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Spectropolarimetry of Double Peaked Broad Hα Lines in Radio Galaxies

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Abstract. Spectropolarimetric observations of 3 broad line radio galaxies exhibiting double peaked broad Hα lines, show that two of the sources (Arp102B and 3C390.3) have single peaked line profiles in polarized flux with a position angle aligned with the jet axis. The third source (3C382) exhibits no polarized line emission at all. The consequences of these observations for the relativistic accretion disk and other BLR models are discussed.

1. Introduction

In one leading model, the broad line region (BLR) is confined to the outer radii of a relativistically rotating accretion disk resulting in a characteristically double peaked line profile with the separation of the peaks a function of the source orientation. This model, developed by Chen & Halpern (1989; C&H), introduces an electron atmosphere above the disk to cause local broadening of the disk emission and hence fit the rounded shape of the peaks. Chen & Eardley (1991; C&E) predict that such a disk atmosphere would produce a *double peaked* polarized line profile with the red wing always more polarized than the blue and that the polarization position angle (PA) would *normal* to the disk axis.

2. Observations and Results

Three sources with similar broad Hα lines, Arp102B, 3C390.3 and 3C382, were observed on the William Herschel Telescope, La Palma using the ISIS dual beam spectrograph. Only Arp102B and 3C390.3 clearly exhibited double peaked broad Hα lines in total flux and polarized broad line emission. These polarized broad line profiles were both *single peaked*, albeit asymmetrically, and the PA of both sources was found to be (to within 5°) *parallel* to the jet axis, varying little over

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the whole spectra. 3C382 exhibited no polarized line emission and the broad Hα line in total flux had red and blue "shoulders" rather than two distinct peaks.

3. The Scattering Model and Results

Assuming the disk and the jet share the same axis, the C&E prediction of the polarized flux profile and PA is not confirmed. We have developed a model in which the broad line emission is scattered by electrons located sufficiently high above the accretion disk that it resembles a point source, using C&H's relativistic disk model as the source function. The scattering electrons are assumed to be moving outwards in a cone aligned with the disk axis.

While profiles similar to those of Arp102B and 3C390.3 are achieved using this model, we predict that in far-field scattering the PA should be normal to the jet axis whereas observations show that it is parallel.

4. Alternative BLR Models

- The Binary Black Hole (Gaskell 1988): single peaked lines are emitted from the BLRs associated with each of the black holes producing a double peaked profile. It is difficult to see how a single peaked profile could be produced in polarized flux except in unusual circumstances (e.g. far-field scattering and velocity smearing), and the PA would still be normal to the jet axis. These observations appear to rule out this model.

- Outflow (Zheng et al, 1991): the BLR moves radially out from the core in two cones. The observed polarized line profiles could then be due either to far-field scattering off the walls of the torus or near-field scattering from a central jet coaxial with the cones but with a smaller opening angle. In both senarios the PA would be aligned with the jet axis.

5. Conclusions

The C&E predictions of the polarized flux profiles and position angles are not confirmed and hence it appears the disk does not have a scattering electron atmosphere. Profiles similar to those of Arp102B and 3C390.3 are achieved using the C&H model for the total flux profile and scattering this flux off radially moving electron clouds confined to cones but this does not fit the observed PA. Of the alternative BLR models, only the outflow model offers the geometry that produces a single peaked polarized flux profile with a PA aligned the jet axis.

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