows that the radio emission would have to be lensed by a factor about 30 greater. The X-ray and emission-line regions would thus have to be the same size, and be either separated from or be larger than the radio region.

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