ENIGMA · Lesson 1 ② Marscher

Considerations

1. Assumption of MHD: $\vec{B}$ field is frozen into plasma → fluid

2. B_ϕ requires a current, $I(r) = \frac{cr}{2} B$
   There must also be a return current, which will cause dissipation of energy where it crosses field lines near base of flow

   Dissipation region could be near black hole (BH)
   → black hole "battery" (Lovelace 1976; Blandford + Znajek 1978)

   In any case, ideal MHD does not include dissipation

3. Current-carrying jets are unstable; Nakamura + Meier (2004, in Plasmas in the Laboratory + in the Universe; available on astro-ph) propose that current-driven kink instability might account for bends observed in pc-scale jets

MHD Simulations

Meier, Koide, + Uchida (2001, Science, 291, 84): partly successful, but did not produce high-T jets

Vlahakis + Königl (2004, ApJ, in press): Poynting-flux dominated jet
$\sim \frac{1}{2}$ of MHD energy is converted to flow energy if $\frac{B}{\sqrt{4\pi\rho c^2}} \gg 1$
⟹ acceleration + collimation can continue out to pc scales

Much more work needs to be done at higher dynamic range (largest to smallest scales of mesh)