NUCLEAR EJECTION - ONE SIDE AT A TIME

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ABSTRACT

Examination of the structures of extragalactic radio sources shows a distinct asymmetry in addition to the more general symmetries which are well known. The most likely explanation for the observed asymmetries is that ejection from the active nucleus occurs in only one direction at a time. This direction then switches back and forth to form the large scale double structures. Implications of this picture for the nuclear engine and the radio source environment are discussed.

The well-known symmetry of extragalactic radio sources has become better appreciated in recent years (see review by R. Ekers, this volume). However, when examined in detail, most double sources are very different on the two sides. I will argue that these differences are of a very specific nature, illustrated in the figure below. Namely, when emission is found on one side of a source, there is generally *not* emission at the same distance on the other side; where one side turns on, the other side turns off. This on/off property may well apply to all extragalactic sources, but is seen in its extreme in one-sided jets (see review by A. Bridle, this volume) and in the D2 sources.

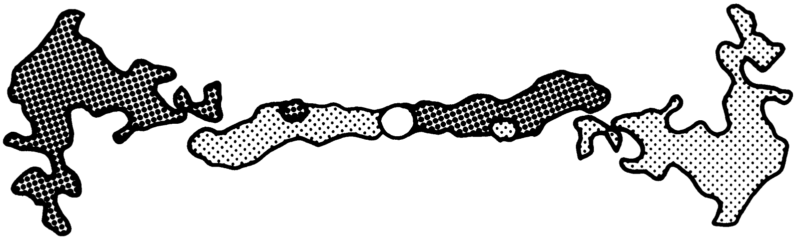

Fig. 1: 4CT 74.17.1, 6cm map (dark, adapted from van Breugel and Willis 1980) overlaid by a copy of itself (light), rotated 180° around core.

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To examine the asymmetries in an unbiased manner, a sample of QSOs was selected from the interferometer surveys of Miley and Hartsuijker (1978) and Fanti et al. (1977), at the WSRT, and Owen, Porcas and Neff (1978) and Potash and Wardle (1979), at Green Bank. All sources were included which had a compact central component, and more than four synthesized beam lengths along the source. The angular distances from the peak on each side to the central component (Θ_1 and Θ_2) were calculated from models of the brightness distributions, without reference to the maps. The values of Θ_1/Θ_2 *and* Θ_2/Θ_1 were then histogrammed, as in Fig. 2, so that each of the 47 sources has been plotted twice.

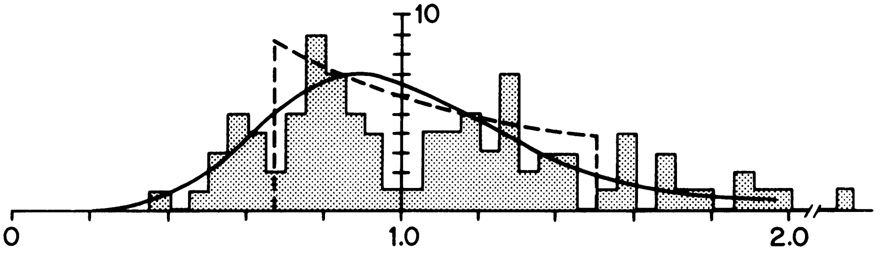

Fig. 2: Histograms of (Θ_1/Θ_2) *and* (Θ_2/Θ_1) for 47 QSOs, as described in the text. The dashed curve shows the expected distribution for intrinsically symmetric sources which undergo the time delay effect due to a fixed ejection velocity of v = 0.2c. The solid curve is the distribution expected if the length of each side of a double is independently drawn from a gaussian population with mean/rms = 3.

The observed distribution was also compared with those expected from random (i.e. mean free path) stopping of ejections, and projection effects on intrinsically bent sources. None of the above effects reproduce the dip observed near $(\Theta_1/\Theta_2) = (\Theta_2/\Theta_1) = 1$. Formally, one can rule out a flat or rising distribution near $(\Theta_1/\Theta_2) = 1$ with 80-90% confidence. As caveats, note that the statistics are still small, some pollution by bent sources exists and the resolution cutoff was chosen somewhat arbitrarily. In support of this result, see Ingham and Morrison (1976), who deduced an intrinsic arm length difference, and Longair and Riley (1979).

Assuming that the dip near 1 in Fig. 2 is real, what are its implications? First, there must be some coordination or physical relation between events on each side of a source, so that they can avoid occuring at the same distance from the nucleus. One possibility is the slingshot mechanism (Valtonen 1979), which preferentially ejects objects with different masses (and velocities, to conserve momentum). Alternatively, a drag force due to motion through the intergalactic medium could cause both bending and a length difference between the two sides. However, both of these mechanisms assume that the shorter side is essentially a delayed version of the longer one. This is difficult to reconcile with many sources which show complex, differing structures on the two sides, yet mesh in jigsaw fashion when displayed as in Fig. 1.

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If the dip in Fig. 2 results, instead, from alternating one-sided ejection, a number of consequences follow. Relativistic particles cannot, by definition, be continuously re-energized by the nuclear source. Close to the central engine, some assymetry must be allowed in any otherwise symmetric models (e.g. Wiita and Siah 1981). Subsequent ejections must be made at the same velocity (within 5-10%), so the dip near $(\Theta_1/\Theta_2) = 1$ is not wiped out. Similarly, there can be only little slowing down of the ejected material, or stopping by intergalactic clouds. Finally, ejection velocities must, in general, be <.05-0.1c, so that time delay effects (see, e.g. Longair and Riley 1979), do not fill in the dip.

As a caveat, it is clear that much of the low surface brightness emission in double sources does not follow this one-sided picture. Although trailing and diffusion offer natural explanations for this failure, they complicate further work. Also, the one-sided ejection picture is incomplete in that it does not predict the overall symmetries of double radio sources (see below).

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DISCUSSION

M. Rees: Is your evidence for asymmetry in component separations consistent with what Dr. Ekers told us about symmetry along some jets, etc?
L. Rudnick: These symmetries are consistent with, but not implicit in the one-sided picture. Producing symmetric large scale brightness distributions in twin jets, or accounting for the overall correlation in length between the two sides of a double may call for a (too?) careful arrangement of time scales for ejection, switching, and particle life.
R.M. Hjellming: One thing that may be reasonable is to have the "engine" orbiting around a dynamic center, with ejection characteristics which are strongly affected by gradients in the surrounding galactic atmosphere.
L. Rudnick: Yes. Some current work by V. Icke suggests that orbits do give alternating jets, but the periods are too long, e.g., for NGC 6251. Icke finds an instability in the equatorial plane of a jet which may produce single jets alternating on the required timescales.