BULK RELATIVISTIC MOTION IN A COMPLETE SAMPLE OF FLAT SPECTRUM RADIO SOURCES

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As part of a multi-epoch and multi-wavelength study of the physics of core dominated radio sources we have investigated the occurrence of apparent superluminal motion and other indications for bulk relativistic motion (b.r.m) in a statistically complete, flux density limited ($S_{5GHz} \geq 1Jy$) sample of 13 objects with flat radio spectra ($\alpha_{5GHz}^{2.7GHz} \geq -0.5$, $S_\nu \sim \nu^\alpha$), $\delta \geq 70°$ and $|b_{II}| \geq 10°$. These sources come from the S5-survey (Kühr et al., 1981) and are optically identified as 7 quasars and 6 BL-Lac objects. They have been observed over a wide range of frequencies, from radio through X-rays (s. Eckart et al.,1986 and references therein). Radiomaps have been obtained at frequencies from 327 MHz to 22.2 GHz with resolutions from arcseconds to 0.2 mas, using the *VLA, MERLIN* and telescopes of the US- and European-VLBI networks. A recent status report on the VLBI-observations is given by Witzel (1987). In this paper we summarize the results on the direct evidence for b.r.m. in this sample as derived from repeated VLBI-observations at 5 GHz, as well as supporting evidence from SSC-calculations and flux density variability of the 5GHz VLBI core components (*Table 1*).

For the sources with unknown redshift we list in *col.6* of *Table 1* the "critical" redshifts beyond which the measured separation rate translates into $v > c$ ($H_0 = 100km/s/Mpc$, $q_0 = 0.5$). Deep optical imaging (Kühr, priv. com.) gives evidence for

Table 1 :

SOURCE	*ID*	$N(VLBI)$ $[5GHz]$	$d\theta/dt$ $[mas/yr]$	z	$z_{crit.}$	v_{app}/c h^{-1}	D_{SSC}^{min}	D_{var}^{min} $h^{2/3}$
0016 + 73	Q	1		1.76			8.0	
0153 + 74	Q	3	< 0.03	2.34		< 1.3		
0212 + 73	BL	3	0.09	2.37		3.9	2.4	1.4
0615 + 82	Q	2	0.05	0.71		1.1	1.3	
0836 + 71	Q	3	0.15	2.16		6.2	4.0	1.9
1039 + 81	Q	2	0.08	1.26		2.5	2.1	1.2
1150 + 81	Q	3	0.13	1.25		4.1	2.2	1.6
1803 + 78	BL	3	< 0.03	0.68[♮]		< 0.6	4.4	
1928 + 73	Q	5	0.60	0.30		7.0	1.7	1.2
0454 + 84	BL	2	0.15		0.16		2.1	
0716 + 71	BL	2	0.09		0.28		1.4	
1749 + 70	BL	2	0.10	> 0.7[♭]	0.25	> 2.2	1.3	
2007 + 77	BL	4	0.30		0.07		2.8	

redshifts from (♮) C.Lawrence (priv.com.),(♭) Wrobel et al. (this vol.)

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$z > 0.3$ in these sources. The results of *Table 1* indicate: {1} *10* out of *12* sources measured at least twice with VLB-interferometry at 5 GHz are candidates for apparent superluminal motion - 4 out of *6* sources with known z measured at least 3 times with VLBI show apparent faster than light motion -. {2} *12* out of the *13* sources show evidence for b.r.m. on the basis of SSC- calculations (s. Doppler-factors D in *col.8* of *Table 1*). {3} For the sources with known z this is in good agreement with the Doppler-factors (*col.9*), derived from the flux density variability of the 5 GHz core components adopting light travel time arguments (obviously, insufficient sampling has to be taken into account). A detailed discussion will follow (Schalinski et al.,in prep.). Thus, we conclude that b.r.m., especially apparent superluminal motion, is a common phenomenon among compact flat spectrum radio sources.

For 2 sources, *0153+74* and *1803+78*, we derived upper limits on v/c. In the case of the quasar *0153+74* (z=2.34) we detected 2 compact components A and B (s.*Fig.1*) - A has an inverted, B a flat spectrum between 1.6 and 5 GHz - with a separation of about 10 mas, and a "bridge" of steep spectrum components with a bending of $\sim 180°$. As A and B remained constant within the errors during almost 7 years, and neither SSC-calculations nor variability show evidence for Doppler-boosting, this source holds promise to be subluminal.

1803+78 (s.*Fig.1*: Schalinski et al.,this vol.) appears to be subluminal on the basis of observations at frequencies lower than 5 GHz, thus showing a discrepancy between expected inverse Compton- and observed X-ray flux densities. However, since the source was detected on transatlantic baselines at 43 GHz and with *IRAS* (s.Witzel,1987 for refs.), and recent 22.2 GHz-VLBI observations indicate the presence of a new component close to the core, relativistic effects cannot be excluded and require further studies at higher frequencies.

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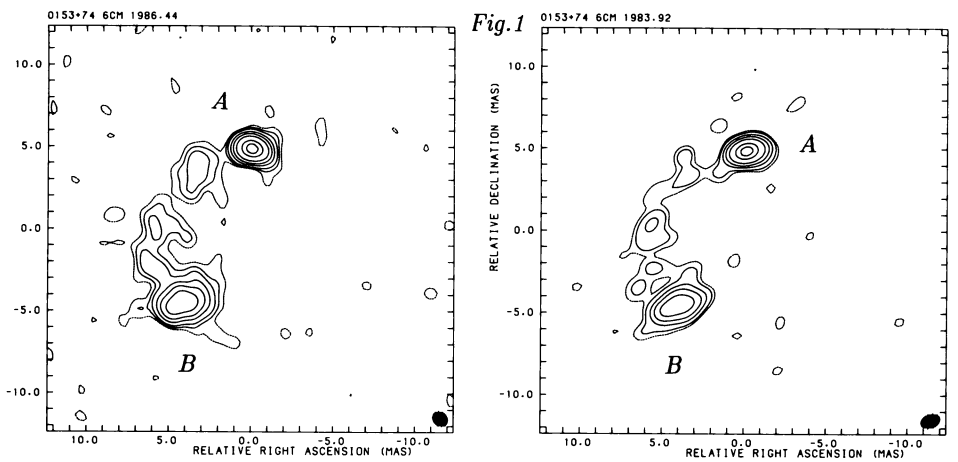

Fig.1

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