A POWERFUL JET/CLOUD INTERACTION IN THE RADIO GALAXY PKS 2250-41

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Extended emission line regions aligned with the radio axis are a common feature of powerful radio galaxies and there is much interest in the origin of the extended gas and excitation mechanism. One model that can produce this alignment is photoionization by anisotropic nuclear continuum radiation. However, strong evidence exists, especially in high redshift radio galaxies, for powerful interactions between the relativistic radio jets and the ISM/IGM. Here we present the results of our study of the southern radio galaxy PKS 2250–41 ($z = 0.308$). This object is the most spectacular found in a sample of southern radio sources studied by Tadhunter *et al.* (1993) and it displays particularly clear evidence for such an interaction (Tadhunter *et al.* 1994; Dickson *et al.* 1995).

1. Radio data

In the radio, PKS 2250-41 was observed with Australia Telescope Compact Array (ATCA) at 8 and 5 GHz. At 8 GHz we achieved a resolution of $\sim 1''$ (contours in Fig. 1). At this resolution, the structure of the source is dominated by two bright and slightly resolved components. The two lobes are situated asymmetrically compared to the centre of the optical nucleus. Despite the high frequency of these observations, no radio core was detected ($S_{\rm core} < 0.8$ mJy and $R = S_{\rm core}/S_{\rm ext} < 0.0013$).

Using the 5 and 8 GHz ATCA data, we have studied the polarization, depolarization and Faraday Rotation in the source as follows:
1) very low fractional polarization (~2.8% at 8 GHz) is observed in the western lobe. In the eastern lobe the fractional polarization is ~10%.

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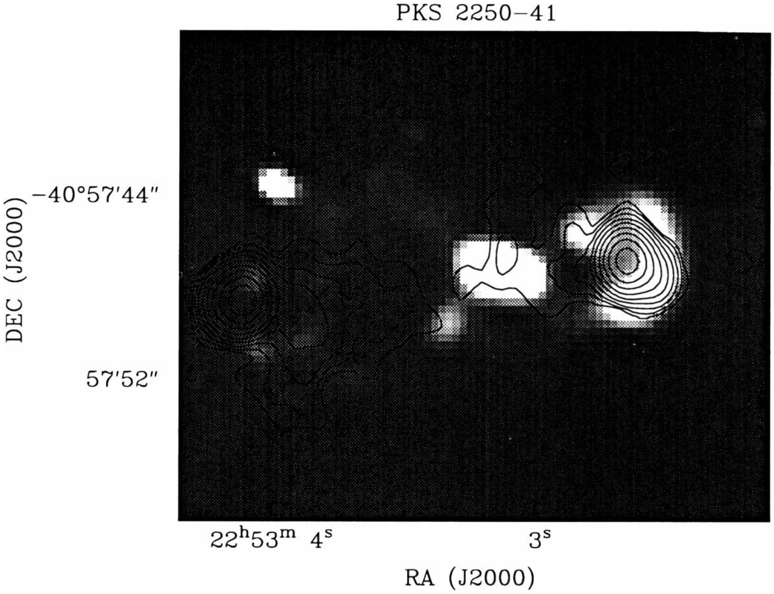

Figure 1.

2) very strong depolarization (~ 0.4 between 5 and 8 GHz) is observed in the western lobe while none is observed in the eastern lobe.
Depolarization can be attributed to beam smearing or internal Faraday depth effects. Higher resolution radio images will be necessary to disentangle these effects.

2. Optical data

In the optical, PKS 2250–41 was observed with the ESO 3.6 m telescope in July 1993 using EFOSC in broad/narrow–band imaging, spectroscopic and polarimetric modes. Our narrow-band [O III]λ5007 image (grey scale in Fig. 1) reveals a remarkable arc of line emission at radius of 6″ (35 kpc) west of the nucleus. The length of the arc is ≈ 8″ (50 kpc), with a projected thickness of 1.″7 (10 kpc). We also see a spatially distinct clump of [O III]λ5007 emission 20 kpc NW of the nucleus. Fainter emission–line arcs are observed to the east of the nucleus, at radii of 8″ (50 kpc) and 10″ (60 kpc).

In Fig. 1, we overlay the [O III]λ5007 image and the 8 GHz total intensity contours. Clearly, the optical and radio emission are closely associated. The western arc of line emission is at the outer edge of the western radio lobe, and the lower surface brightness eastern arc lies at the inner edge of the eastern radio lobe. Optical continuum emission is also seen coincident with the western lobe and at the inner edge of the eastern lobe.

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The spectra of PKS 2250-41 show that the extended arc has a much lower ionization state than the nucleus with a typical ratio [OII]/[OIII] between 2 and 3. Moreover, we find that in the western arc the low ionization lines —[NII], [SII] and [OI]— have a velocity dispersion up to $\Delta V \sim 500 \mathrm{kms}^{-1}$ while the high ionization [O III]λ5007 lines have a much lower velocity dispersion. The large velocity dispersions in the extended arc suggest a kinematic disturbance of the emission–line gas by the radio jet.

The spectrum of the western arc can be explained either by photoionization from the active nucleus or by jet-induced shocks (e.g. Sutherland *et al.* 1993). However, the latter seems to be better at reproducing line ratios (e.g. HeII/Hβ) and the observed difference in linewidth for the different ionic species. Furthermore, the correlation between the linewidth and the ionization state implies that the kinematic disturbance of the emission–line gas and the ionization mechanism are intimately related.

3. Origin of the extended gas

The observed $\geq 10^6$ $M_\odot$ mass of warm gas at a distance of 35 kpc from the nucleus of PKS 2250-41 might originate from either (a) jet-induced cooling of a pre-existing hot interstellar medium (Daly 1992; de Young 1989) or (b) pre-existing warm/cool gas clouds interacting with the radio jet. If we assume (a), the phenomenon should be observed in many more radio galaxies. If we assume (b), then where did this gas come from? The approximate mass of emission–line gas is consistent with a merger remnant. Our broad–band images show a companion galaxy to the east of the nucleus which shows signs of gravitational interaction with PKS 2250−41 in the form of tidal tails. Alternatively, we are observing a direct collision between the jet and a companion galaxy. This is supported by the colours of the continuum (following the subtraction of the nebular continuum) that are consistent with what is expected for a late-type spiral galaxy.

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