SUPERLUMINAL EXPANSION OF 3C 273

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Figure 1 shows hybrid maps of the core of 3C 273B at five epochs, made with arrays of 4 or 5 VLBI antennas. The maps span a period of 3.5 years. They all show a bright eastern peak and a lower-brightness extension to the west. There is a local maximum in the western extension between 6 and 8 milliarcsec from the main peak. This "blob" moves steadily further away from the main peak along a roughly straight line in PA $-116° \pm 2°$. Compare this with the position angle of the 25-arcsec optical jet, $-137°$. The maps show a slight curvature to the south with increasing separation from the main peak. Lower-resolution VLBI maps at lower frequencies show that this curvature continues at greater separations, suggesting a smooth connection between the milli-arcsecond position angle and the position angle of the optical jet. In our latest map (1981.09) the blob is no longer detectable with the limited dynamic range of the VLBI network (about 20:1).

The separation of the western blob from the eastern peak increased steadily between 1977 and 1980, with no evidence for acceleration or deceleration. The angular expansion rate is 0.76 ± 0.04 milli-arcsec/year, corresponding to a linear expansion rate of $v/c = (5.3 \pm 0.3)/h$, assuming $z = 0.158$, $H_o = 100h$ km/(s Mpc), and $q_o = 0.05$; 1 milliarcsec = 6.0/h l.y. = 1.9/h pc.

In the relativistic jet model the expansion is presumed to represent a physical motion almost directly towards the observer; we are looking down a jet of relativistic material expelled from the quasar. The eastern end of 3C 273B is the "core", the point at which the jet becomes optically thick. In a steady flow, this point remains fixed even though the radiating material has a high velocity. The moving (western) component is a "knot" propagating outwards along the jet. In order to account for an apparent transverse velocity v as large as 5.3c, the angle ϕ between the jet and the line of sight must be small. For h=1, ϕ must be less than 21°, and the space velocity is minimized at $\phi = 11°$. These angles will be smaller for smaller values of h. The probability that ϕ should be as small as 11° in a randomly selected quasar is 1%, or 2% if the jet is two-sided.

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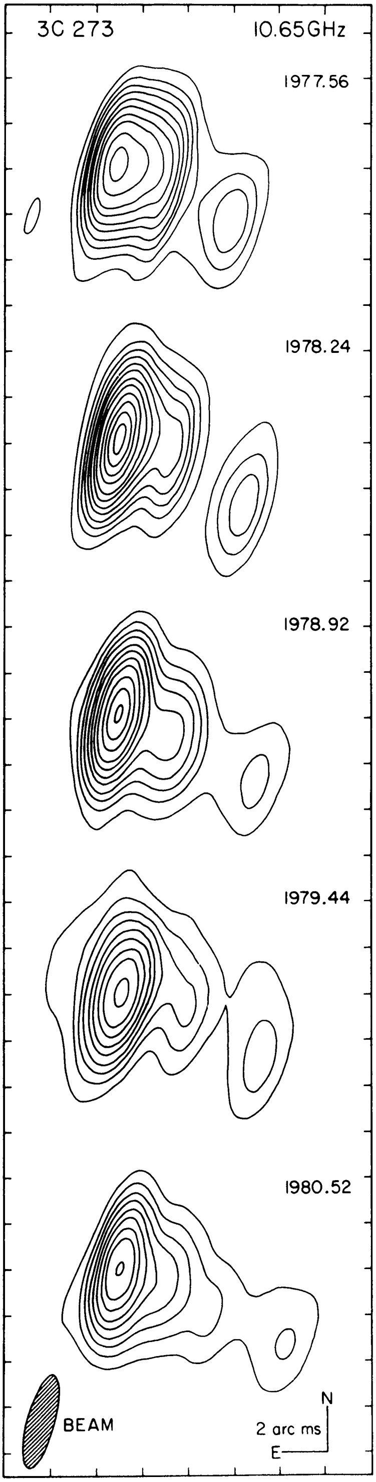

3C 273 is far from being a randomly chosen quasar: it is the closest quasar in the 3CR sample and has an intrinsic optical intensity about 4 times the intensity of the other quasars in the sample. It is surprising that it should also be exceptional in having a jet pointing almost directly at us. A possible explanation is that the optical radiation, like the radio, is not isotropic. There is no direct evidence for this, but beaming of the optical continuum cannot be ruled out. If the optical radiation is isotropic, then the small angle between the radio jet and the line of sight causes grave difficulties for the simple relativistic theories. For example, if the difference in radio intensity between optically selected and radio-selected quasars is due to the relativistic beaming of the radio radiation, because radio-selected quasars point towards us, we would expect to see 50 to 100 radio-quiet quasars of comparable optical magnitude to 3C 273, which we do not.

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REFERENCE

Pearson, T.J., Unwin, S.C., Cohen, M.H., Linfield, R.P., Readhead, A.C.S., Seielstad, G.A., Simon, R.S., and Walker, R.C.: 1981, Nature, 290, pp. 365-368.

Figure 1.
Maps of 3C 273B at 10.65 GHz at five epochs, from Pearson et al. (1981), who give details of the observations. Contour levels and restoring beam are the same for all maps. (Reproduced by permission of Macmillan Journals Ltd.)