ENIGMA Winter School – Lesson 3 Marscher

I. Values of Γ

A. From superluminal motion: $\beta_{app} = \frac{\beta \sin\theta}{1-\beta\cos\theta} \leq \Gamma\beta$

$(= \Gamma\beta$ for $\theta = \sin^{-1}(\frac{1}{\Gamma}))$

Observed in compact radio sources (flux-limited sample):
β_{app} as high as ~40 (γ-ray blazars: Jorstad et al. 2001 ApJS, 134, 181; Kellermann et al. 2004, ApJ, submitted)

[statistical studies indicate that high-Γ jets are rare in volume but easy to detect because of beaming → vastly over-represented in flux-limited surveys]

B. Theoretically:

$\Gamma \sim \frac{1}{2}\left(\frac{B^2/8\pi}{\rho c^2}\right)$ at base of jet (Conversion of Poynting flux to kinetic energy in magnetic launching models)

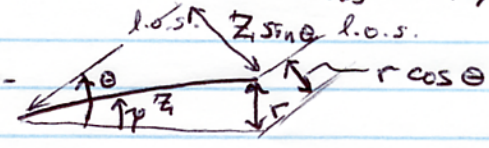
But: If $\Gamma \gtrsim 10$ close to central engine, high-density photon field will interact with electrons → momentum loss ("Compton drag" – Phinney 1987, in Superluminal Radio Sources, ed. Zensus + Pearson, 301)

⇒ argues in favor of acceleration of jet out to pc-scales

II. Opening Angles

FRII Radio galaxies viewed at $\theta \sim 90°$: ψ typically $1°$–$3°$
– But most of these probably have low Γ's

Blazars: (ex) 3C 279: $\psi_{obs} \approx 5°$ but $\psi_{obs} = \psi/\sin\theta$ ($\theta \ll 1$)



derivation: from figure, in l.o.s. coordinates, $\sin\psi_{obs} = \frac{r\cos\theta}{z\sin\theta}$

and $r = z\tan\psi$ → $\sin\psi_{obs} = \frac{z\tan\psi\cos\theta}{z\sin\theta} \approx \psi/\sin\theta$ for $\psi \ll 1$, $\theta \ll 1$

In 3C 279, $\Gamma \gtrsim 25$; β_{app} as high as 25
⇒ $\theta \lesssim 2°$, so $\psi \approx 5° \sin 2° \approx 0.°2$!