Group Project 5 :

Magneto-rotational Instability in Accretion Disks

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The activity of accretion disks

What is an accretion disk?

1. Rotating disks surrounding around the central objects

   Ex.) proto-stars, white dwarfs, neutron stars, black holes

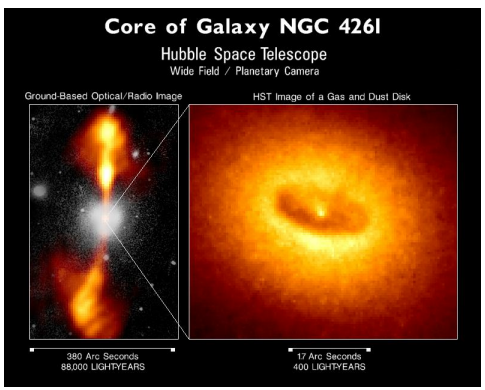
2. Origin of the various energetic activity observed by various wavelength

   Ex.) well collimated jet, chaotic variation of X-ray flux,

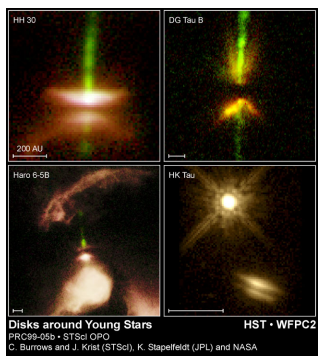
   sporadic increase of X-ray (radio or IR) intensities (flare)

Examples

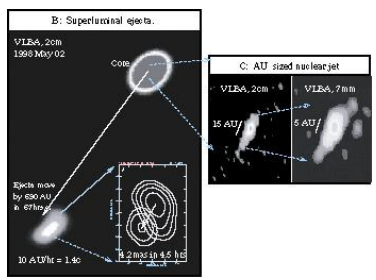
AGN



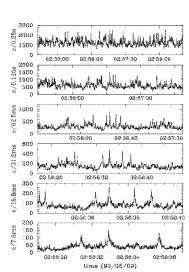
YSO

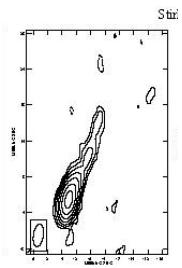


Micro-Quasar



X-ray binary (Cyg X-1)





The origin of the angular momentum transport

In standard theory of accretion disk (Shakura & Sunyaev 1973)

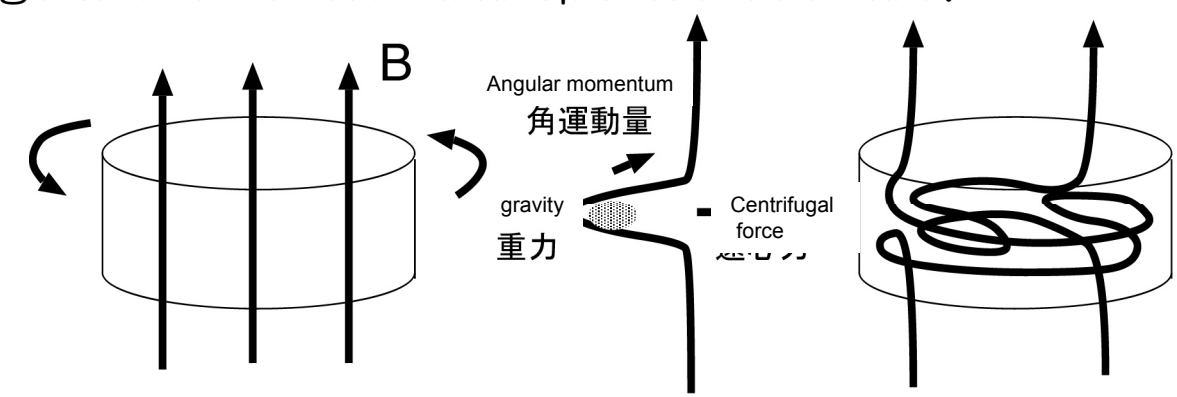
$T_{r\varphi} = \alpha P$ The viscous stress is proportional to the gas pressure.
The origin of viscous stress is the turbulence.

From Blablus & Hawley (1991), the phenomenological parameter α will be the Maxwell stress which is generated by MRI.

What is the magneto-rotational instability?

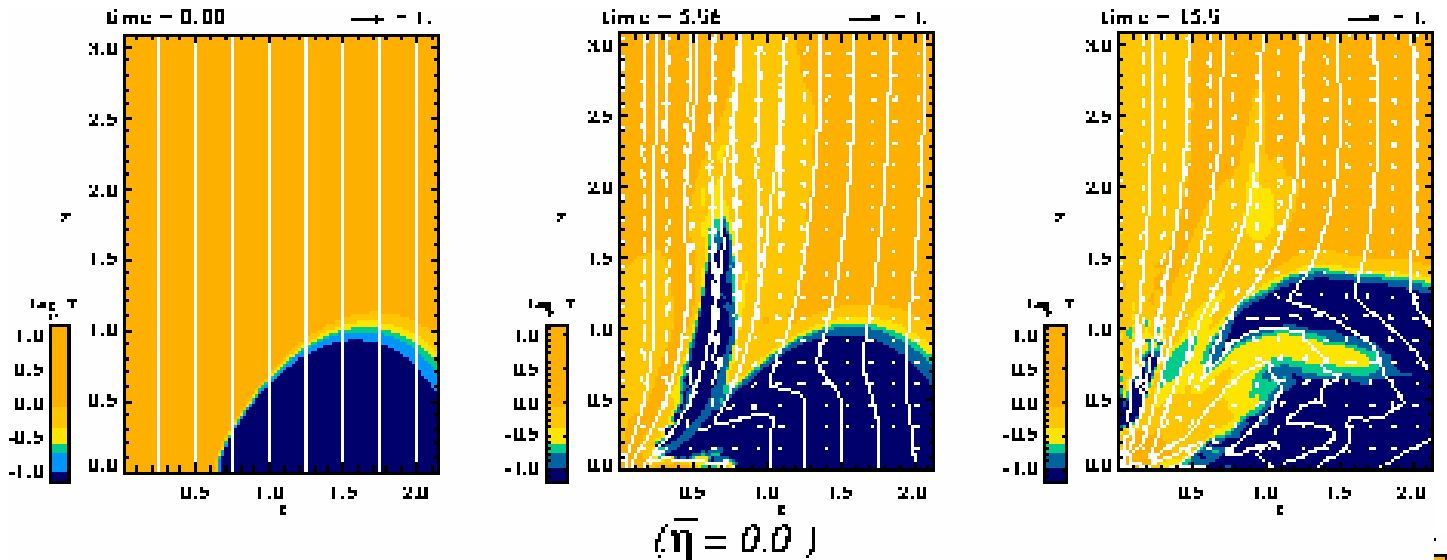
- Disk has a differential rotation
- (Gravity – centrifugal force) > magnetic tension

⇒ angular momentum transported outward.

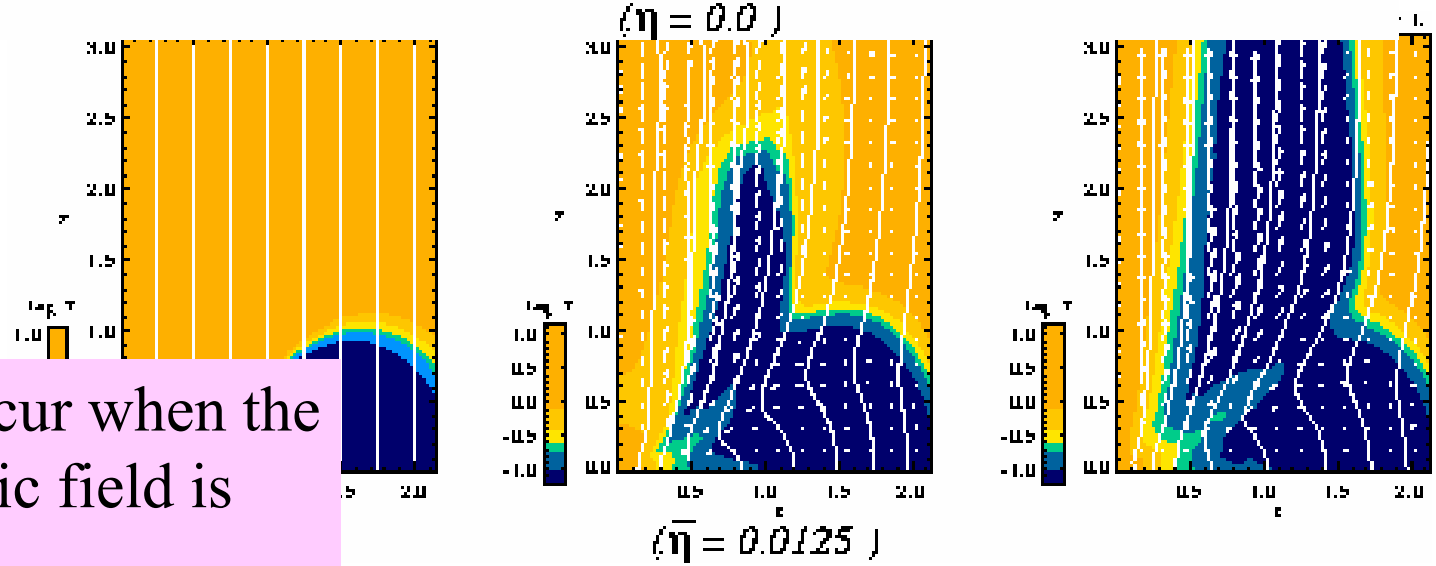


Numerical simulations including the magnetic resistivity
(Kuwabara et al. 2000, PASJ 52, 1109)

ideal



Mildly resistive



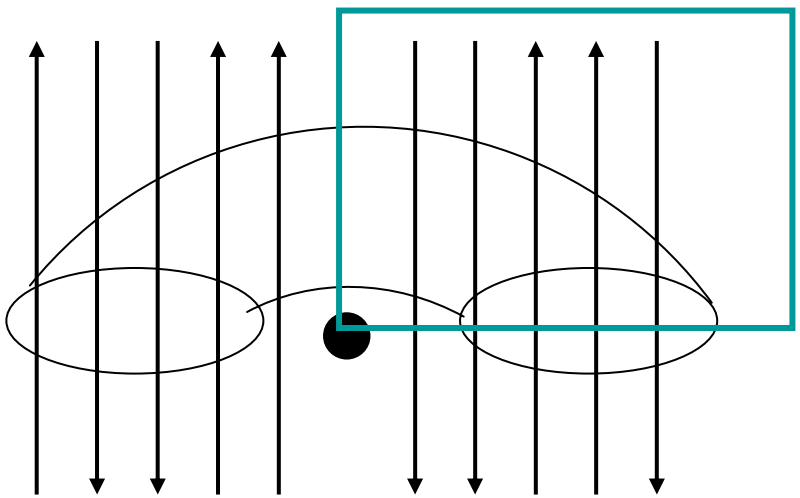
What does occur when the initial magnetic field is net zero?

Projects of this year

We consider the evolution of magneto-rotational instability and the effect of the jet formation when accretion disks have the net zero magnetic fields.

- The effect of magnetic diffusivity
  - Uniform resistivity or anoumarous resistivity
- The dependence on plasma beta
- The dependence on the radius of the initial torus

Examples of initial model



The net zero vertical field model

Axisymmetric 2.5D-MHD including the magnetic diffusivity.

The initial magnetic field is only vertical direction.

Simulation box

$0 < r < 2,\ 0 < z < 2$

Initial net 0 fields

$$\int B \cdot \vec{n}\, dS = 0$$

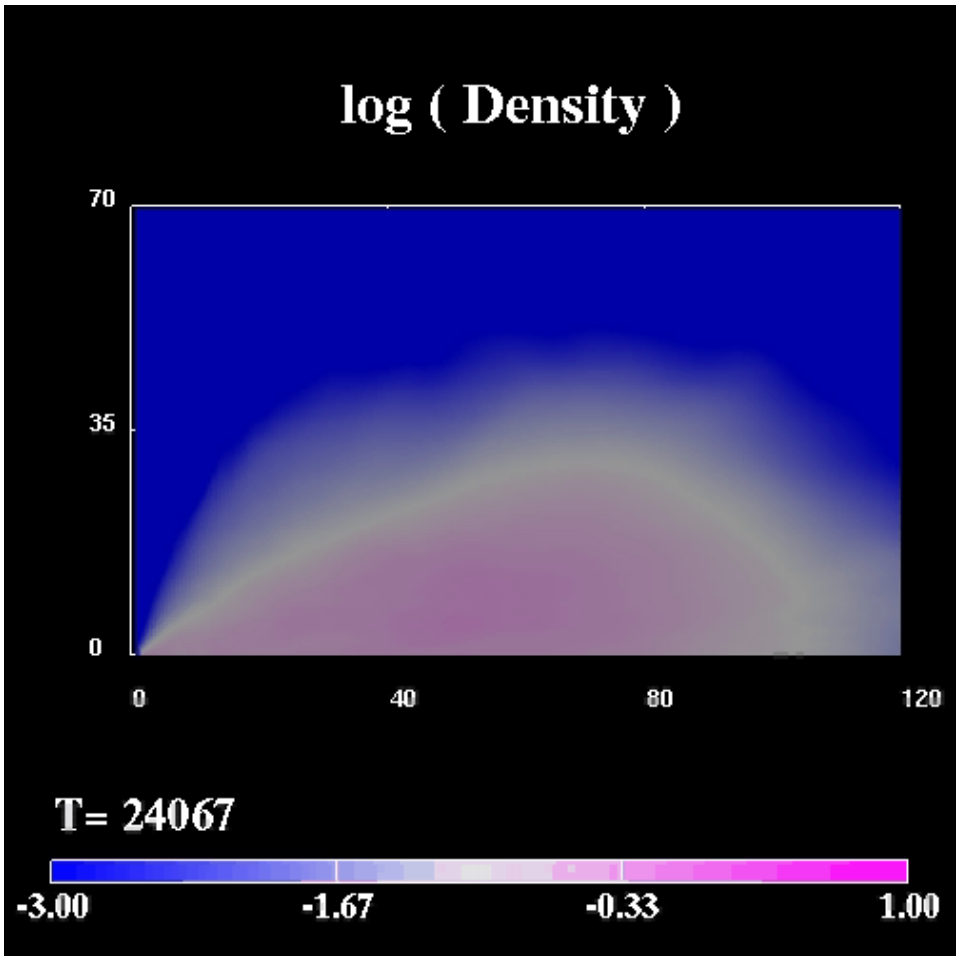
Typical parameter

plasma beta = Pgas/Pmag = 100

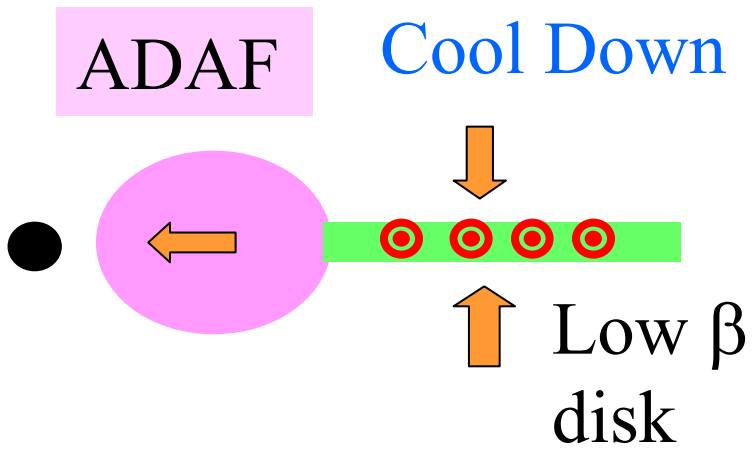
resistivity = 0.005

vertical perturbation: $\sin(2\pi y k_{//})$

Formation of Low-beta Disk



Distribution of β=Pg/Pmag



A schematic picture of numerical results. Magnetic pressure supports the outer disk.