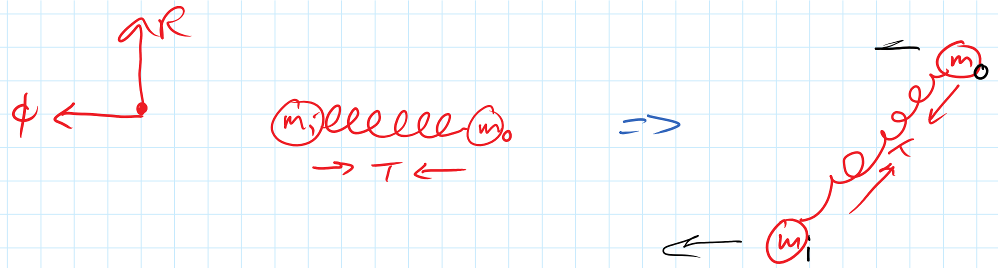
Modern Accretion Theory - Intro. to MRI

SS73 guessed that the viscosity would be due to something driving turbulance in the disk. Possibly magnetic fields. Disks are ionized & $\vec{B}$-fields are common in the Universe.

Now know that the turbulence & viscosity is driven by the Magnetic Rotational Instability.

Consider the following mechanical analogy:



- in a Keplerian disk, m_i is now rotating faster than m_o

T is pulling out on m_i and in on m_o

m_i loses ang. mom. & falls further in

m_o gains ang. mom. & moves out

... this continues to grow ..

Spring has to be weak

If one analyzes this mass/spring system w/ spring constant K & masses m, the condition for instability is

$$\frac{2K}{m} + R\frac{d\Omega^2}{dR} < 0$$

Since accretion flows always have ang. vel. that decrease w/ R ∴ a sufficiently weak spring will lead to instability.

In its simplest form, the MRI is exactly like this w/ the vert. comp. of the B-field acting like the spring.

In terms of $\vec{B}$-fields, a weak spring means a subthermal B-field, i.e. Alfven velocity $V_{Az} = \frac{B_z}{(4\pi\rho)^{1/2}} \lesssim c_s$

The MRI produces turbulence that transports ang. mom. outwards.

Growth rate is dynamical time.

Simulations give crude agreement w/ α-disks w/ $\alpha \sim 0.01$-0.2

but v. time & space dependent.