RECENT WSRT AND VLA OBSERVATIONS OF THE JET RADIO GALAXY NGC 6251

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NGC 6251, a 14th mag elliptical galaxy, was shown by Waggett et al. (1977) to have large-scale radio emission features with a total angular extent of ~ 1.1°, which corresponds to a projected linear size of about 1.7 Mpc (H_0 = 75 km s^{-1} Mpc^{-1}). A bright radio jet links a central core source embedded in NGC 6251 to the extended emission on the northwest side of the galaxy.

We have observed the radio emission associated with NGC 6251 at 49cm wavelength with the Westerbork Synthesis Radio Telescope. The resulting radio map, made with a 55 arcsec beam (FWHM), is displayed in Figure 1. This map clearly indicates that in addition to the main jet oriented in position angle 296°, there is a faint counter jet extending to the southeast from the central core source. The cross-sectional integrated emission from the counter jet is only about 1/60 that of the main jet, which explains why the counter jet has not been detected previously. The 49cm map also indicates that the main and counter jets have rotational symmetry, changes in position angle of the main jet on its way to the northwest hotspot marked "A" being opposite to those of the counter jet on its way to feature "B". However, while hotspot A marks the end of collimated emission associated with the main jet, the counter jet appears to have additional loosely collimated emission extending some 13.9 arcmin (~360 kpc) from feature B to the outer hotspot marked "C". Note that hotspots A and C at the ends of the jets have rather similar surface brightnesses (to within a factor 2).

The bright inner 4 arcmin regime of the main jet seen in Figure 1 has been the subject of extensive VLA observations. These observations show that the Faraday rotation measure (RM) distribution and the projected magnetic field structure of the inner main jet are rather unusual. While the RM over the jet (and the northwest outer lobe) at distances greater than 90 arcsec (38 kpc) from the central core source is roughly constant with values lying between -40 and -60 rad m^{-2}, at distances of less than 40 arcsec (17 kpc), the RM has values ranging from -10 rad m^{-2} (at ~40 arcsec distance) to -130 rad m^{-2} (at ~18 arcsec distance). These variations of the RM over the inner part of the NGC

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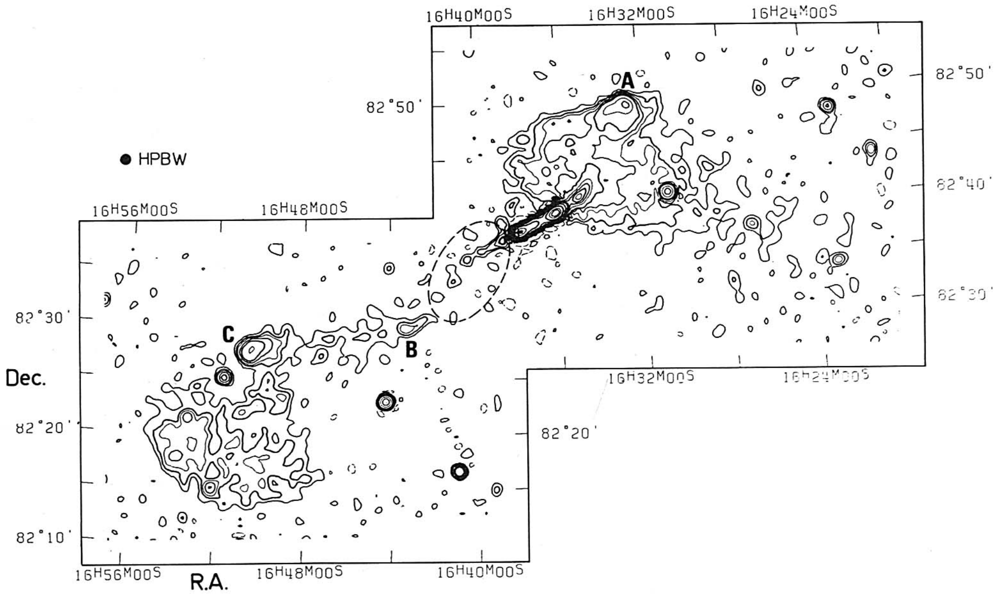

Fig. 1. NGC 6251 at 49cm wavelength. The region inside the ellipse has contours at -2 (dashed),2,3.75,6,9 mJy/beam. In the rest of the map the contours are -3 (dashed),3,6,9,13.75,20,40,60,80,100,150,250,400,500 mJy/beam. A cross marks the position of the central core source.

6251 jet are displayed in Figure 2. We believe that a rather constant fraction of this RM, ~ -50 rad m^{-2}, is due to the foreground Faraday screen of our own galaxy. The remaining variations might be due to one or a combination of the following possibilities. Firstly, about ± 30 rad m^{-2} of the RM might occur within the jet but in a significantly ordered magnetic field so that RM variations across the jet would be expected.(An estimate of $|30|$ rad m^{-2} RM internal to the jet is derived from the fact that the degree of polarization seen at 21cm wavelength is typically 0.6 of that seen at 6cm wavelength.) Secondly there may be ionized gas outside the jet but near or within NGC 6251 itself which produces the observed RM variations. The mass of ionized gas involved could then be as large as 2 x 10^9 solar masses.

That the RM variations must at least partially occur within the jet is suggested by the rough alignment between the RM contours over the distance ~20 to 30 arcsec from the core source in Figure 2 and the projected magnetic field structure also displayed there. Between 20 and 40 arcsec distance from the core the projected magnetic field has a diagonal orientation with respect to the jet extension as do the RM contours over 20 to 30 arcsec distance from the core.

This diagonal orientation of the projected magnetic field with respect to the main axis of the jet is also seen over the distance range 180 arcsec (77 kpc) to 260 arcsec (111 kpc). Elsewhere the

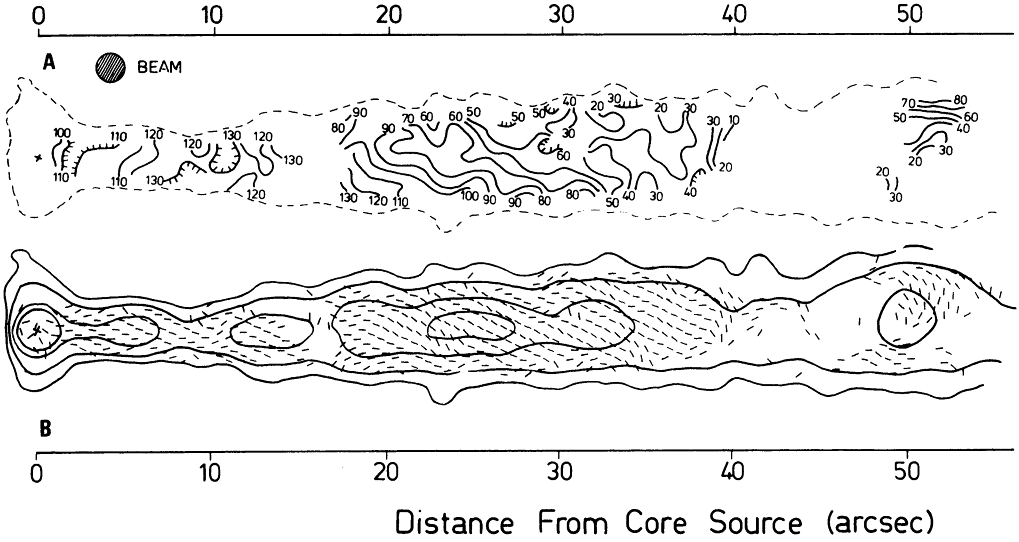

Fig. 2. (a) Contours of Faraday rotation measure (RM) over the inner part of the NGC 6251 jet. Negative signs have been omitted from all contour labels, i.e. a contour label of 100 implies a RM of -100 rad m^{-2}. The outer dashed line corresponds to a total intensity contour of 0.25 mJy/beam at 1662 MHz where the beam is 1.65 arcsec (FWHM). (b) Vectors indicating the orientation of the projected magnetic field in the jet superimposed on total intensity contours of 0.25, 1, 3 and 5 mJy/beam at 1662 MHz. Note that especially near the outer edges of the jet scatter in the vector orientations occurs because of low signal-to-noise ratio in the polarized flux density measurements used to generate this map.

magnetic field is aligned either parallel or perpendicular to the jet extension, a configuration already seen in many other radio jets such as that of 3C 31 (Fomalont et al., 1980).

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DISCUSSION

LAING: I belive that your results show that the E-vector PA is proportional to λ^2 over 300° of rotation close to the nucleus. One cannot get more than 90° out of a simple slab model and this implies that most of the rotation is caused by gas associated with NGC 6251, but located in front of the jet. The depolarization may be due either to : (a) thermal matter within the jet, or (b) foreground gas clumped on a scale much smaller than the beam.

WILLIS: I agree with your remark that the E-vector roation proportional to λ^2 for over 300° of rotation indicates that a large part of the rotation must be due to gas outside the jet. However, I think we must be careful in the application of the simple slab model to jets; the magnetic field may be quite complicated.