SMALL STEEP-SPECTRUM SOURCES: JETS COLLIDING WITH AMBIENT GAS

Wil van Breugel, Radio Astronomy Laboratory, UC Berkeley, USA
Nan Ren-dong, Visiting Astr. at NFTA, Dwingeloo, The Netherlands
R. T. Schilizzi, NFRA, Dwingeloo, The Netherlands
C. and R. Fanti, Istituto di Radioastronomia, Bologna, Italy

A large fraction of sources in flux limited radio samples consists of compact steep spectrum (CSS) sources (Fanti *et al.* 1987). These objects have their dominant emission on kiloparsec scales and are found in a variety of active galaxies, including Seyfert II's, peculiar galaxies and quasars. Observations of very nearby CSS sources have shown good correlations between their complex radio structures and optical emission-line gas suggesting violent interactions between jets and dense gas in their ambient interstellar media (van Breugel *et al.* 1984). Similar jet/gas interactions may occur in more distant and more powerful CSS sources.

To investigate the radio morphologies of CSS *quasars* we have made global VLBI observations at 18 cm of 3C 119, 3C 287 and 3C 343. Using special imaging techniques high quality, noise limited maps were obtained (Nan Ren-dong *et al.* 1987). While the details of the low brightness features of these sources must be regarded with caution, it is clear from these data that the radio source structures are extremely complex, showing large curvature (3C 119, 3C 287) and seemingly detached regions of radio emission (3C 119, 3C 343). Similar radio morphologies have been found in the CSS quasars 3C 309.1 and 3C 380 (Wilkinson *et al.* 1985).

The extreme complexity of these CSS quasars suggests that the canonical "unified" scheme for quasars and galaxies, namely of relativistic jets seen end on, may be too simplistic. Other, statistical arguments which are difficult to accomodate in such a scheme are given by Fanti *et al* 1987. As before we suggest therefore that more realistic models include the "disturbing" effects on the (relativistic ?) jets by their environment.

Optical observations of powerful radio sources show increasingly that tidal interactions and merging of galaxies are *generally* (not rarely) important. Many powerful radio galaxies have nearby companions and exhibit peculiar morphologies indicative of merging activity (Heckman *et al.* 1986). Similarly, also many quasars have nearby companions (Heckman *et al.* 1984), and very suggestive evidence has been found from optical emission-line images that tidal interactions may occur in the *steep spectrum* (not flat spectrum !) quasars (Stockton and MacKenty, 1987).

Tidal interactions and merging of galaxies can affect radio source morphologies in important ways. The active nucleus might precess (temporarily) and/or exhibit orbital motion resulting in peculiarly twisted radio jets. If at least one of the interacting galaxies is gas rich, radio jets may collide with gaseous merging debris causing jet brightening (knots), deflection, decollimation and deceleration because of internal shocks, turbulence and possibly entrainment of ambient gas. In nearby radio galaxies both effects are well known to occur (Miley 1980; van Breugel 1985). The bright radio knots, large curvature and flaring of the jets at ~ 100 pc from the nucleus in 3C 309.1 and 3C 380 (and possibly in 3C 119) indicates that this may also occur in CSS quasars.

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Precession models of (relativistic) jets in their simplest - ballistic - form can qualitatively account for many of the observed peculiar radio morphologies (Gower *et al.* 1982). It would seem worthwhile to perform more realistic numerical simulations in which the effects of a dense and inhomogeneous ambient environment would also be incorporated since large curvatures can in part also be attributed to jet/gas deflections and ram pressure effects.

An interesting consequence of the assumption that CSS sources are jets propagating through dense inhomogeneous interstellar media is that the VLBI observations then would seem to suggest that the complex CSS *quasars precess rapidly and may be intrinsically one-sided.* This is because twin jets, after violent collisions with dense gas, would both be expected to brighten and slow down so that both might also be expected to be observable. Radio observations suggest that most CSS quasar jets are one-sided, examples are 3C 119, 3C 309.1 and 3C 380, but the sample with good VLBI maps is still small.

By the same assumption, the CSS *galaxies do not precess and are intrinsically two-sided*, since they have simple double morphologies. If one were to insist that quasars and galaxies are related, one might suppose that (CSS) quasars are merging systems which could perhaps evolve into (CSS) galaxies when the merging process is completed: precession stops, ambient gas acquiesces, nuclear activity lessens and becomes more stationary, and steady twin jets develop fully.

We end with noting that the jet/gas interactions in CSS sources do not only have consequences for the jets, they may also have considerable impact on the interstellar media themselves, including heating of ambient gas and even inducing star formation. For example, a jet-induced starburst has been found in Minkowski's Object (van Breugel *et al.* 1985), and recent evidence suggests that this may commonly occur in powerful, distant ($z \gtrsim 0.5$) radio galaxies (McCarthy *et al.* 1987. CSS sources with evidence for ongoing star formation are for example NGC 1068, (Wilson 1986), 3C 459 (Ulvestad 1985) and 3C 48 (Neugebauer *et al.* 1985). High resolution (Space Telescope) optical imaging observations of these and other CSS sources would of course be needed to determine whether any enhanced star formation is indeed morphologically associated with the radio emission in these objects.

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