THE LARGE SCALE STRUCTURE OF SUPERLUMINAL RADIO SOURCES

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The standard model for apparent superluminal motion is that of relativistic motion in a jet pointed nearly along the line of sight. Variants of this model give a natural explanation for the extremely asymmetric morphology observed in the radio cores of these sources. Despite this, examination of the large scale structure in superluminal radio sources strongly suggests that large scale symmetrical structure with two large radio lobes placed on either side of the compact emission is a common phenomenon among these objects. When a comparison is done between the large scale structure typically seen in double quasars and that seen in superluminal sources, it is found that the de-projected physical sizes estimated for superluminal quasars are similar to the size scales observed in the double quasars. Large scale radio structure is probably as common among apparent superluminal sources as it is in radio quasars.

In Table 1 we present a summary of superluminal sources and their observed angular sizes, along with apparent transverse velocities and de-projected sizes derived from their measured proper motions. For a few of the sources in Table 1, the de-projected sizes are significantly larger than the sizes observed in double quasars. This implies that simple de-projection over-estimates the physical sizes of some superluminal quasars, and that for those cases it appears that the angle to the line of sight of the superluminal motion is much less than the angle to the line of sight of the axis defined by the large-scale radio lobes.

For example, in the radio quasar 1928+738 the superluminal motion in the core implies that the core is oriented less than 15° to line of sight. However, the de-projected angular size would then be about 850 kpc for that projection angle. Unless 1928+738 is substantially larger than other double radio quasars, the extremely large angular size of 1928+738 suggests that the large scale structure is significantly misaligned to the line of sight at an angle much greater than 15°.

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TABLE 1: Angular Sizes of Superluminal Sources

Source	Morphology[a]	z	Size arc sec	v/c[b]	Theta_{max}[c] degrees	Minimum Apparent size h^{-1} kpc	Deprojected size[d] h^{-1} kpc	Ref
3120	C	0.033	720	2.1	51	370	424	(1)
NRAO140	D	1.258	11	5.4	21	61	170	(2)
3C179	C/D	0.846	16	4.2	27	80	176	(3)
3C216	C	0.668	2	2.5	44	9	13	(4,5)
3C245	D	1.029	9	3.1	36	48	82	(6)
3C263	D	0.652	44	1.3	75	199	206	(6)
3C273	A	0.158	20	5.3	21	36	100	(1)
3C279	C/D	0.538	18	3.5	32	74	140	(1)
3C345	D	0.595	20	8.2	3	85	1620	(2,7,8)
1642+690	D	0.75	11	9.3	12.3	53	249	(9,10)
4C34.47	D	0.206	180	3.2	35	406	713	(11)
1928+738	D	0.302	80	7.5	15.1	235	848	(12,13)
3C395	D	0.635	1	10.5	10.9	4	21	(14,15,16)
BL Lac	C	0.07	25	2.0	53	22	28	(2,6)

NOTES TO TABLE 1

[a] A = Asymmetric, C = Complex, D = Double

[b] We assume $H_o = 100\ h^{-1}$ km s^{-1} Mpc^{-1} and $q_o = 0.5$.

[c] Assumes that large scale emission is misaligned to the line of sight by the angle predicted by the apparent superluminal motion. No correction is made for the presence of radio lobes, so this is the maximum size for the source.

[d] $\text{Theta}_{max} = 2 \cot^{-1}$ (v/c) for all sources except 3C345 for which additional constraints are available (Cohen and Unwin 1984). If v/c were the only constraint, Theta_{max} = 14 for 3C345 and the deprojected size is > 351 h^{-1} kpc.