Self-similar model of Relativistic Astrophysical Jet

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Outline

- Motivations
- Self-similar model
- Modeling of extragalactic jet
- Classification FRI/FRII
- Conclusion

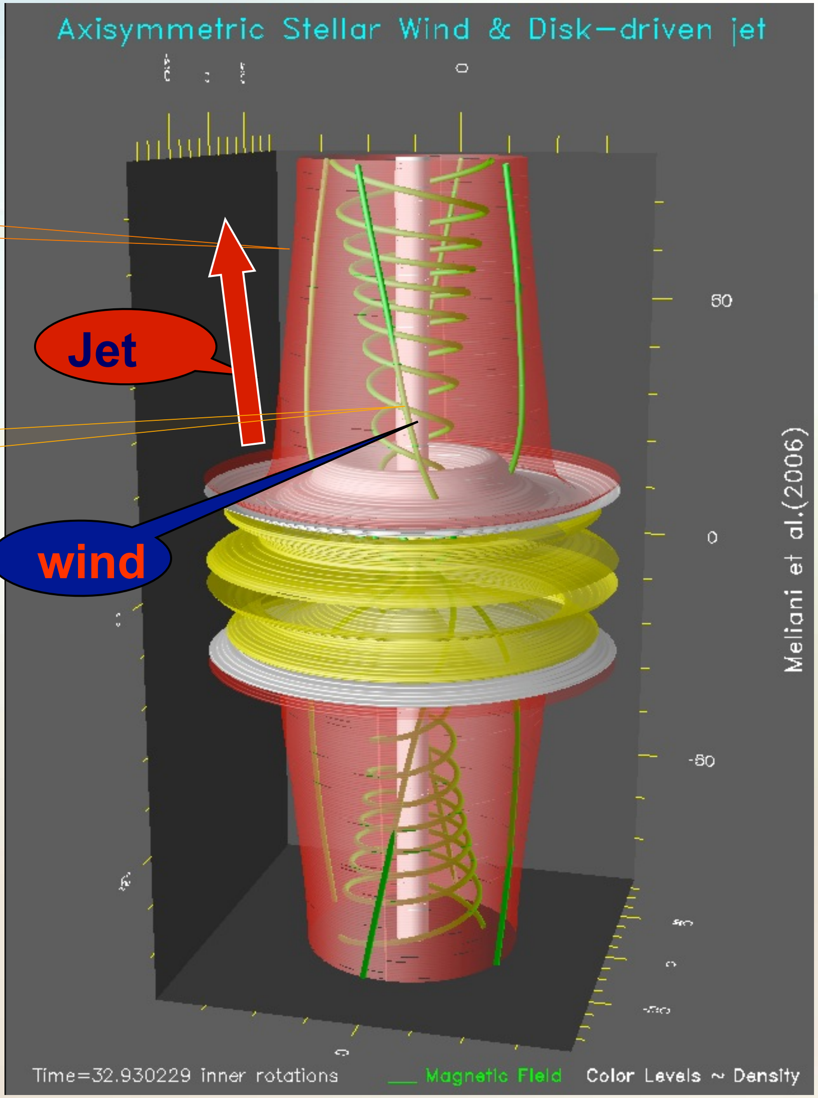
Jet in Active galactic nuclei

Spin jet

Jet launching

✓Ejection from disk

✓Ejection from inner corona



Results

The energy and angular

Momentum is extract by jet and wind

Meliani, Casse, Sauty, 2006

Self-similar model of relativistic jet (Schwarzshild metric)

•Self-similar method

α: magnetic flux

α: function of the radius R and the angle θ

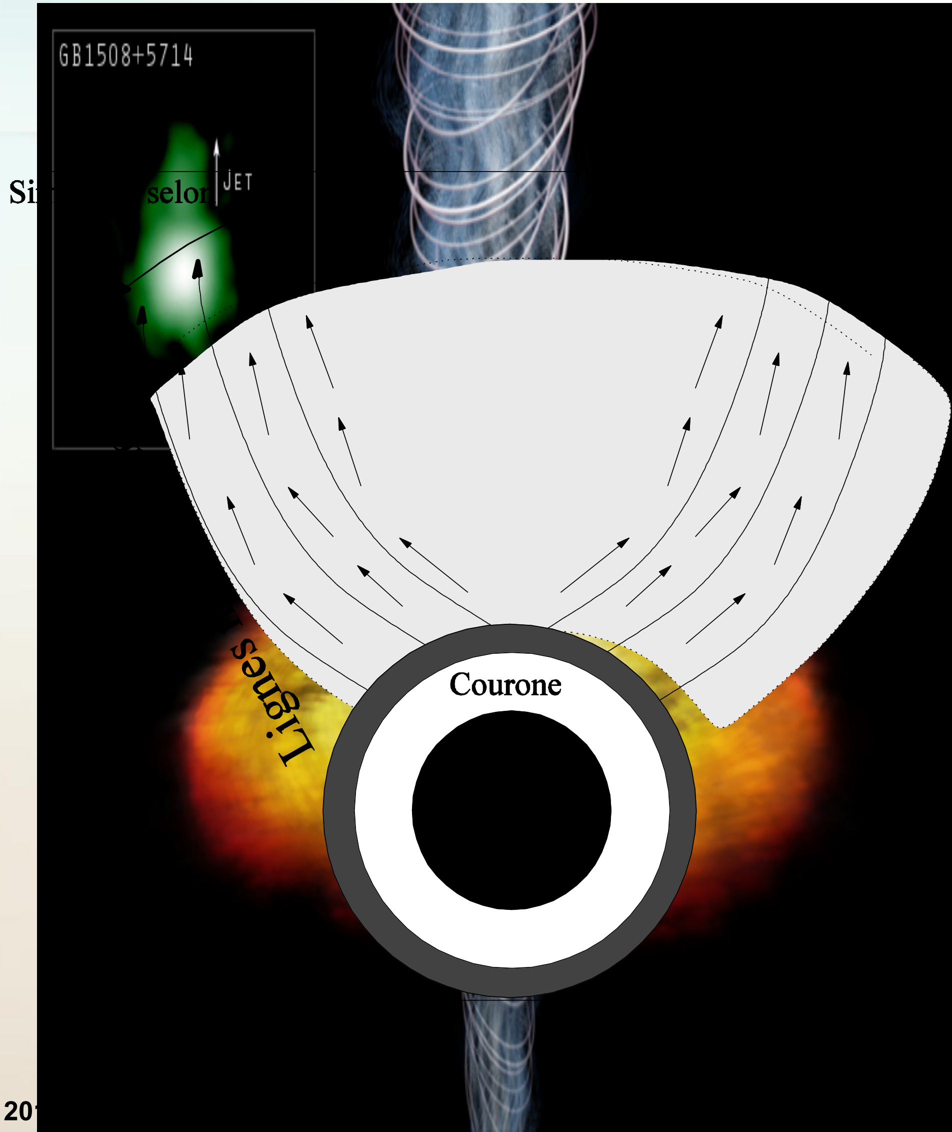
$$\alpha = f(r)\sin^2(\theta)$$

First ordre in **α**

P ~ (1+κ **α**) = **(pression)**

n ~ (1+δ **α**) = **(densité)**

Ω~ λ/√(1+δ **α**)= **(rotation)**



GRMHD equations

Stationnary GRMHD equations 3+1

$$\nabla \cdot (h\gamma n V) = 0.$$

$$\gamma n (V \cdot \nabla)\left(\frac{\gamma w V}{c^2}\right) = -\gamma^2 n w \nabla \ln h - \nabla P + \rho_e E + \frac{J_e \times B}{c},$$

$$nV \cdot \nabla w = V \cdot \nabla P.$$

$$\nabla \cdot E = 4\pi \rho_e,$$

$$\nabla \cdot B = 0,$$

$$\nabla \times (hE) = 0,$$

$$\nabla \times (hB) = \frac{4\pi h}{c} J_e,$$

$$E = -\frac{V \times B}{c}.$$

Pressure along the rotation axis

$$\frac{d\Pi}{dR} = -\frac{2}{h^2}\frac{1}{G^4}\left(\frac{dM^2}{dR} + \frac{F-2}{R}M^2\right) - \frac{1}{h^4 R^2 M^2}\left(\nu^2 h_\star^4 - \mu \frac{M^4}{G^4}\right),$$

Alfven Number

$$\frac{dM^2}{dR} = \frac{\mathcal{N}_M}{\mathcal{D}},$$

Streamline expension

$$\frac{dF}{dR} = \frac{\mathcal{N}_F}{\mathcal{D}},$$

ODE

Radial function

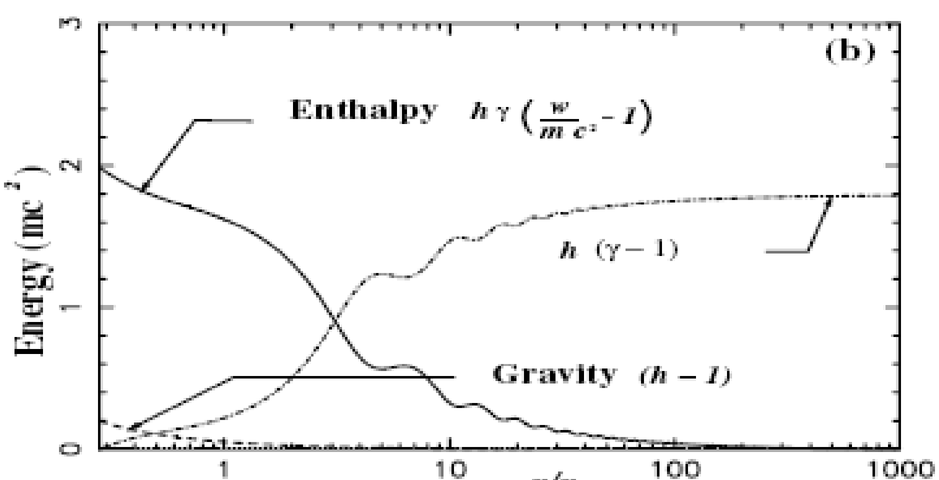
Thermal and magnetic acceleration

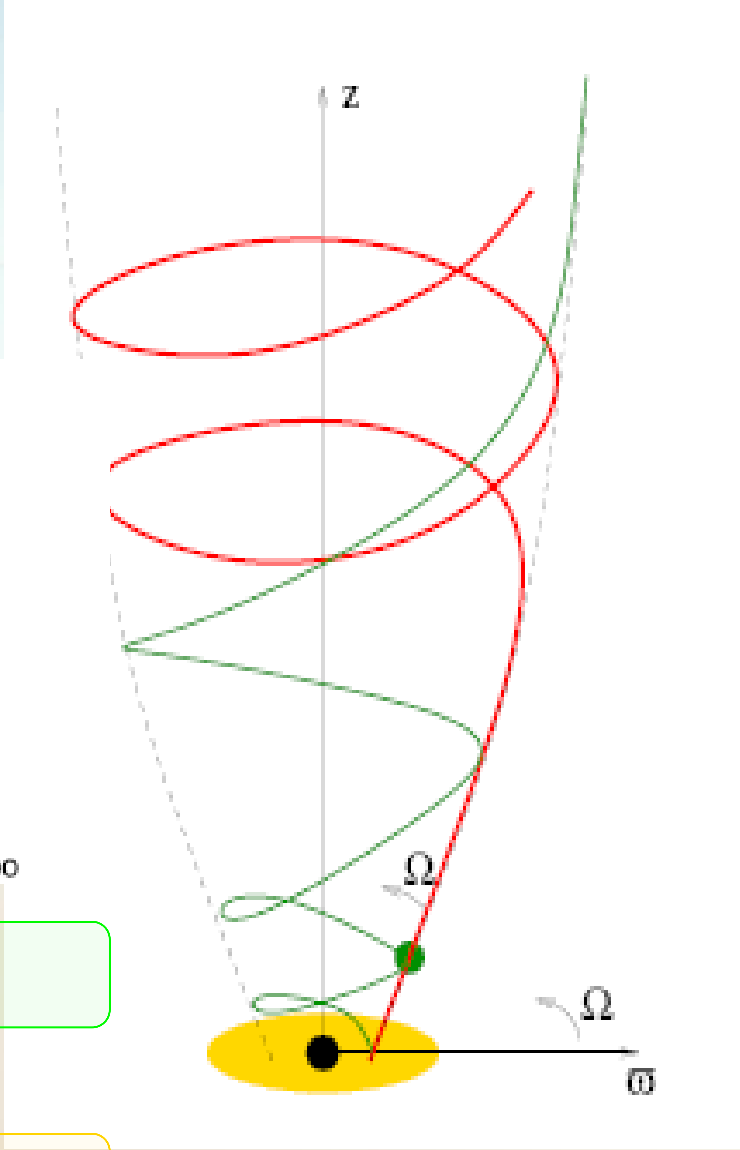
Curvature function of the space-time

$$\mathcal{E} = h\gamma w - h\frac{\varpi\Omega}{\Psi_A}B_\varphi,$$

Enthalpy

Poynting flux





Magnetic acceleration: Alfven Surface

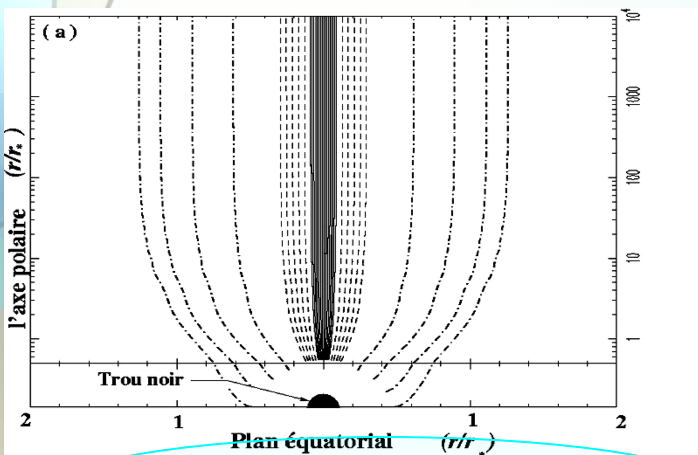
After Alfven surface

Thermal acceleration : heating

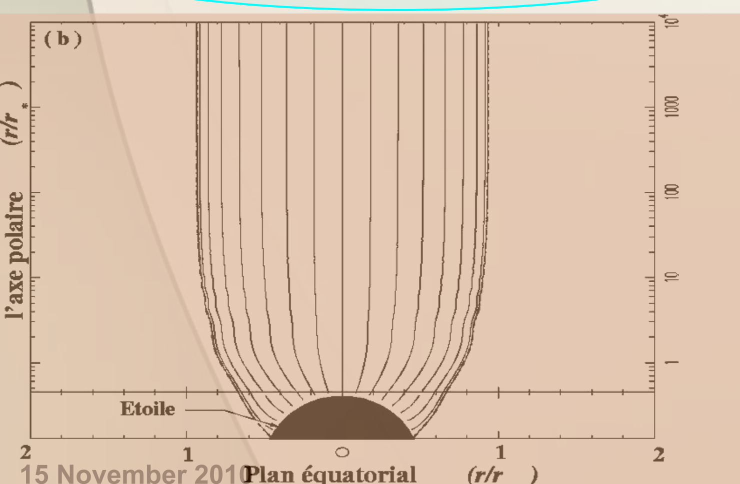
AGN-YSO jet

- **Formation and collimation the jet around schwarzshild BH**

Jet- BH



Jet - YSO



Thermal acceleration
γ ~ 20 (heating)
Magnetic/thermal collimation

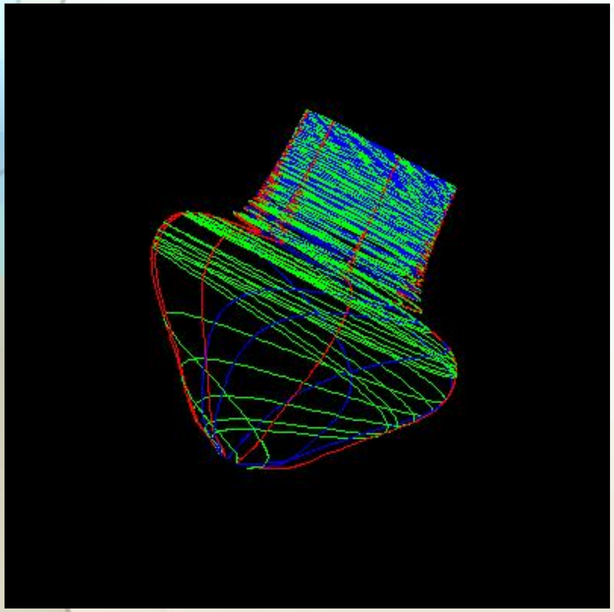
Relativistic effects

- **Decrease of the magnetic collimation efficient**
- **Enhance the thermal acceleration**

Application

Fanaroff Riley galaxies (Radios galaxies)

Magnetic ligne in 3D



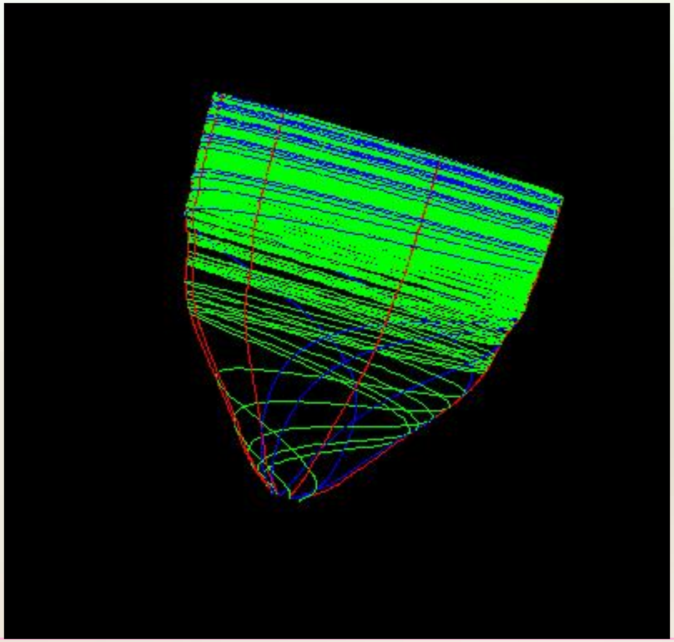
Jet in Fanaroff Riley I galaxies

Collimation by the external pressure

Quantity of the Poynting flux ejected in the jet

Jet in Fanaroff Riley II galaxies

Magnetic collimation



Magnetic ligne in 3D

Conclusion

- The disk coronae has sub-Kepler rotation
- The difference YSO/AGN jets are not only scaling
  - Special relativity : decreases the efficiency of the Lorentz force to collimate the jet
  - General relativity: Enhance the thermal efficiency to accelerate the jet