THE MAGNETIC SWITCH AND THE FR I/FR II BREAK

D.L. MEIER[1], P. GODON[1], S. EDGINGTON[1], D.G. PAYNE, AND K.R. LIND[3]

[1] *Jet Propulsion Laboratory, Caltech, Pasadena, CA, USA*
[2] *Intel Corporation, Hillsboro, OR, USA*
[3] *Digital Equipment Corporation, Livermore, CA, USA*

Abstract. It is proposed that the Fanaroff and Riley division between class I and class II radio sources may be due to phenomena occurring in the coronae of magnetized accretion disks around black holes.

Extragalactic radio sources have been divided into two groups by Fanaroff & Riley (1974). FR I sources usually have low luminosity ($P_{radio} \lesssim 10^{25}\,W\,Hz^{-1}$), with the maximum radio emission in the jets occurring close to the host galaxy. FR II sources generally have high luminosity, with nearly all having the peak emission far from the galaxy at the end of two jets. The division in radio power is especially sharp when galaxies of the same optical magnitude are considered. In addition, brighter, more massive galaxies undergo the FR I/FR II transition at a significantly higher radio luminosity than fainter galaxies: $log\,P_{radio}^{break} = -0.66M_{24.5} + 10.35$ or $P_{radio}^{break} \propto L_{opt}^{1.65}$, where $M_{24.5}$ is an isophotal optical magnitude (Ledlow & Owen 1996).

The common interpretation of these results is that both classes are produced by twin jets ejected from an "engine" in the center of the galaxy, but the jets in FR I sources are transonic or subsonic, while those in FR II sources are supersonic, with the transition in jet speed occurring at $V_{jet} \approx 0.6c$ or $\gamma \approx 1.25$ (Bicknell 1985, and references therein). On *kiloparsec* scales (Wardle & Aaron 1997) jet speeds appear to be $\sim 0.1c$ ($\gamma \sim 1.005$) for FR Is and $0.6 - 0.8\,c$ ($\gamma \approx 1.25 - 1.67$) for FR IIs. On *parsec* scales, data are limited, but indicate a possible trend with $\gamma \lesssim 3$ for FR Is and $\gamma \approx 2 - 10$ for FR IIs (Pearson 1996). If further observations confirm these jet speed differences in the central core, the origin of the FR I/FR II division must lie near or in the central engine itself.

Recently (Meier *et al.* 1997a) the authors performed a large numeri-

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cal study of one of the more promising models for producing jets in radio sources and other objects — magnetohydrodynamic acceleration in of rotating accretion disks around black holes (Blandford & Payne 1982). Our main results were: 1) the Alfvén velocity in the corona above the disk can be quite high, even for modest disk magnetic field strengths; and 2) there is a sharp difference in the speed of the jet produced when the coronal Alfvén velocity is below the escape velocity and when it exceeds the escape velocity. In the former case, jet velocities are only a few tenths c, but in the latter velocities of $\gamma \gtrsim 10$ are common. There is, however, no corresponding transition in jet power; it varies smoothly across this "magnetic switch".

We propose that this effect may be the reason for the FR I/FR II division. It explains why a sudden change in jet speed occurs at a given radio power. Furthermore, it can quantitatively reproduce the slope of the Ledlow & Owen relation. Using the expression for jet power from Blandford & Payne (1982), our theoretical expression for the FR I/FR II break (Meier *et al.* 1997a), Shakura & Sunyaev's (1973) accretion disk models, and the well-known Kormendy & Richstone (1995) results to relate black hole mass to galaxy optical luminosity, we obtain a theoretical expression for the jet power at the break of $P_{jet}^{break} \propto L_{opt}^{1.625}$, in very close agreement with the *slope* of the observed relation. (Better models of the disk corona are needed to predict the *intercept* itself.) The reader is invited to consult Meier *et al.* (1977b) for more details on this model.

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