Jets, disc-winds and oscillations around Kerr black hole

“Extragalactic jets on all scales - launching, propagation, termination”, jointly organized by MPIA and IIT Indore.

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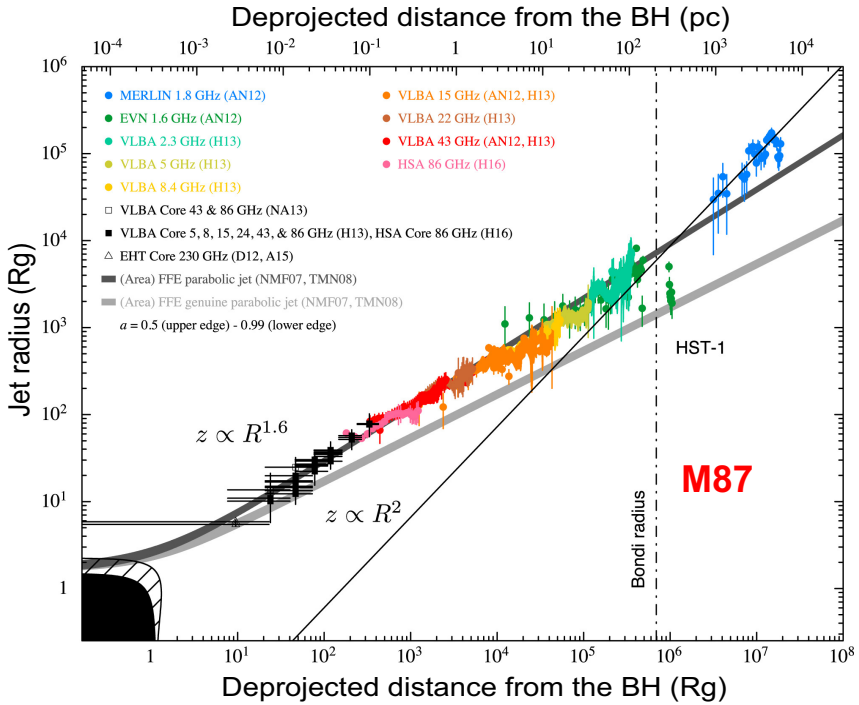
Credit: NRAO/AUI

Motivations:

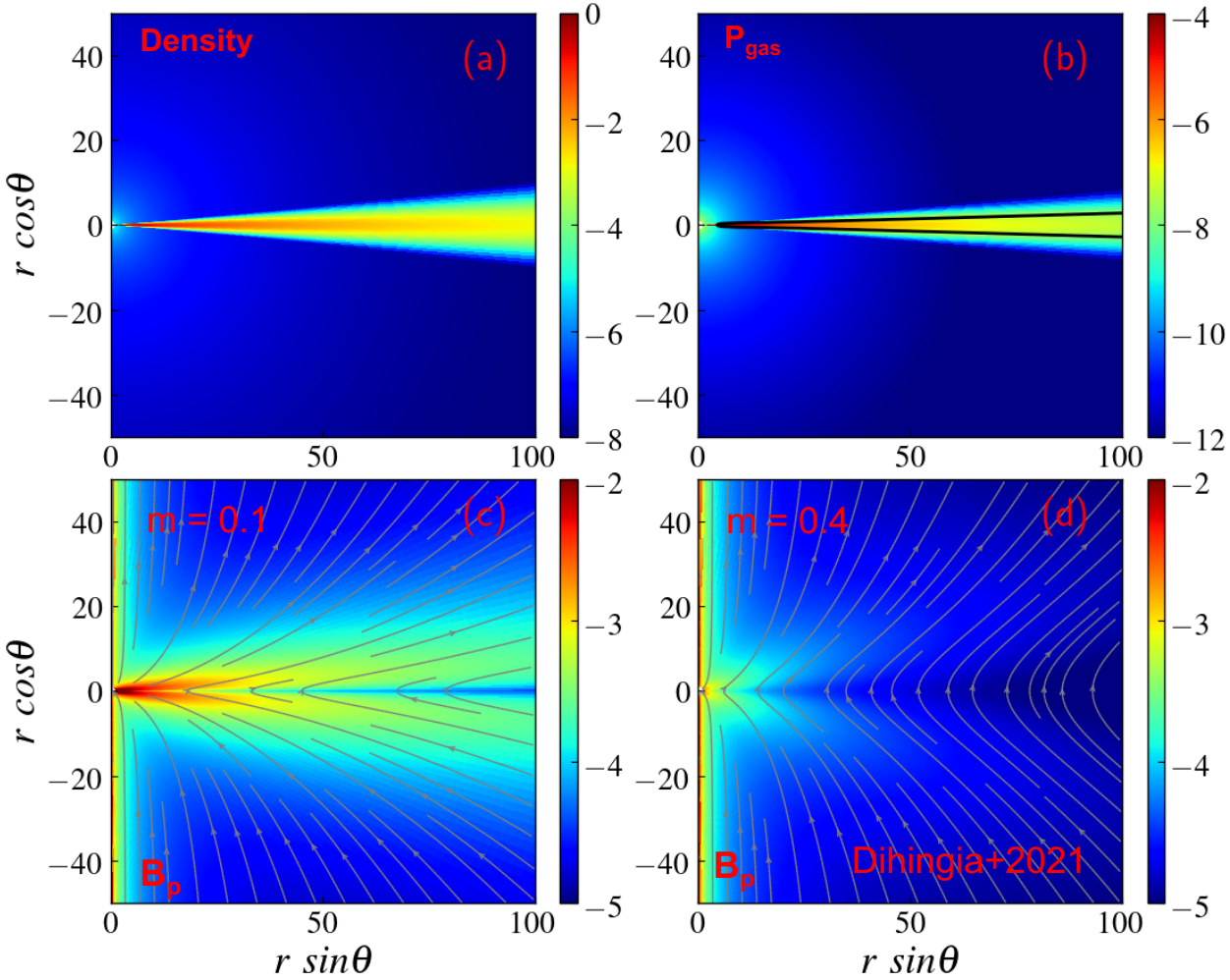
Torus based GRMHD simulations:
DeVilliers+2003, Gammie+2003,Noble+2006, DelZanna+2007, Tchekhovskoy+2010, Liska+2018, Nathanail+2020, and more.

Disc based GRMHD simulations:
Koide+1999, Qian+2018, Vourellis+2019,2021, Dihingia+2021.



Jet launching radius for M87 is about 5.5 Rg (Nakamura+2018), while for Cyg A it is about 227 Rg (Boccardi+2016)

Initial setup:



Initial setup for thin disc around Kerr BH. Using code BHAC **(**Porth+2017; Olivares+2019**)**

Our initial conditions are based on the Novikov & Thorne model (Novikov & Thorne (1973)).

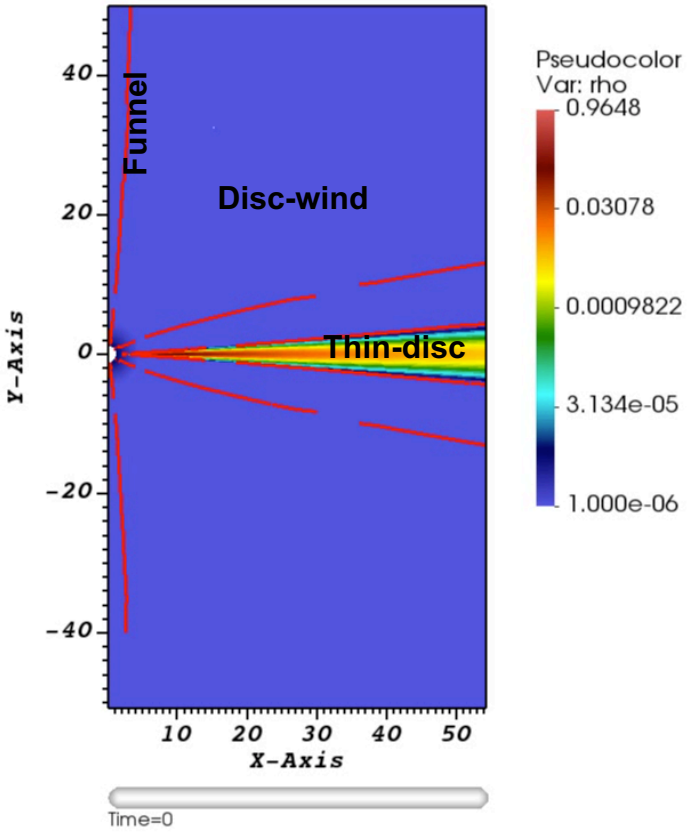
Vector potential:

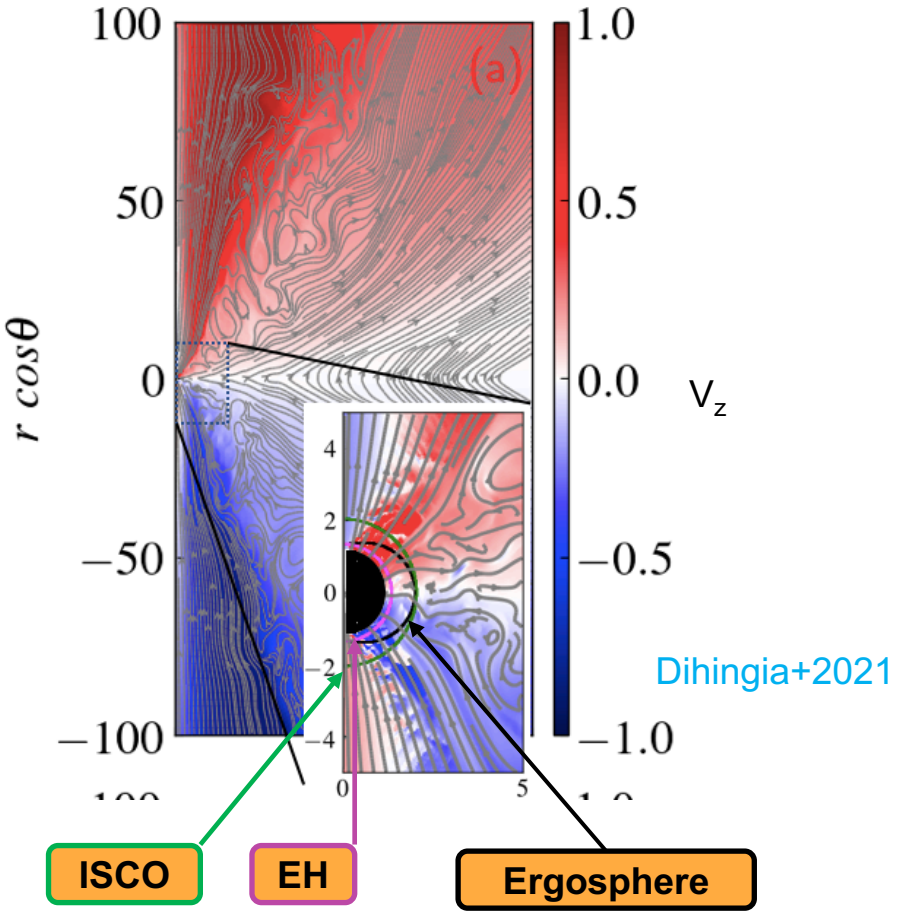
$$\mathcal{A}_\phi \propto (r\sin\theta)^{3/4}\,\frac{m^{5/4}}{(m^2+\tan^{-2}(\theta-\pi/2))^{5/8}},$$

Zanni+2007

Temporal Evolution

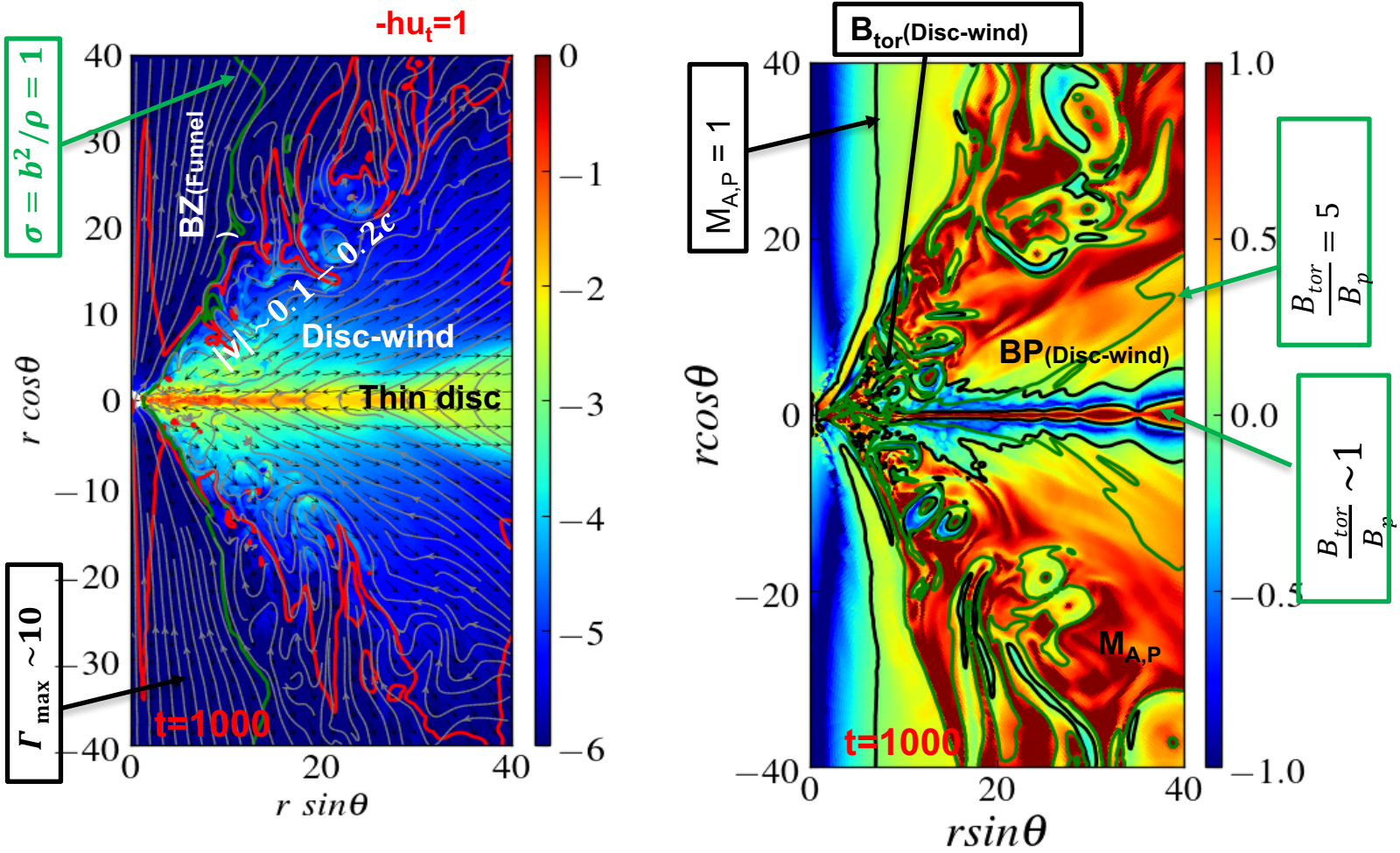
Density evolution



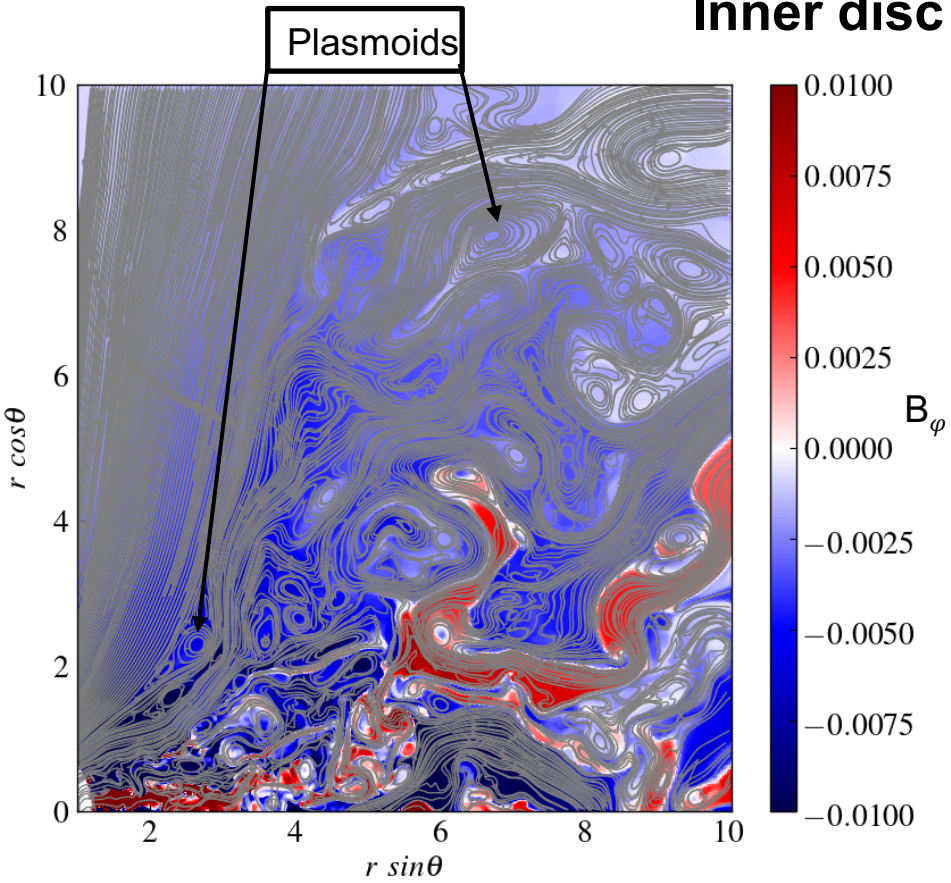


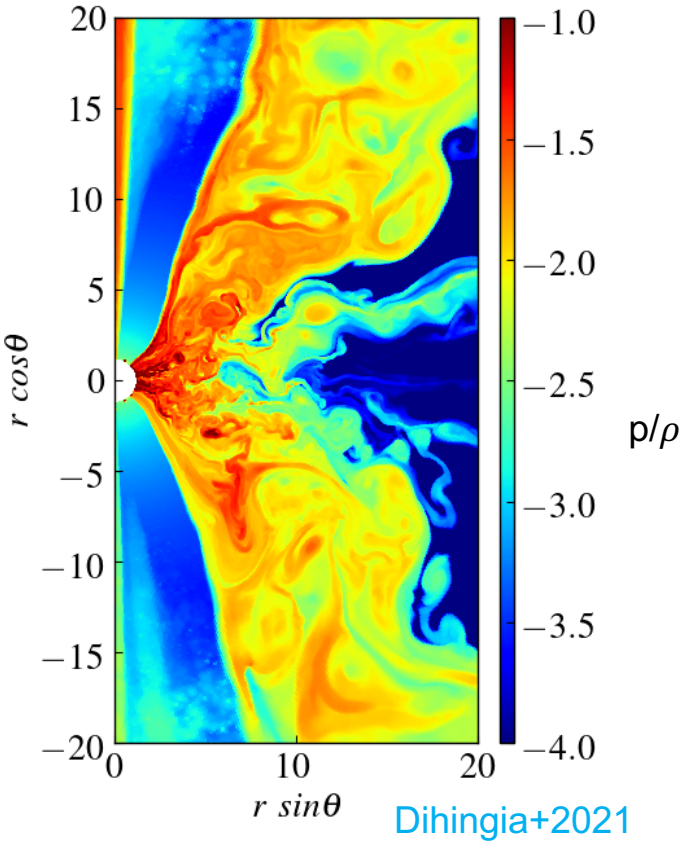
Dihingia+2021

Wind and jet:


-hu$_t$=1
$\sigma = b^2/\rho = 1$
BZ(Funnel)
$|V| \sim 0.1 - 0.2c$
Disc-wind
Thin disc
$\Gamma_{max} \sim 10$
t=1000
r cosθ
r sinθ
B$_{tor}$(Disc-wind)
M$_{A,P}$ = 1
BP(Disc-wind)
M$_{A,P}$
$\frac{B_{tor}}{B_p} = 5$
$\frac{B_{tor}}{B_p} \sim 1$
rcosθ
rsinθ

Inner disc structure:





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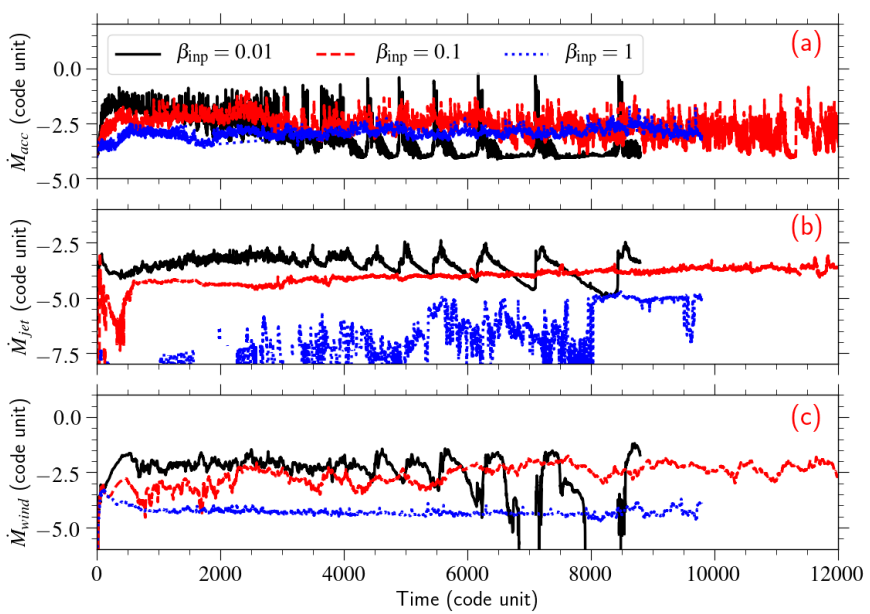
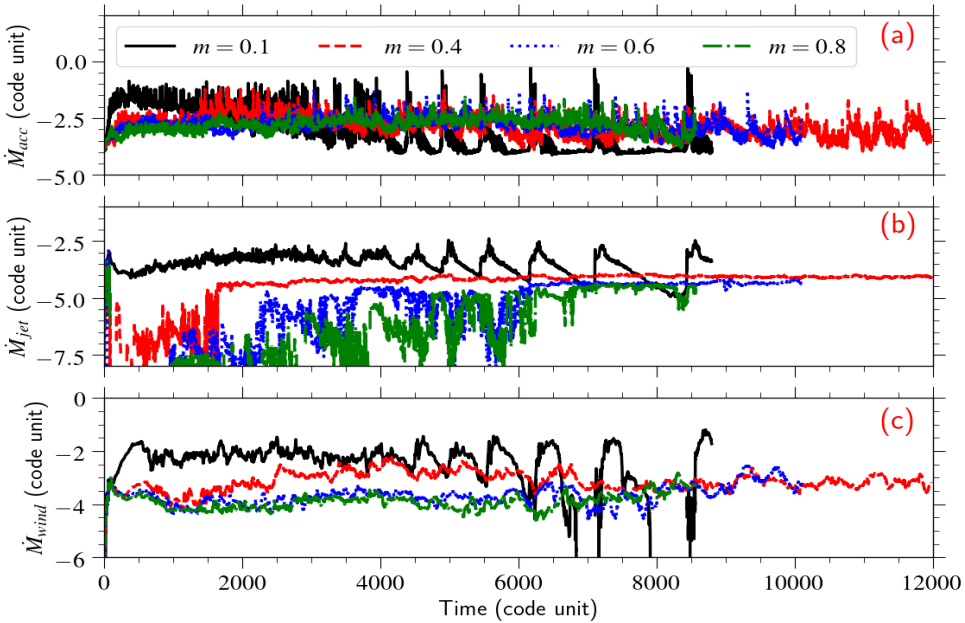
Source of turbulence: **MRI** ($\boldsymbol{\beta > 1}$) and **MRTI** ($\boldsymbol{\beta < 1}$).

Mass flux rates:





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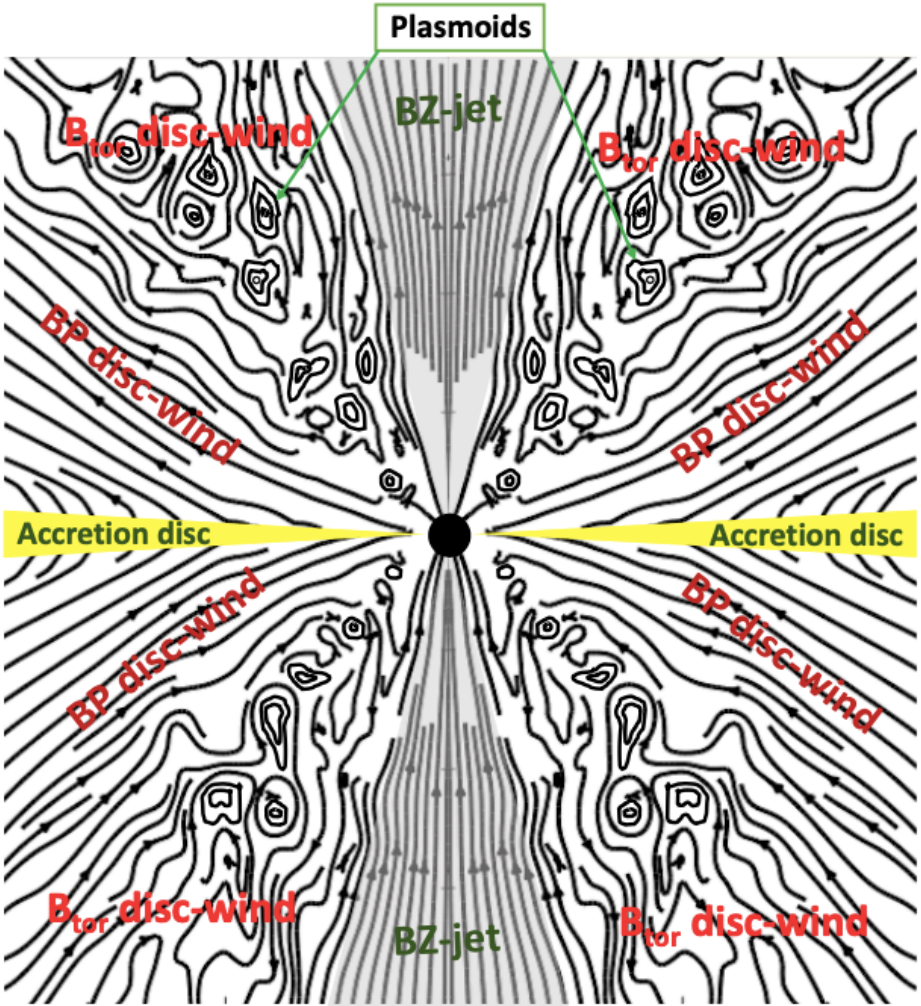
$$\dot{M} = 2\pi \int \sqrt{-g}\rho u^r d\theta.$$

$\sigma < 1$ or $\eta < 2$, and $-hu_t > 1$. $\dot{M}_{\rm wind}$

$\sigma > 1$ or $\eta > 2$, and $-hu_t > 1$ $\dot{M}_{\rm jet}$

Toy model:



Dihingia+2021

Summary:

1. We Observe BZ jet, turbulent B_{tor} disc-wind, and BP disc-wind in our simulation.
2. Lower value of m and plasma beta are prone to BP driven wind.
3. Plasmoids are formed in the B_{tor} disc-wind.
4. The oscillations in the inner part of the accretion disc can be relate to flaring activities in the jet.