B2 QUASARS AND RELATIVISTIC MOTION

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1. INTRODUCTION

Relativistic motion has been established with a certain degree of confidence only on VLBI scales, but its application to larger scales has encountered severe difficulties (see e.g. De Young, 1984).

Often relativistic effects or more generally Doppler effects are invoked for convenience, in order to explain a particular property of AGN's; we mention the unified scheme proposed by Orr and Browne (1982), which gives a natural explanation for the observed differences between flat- and steep-spectrum radio quasars.

In this note we make use of the B2 sample of radio quasars (Fanti et al., 1979), for which new high resolution (0.3-3 arcsec) maps, made with the VLA, recently have become available (Rogora, Padrielli and de Ruiter, 1985a, 1985b). We have tested two models that both explain some observed properties of quasars as caused by high ejection velocities, thus giving rise to relativistic or, at least, appreciable Doppler effects.

2. THE UNIFIED SCHEME OF ORR AND BROWNE

The first model we tested is the unified scheme, proposed by Orr and Browne (1982). According to them the strength of a radio core relative to the extended emission depends on the orientation of the relativistic beam in the core: a dominant core is beamed towards the observer.

Our data do not sustain the unified scheme; the distribution of R (flux of core/flux of extended regions) does not fit the theoretical distribution based on random orientation of the radio sources. Our values of R are systematically higher by a factor of about five (see figure 1). This could be repaired by increasing the minimum R (R_T in the notation of Orr and Browne, 1982) and increasing the spread in R_T, but then the unified scheme loses its sense - in the extreme the spread in R_T could account for the entire distribution of R. We prefer a simpler explanation: the generally higher values of R reflect an increasing dominance of the radio core over extended emission, when

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going to lower radio luminosities (as is the case when comparing the B2 sample with the 3C quasars used by Orr and Browne, 1982).

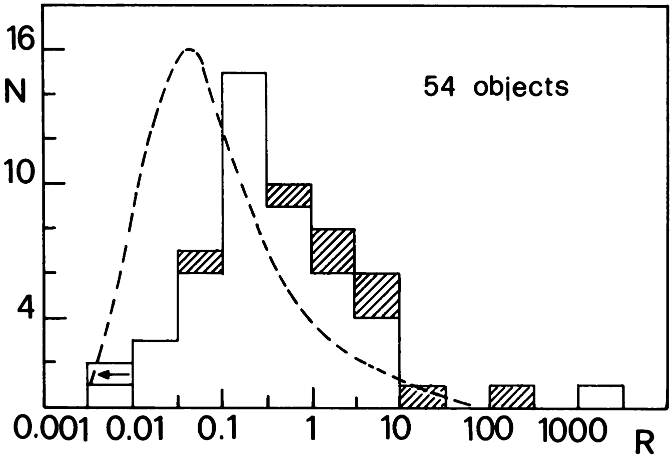

Figure 1. Histogram of R (core flux/flux of extended region) for 54 B2 quasars. Cross-hatched are D2 type sources. The dashed line represents the distribution predicted by the unified scheme.

3. ARM LENGTH RATIOS

We also tested for Doppler effects that might affect the arm length and flux ratios of the extended components. As in other samples the best agreement between observed and theoretical distributions of arm length ratio (l) is obtained for velocities of the extended components of the order of 0.2 to 0.3c (see Katgert-Merkelijn et al., 1980 and Longair and Riley, 1979). The B2 quasar data are plotted in figure 2. The agreement between the observed distribution and the one expected from Doppler effects is only superficial and in particular it does not explain values of l larger than, say, two. Such large ratios, up to about five, are present in the B2 sample (see figure 2). Moreover, the expected correlation between l and flux ratio of the two extended components is completely absent. If anything, there is a slight indication that the highly asymmetric sources have the brightest component closest to the radio core, opposite to what would be expected if high velocities were to play a significant role (see also Saikia and Wiita, 1982, and De Young, 1984).

We have searched for a different model that does not need Doppler effects to reproduce the observed distribution of l.

The question of arm length ratios has been extensively discussed by Rudnick and Edgar (1984); none of the models given by them fitted their data well and the same is true for the B2 sample. However, it is possible to construct a simple probabilistic model that reproduces the distribution of l satisfactorily, even up to ratios of the order of five. In this, what might be called free cone model we treat the radio

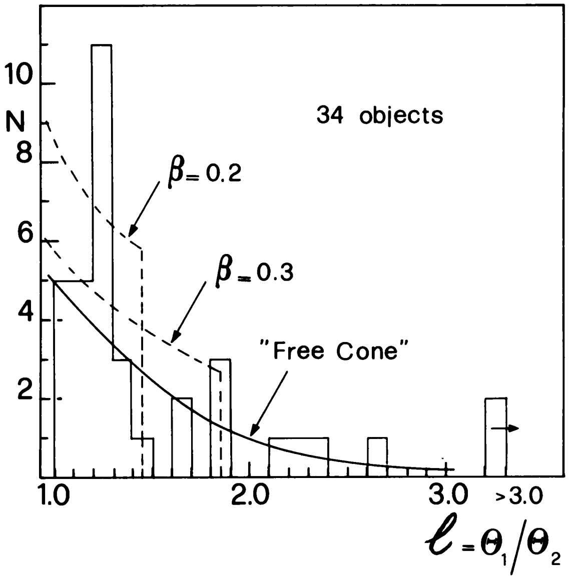

Figure 2. Histogram of arm length ratios (ratio of distance core to farthest and core to closest component), for 34 B2 quasars. Dashed lines give expected distributions due to Doppler effects. Solid line is prediction by "free cone" model (see text).

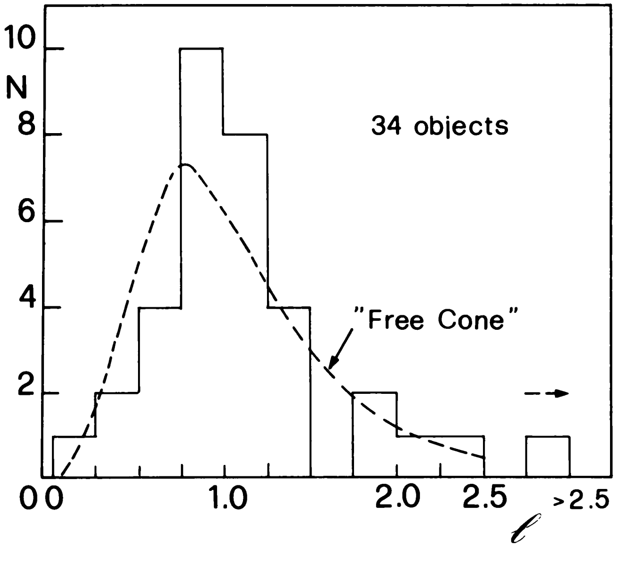

Figure 3. Same data as in figure 2, but arm length ratio is now defined as ratio core-western and core-eastern component. The dashed line is the "free cone" distribution. The mean arm length ratio for the B2 quasars is equal to 1.16 against 1.21 predicted.

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source as a cone with a small but finite opening angle. The material that emits the radio radiation moves inside this cone outward with a small, non-relativistic velocity. We then calculate the probability to encounter an obstacle (e.g. cloud) inside the cone and assume that the radio source at that point is stopped. If we always take the ratio western:eastern component $\underline{l}$ will be between zero and infinity. The resulting theoretical distribution has a number of advantages: it has a well defined mean (1.209) and standard deviation (0.978), which often do not exist in this kind of problem. More important, it fits the observed $\underline{l}$ distribution as derived for the B2 sample quite well. In figure 3 the theoretical "free cone" distribution, $f(\underline{l})=3\underline{l}^2/(1+\underline{l}^3)^2$, is shown. Considering the simplicity of the model the agreement with the observed distribution is satisfactory.

It should be stressed that the way we arrived at the theoretical distribution is naive and does not necessarily represent the behaviour of a real radio source. Rather, the free cone model should be considered as an illustration to the fact that the observed arm length ratio distribution can be reproduced without invoking Doppler effects.

4. CONCLUSIONS

We conclude from an analysis of the B2 quasar sample that:

i) no compelling evidence exists for relativistic effects that depend on the orientation of the radio sources. In particular the unified scheme does not seem to work.

ii) arm length ratios can be easily explained by a model that invokes interaction of the radio source (considered as material moving outward in a cone with small but finite opening angle) with randomly located external clouds. In particular no Doppler effects are required to explain the observed arm length ratios.

It follows that the only strong evidence for relativistic effects in AGN's is and remains superluminal motion.

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DISCUSSION

Barthel : Two comments : (1) Longair & Riley determined the average hot-spot advance velocity for 3C sources in general - not only quasars. Different beasts ! (2) Did you calculate R at 5 GHz emitted frequency ? Steep spectrum cores may explain some discrepancy. Please note that I am not a fan of beaming, though.

De Ruiter : We did not calculate R at 5 GHz emitted, because not all objects have known redshifts. Since we expect that most quasars in the B2 sample have z of the order of or less than one the discrepancy cannot be resolved this way.

Swarup : Is it not possible that the relativistic beaming model may predict higher values of f_c in the Bologna sample at 408 MHz which is much fainter than the 3CR sample at 178 MHz.

De Ruiter : We have taken the predictions as given by the unified scheme of Orr and Browne. It is true that the Bologna quasars are fainter but not that much. The only way to save the unified scheme is to assume that in the Bologna sample the orientation angle is not random.

Kapahi : Is it possible that some of the B2 quasars you are considering got into the sample because their radio structure was first determined at high frequencies, which led to a confirmation of their identification with B2 radio sources or to the determination of their redshifts ?

De Ruiter : The identifications originally were made using the 408 MHz data, and were based on the uv excess nature of the objects. Only afterwards higher frequency radio data were used to confirm the identifications.

"3C273 contains all the ingredients of a classical double source like Cygnus A, with core, jet, hotspots, wiggle, extended lobe, but on one side only."

- Richard Davis (p.214)