Astrophysical jets from strongly magnetized systems

A non isotropic accretion disk dynamo

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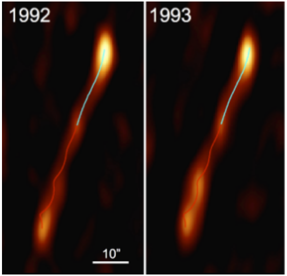
Astrophysical Jets

Jets span orders of magnitude in terms of extension, time scales, and energy scales

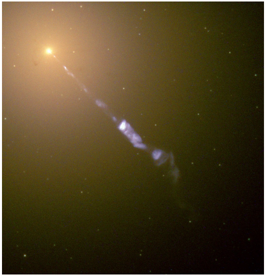
Ingredients:

- Accreting object
- Accretion disk
- **Magnetic field**

(Blandford & Znajek 1977,
Blandford & Payne 1982,
Uchida & Shibata 1985,
Casse & Keppens 2002,
Fendt 2006,
Zanni et al. 2007)



1E1740.72942. VLA



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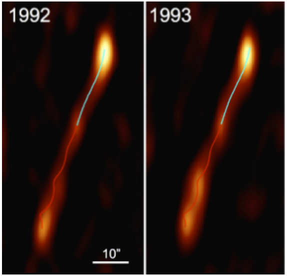

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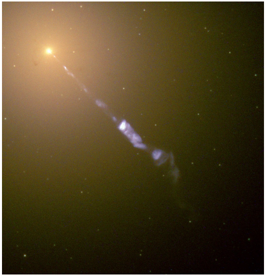

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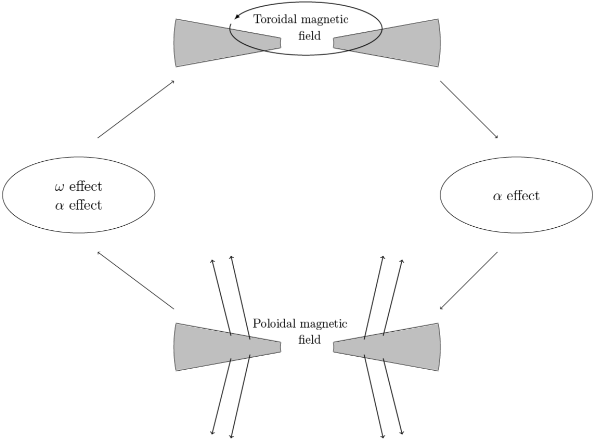
How does the magnetic field originate?

Possible origins: **Dynamo process**

Mean-field dynamo (Krause & Rädler 1980, Rüdiger et al. 1995, Stepanovs et al. 2014):



The dynamo tensor

$$\partial_t \boldsymbol{B} + \nabla \times [\boldsymbol{B} \times \boldsymbol{v} + \bar{\bar{\eta}}(\nabla \times \boldsymbol{B}) - \bar{\bar{\alpha}}\boldsymbol{B}] = 0$$

General properties:

- Non-isotropic
- Depends on midplane sound speed
- Change of sign across the midplane

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- Can we constrain the dynamo components?

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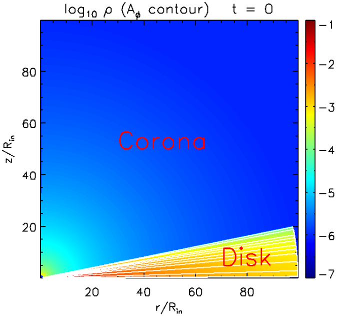
1st numerical simulations of jets launched by a non isotropic accretion disk dynamo

(Mattia & Fendt 2020 a, b)

Setup

Numerical setup:

- PLUTO code (Mignone et al. 2007)
- Dynamo resistive MHD
- Axisymmetry
- Disk + corona, weak seed field



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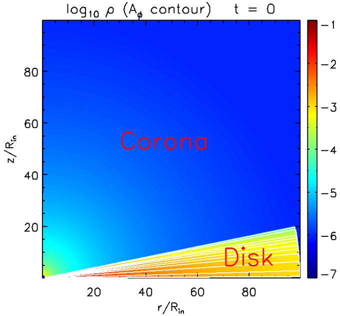
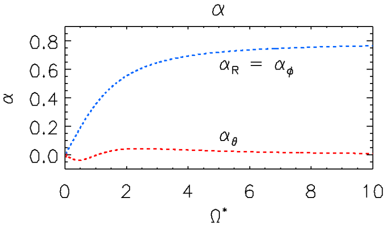


Dynamo model:

- Accretion disk dynamo (Rudiger et al. 1995).
- Turbulence vs rotation: Coriolis number Ω^*.

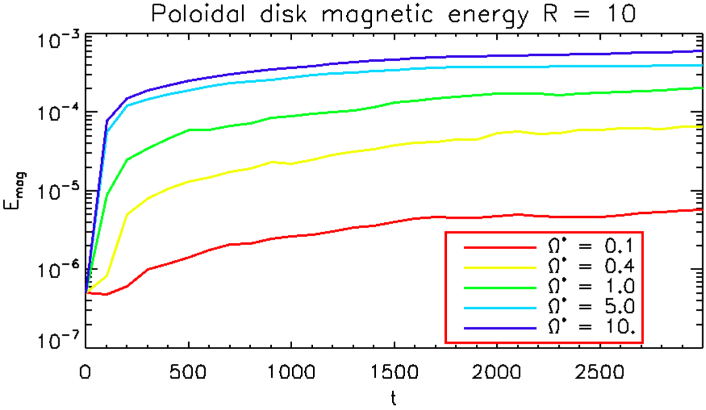


Reference simulation

Magnetocentrifugal disk wind from dynamo-generated magnetic field

Amplification of the magnetic field

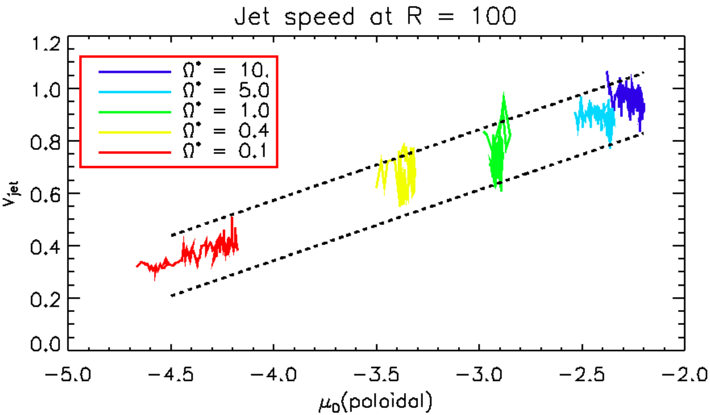
Effect of the dynamo on the poloidal magnetic field



A stronger α effect leads to a stronger magnetic field amplification.

Jet speed and disk magnetization

Effect of the dynamo on the jet speed:



A stronger magnetic field leads to a faster and more collimated jet.

Conclusions

- We applied a non-isotropic mean field dynamo in the context of jet launching simulations
- A mean-field disk dynamo is an efficient mechanism for magnetic field amplification
- The dynamo-generated magnetic field topology is favorable for fast collimated disk winds/jets
- A stronger α-effect leads to a faster and more collimated jet
- This work can be found in:

G. Mattia & C. Fendt 2020a, ApJ, 900, 59

G. Mattia & C. Fendt 2020b, ApJ, 900, 60