THE ROLE OF THERMAL PRESSURE IN JET LAUNCHING

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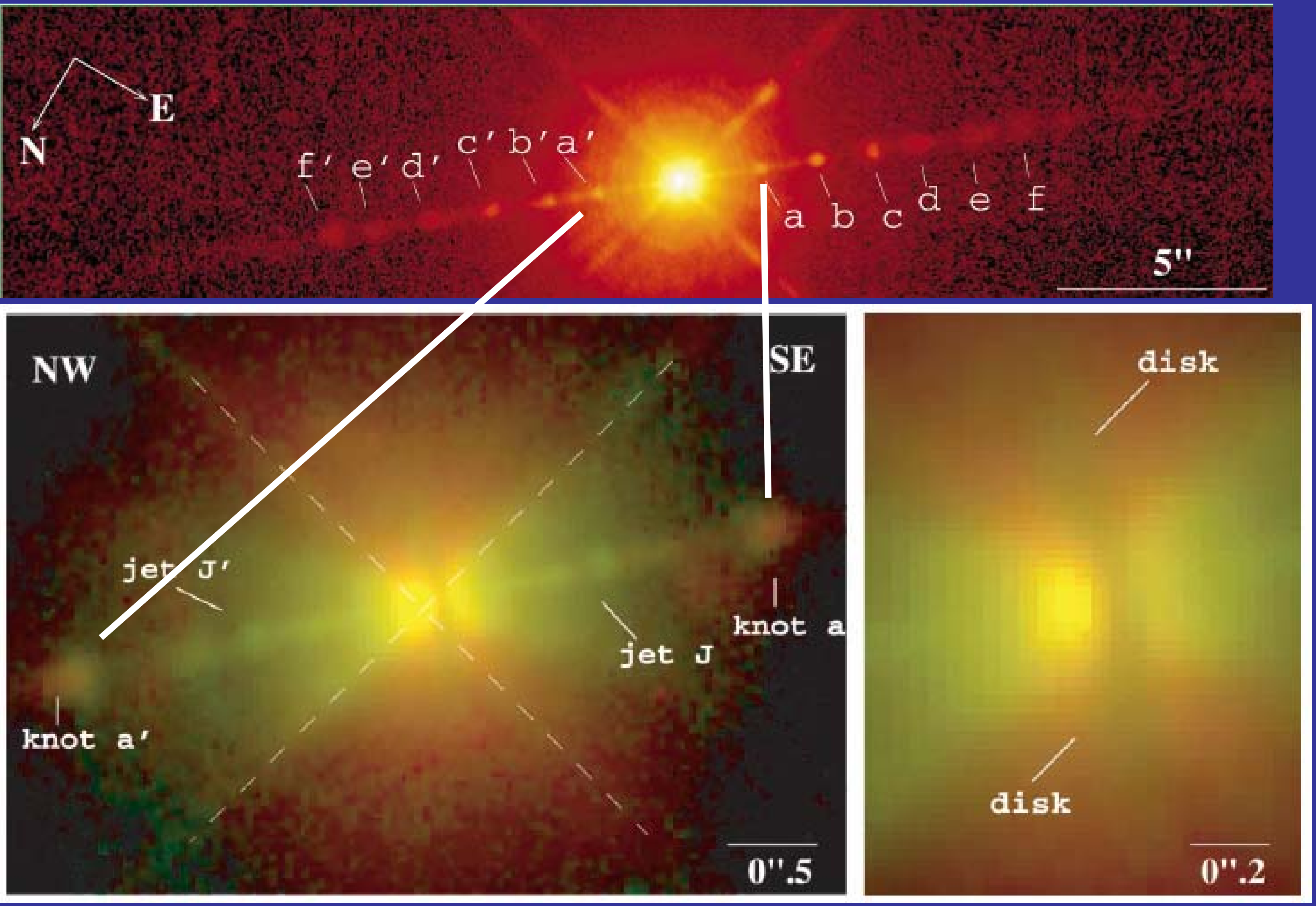
MOTIVATION

- In the inner boundary of the disk the gas has the maximum available energy per unit mass.
- Large gradients in one or more of the physical parameters exist. These allow strong dissipation of the disk's kinetic energy.
- Strong dissipation is best done via shocks, which build large pressure gradients, mainly

perpendicular to the disk plane.

Speed: ~ 200 km/sec

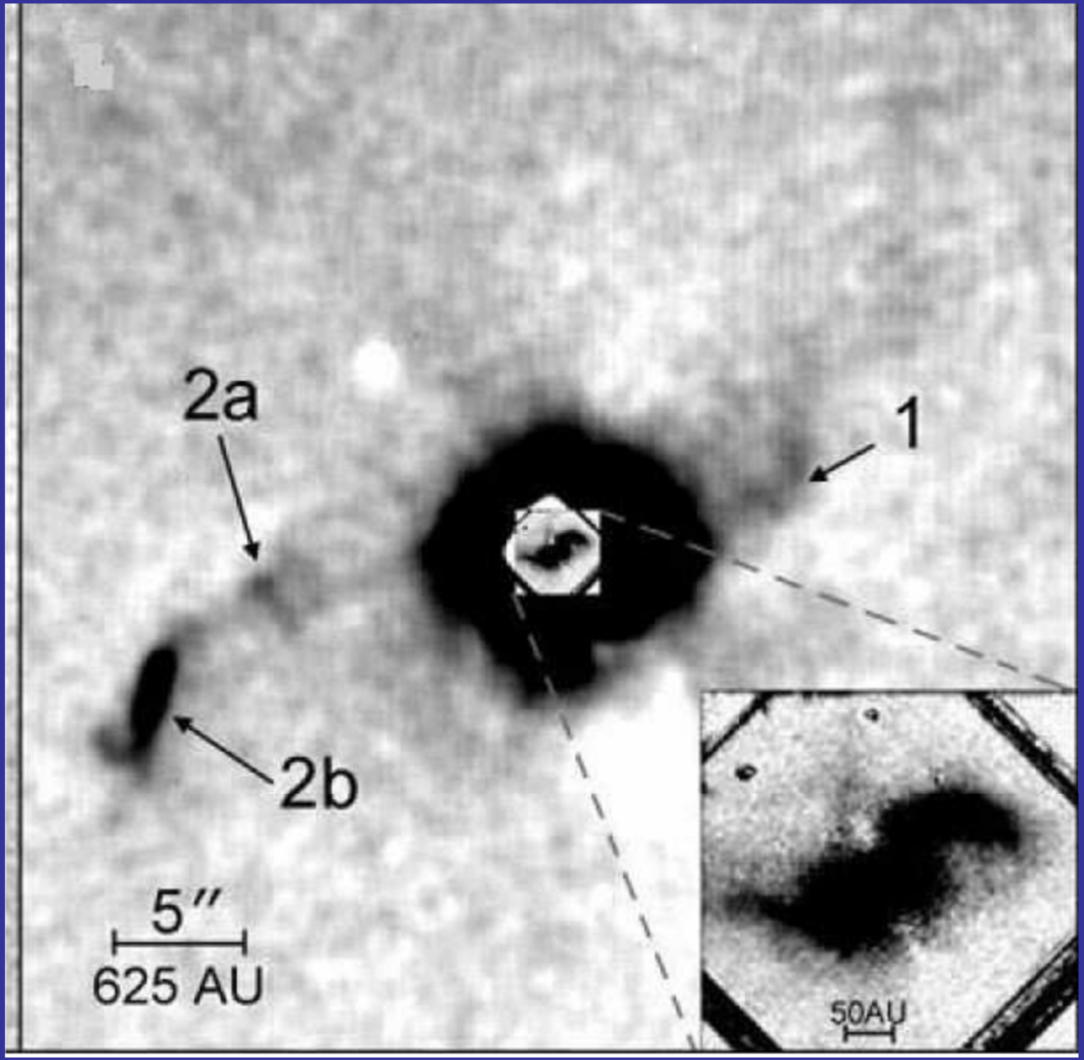
A pair of blobs is ejected every ~ 40 years



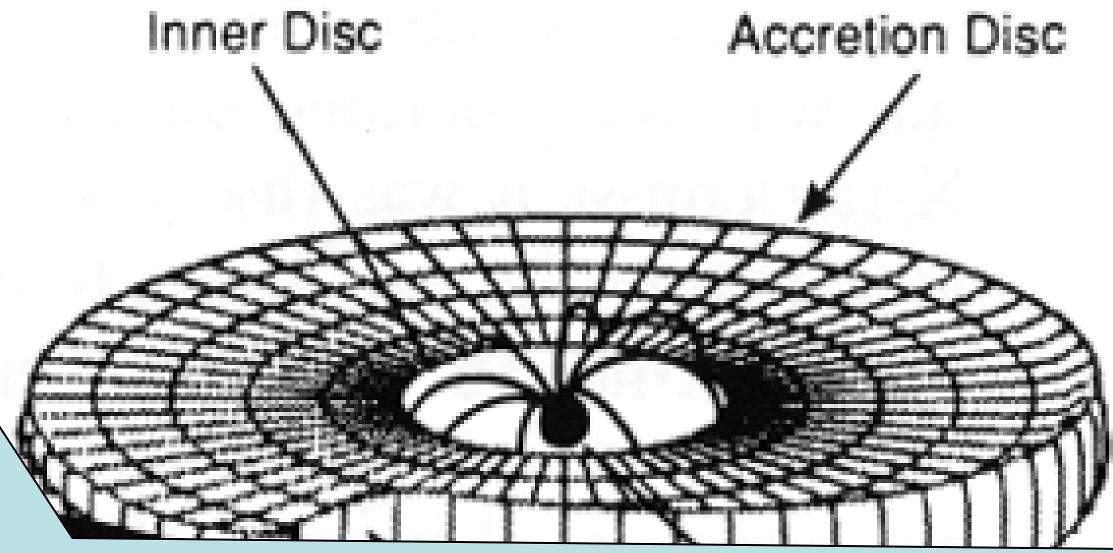
HENIZE 2-90: A planetary nebula (Sahai, R.)

H_2 Close-up Image of Elias 29 Late –Stage Protostar: Dynamical Age ~ 100 yr

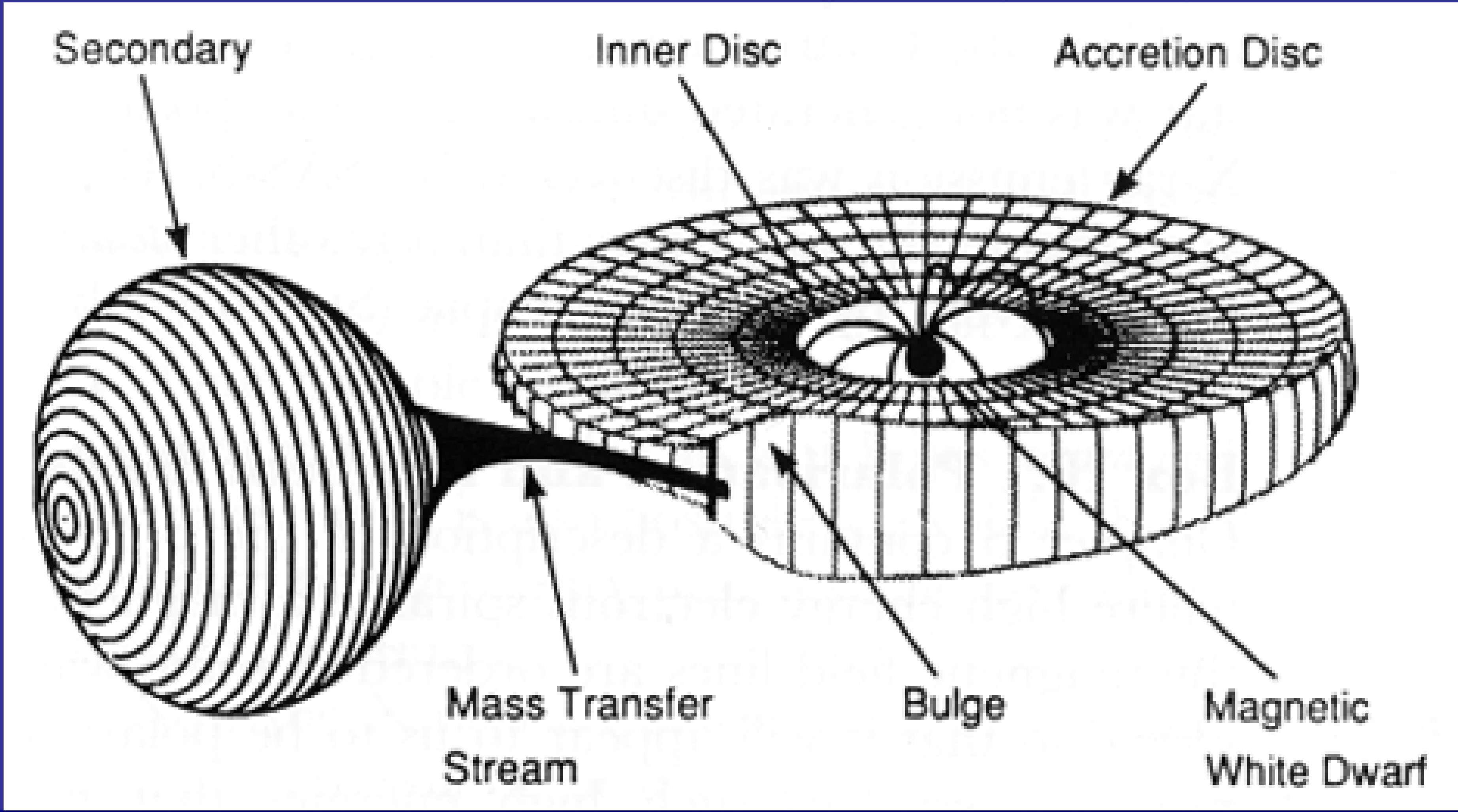
(See poster III.2 by *Mary Barsony*).



Large scale magnetic field cannot precess so fast



Disk truncated by stellar magnetic fields:



Cataclysmic variable systems:

Intermediate polar (QD Her): NO JETS

BASIC INGREDIENTS

1) The kinetic energy in the inner part of the accretion disk is transferred stochastically, mainly by shock waves, to internal energy on a dynamical time scale.

- spatiotemporally localized accretion shocks (SPLASH)

2) Radiative cooling time is long.

3) Energy is transferred to smaller and smaller mass.

4) A small fraction of the mass residing in the inner disk takes most of the energy released in stage (1), and escapes as an outflow.

YSOs

(Torbett, M. V. 1984; Torbett, M. V., & Gilden, D. L. 1992)

Following Soker & Regev (1993) and Soker & Lasota (2004):

Two conditions:

(1) Weakly shocked blobs in the transition layer will expand, and disturb the transition layer in such a way that a strong shock will develop: $\tau_{\gamma\text{-diffusion}} > \tau_{\text{adiabatic}}$

(2) The strongly shocked gas will cool slowly, such that the thermal pressure has time to accelerate the jet's material:

$$\tau_{\gamma\text{-diffusion}} \gg \tau_{\text{Ejection}} > \tau_{\text{Dissipation}}$$

These lead to a requirement for the minimum value for the mass accretion rate.

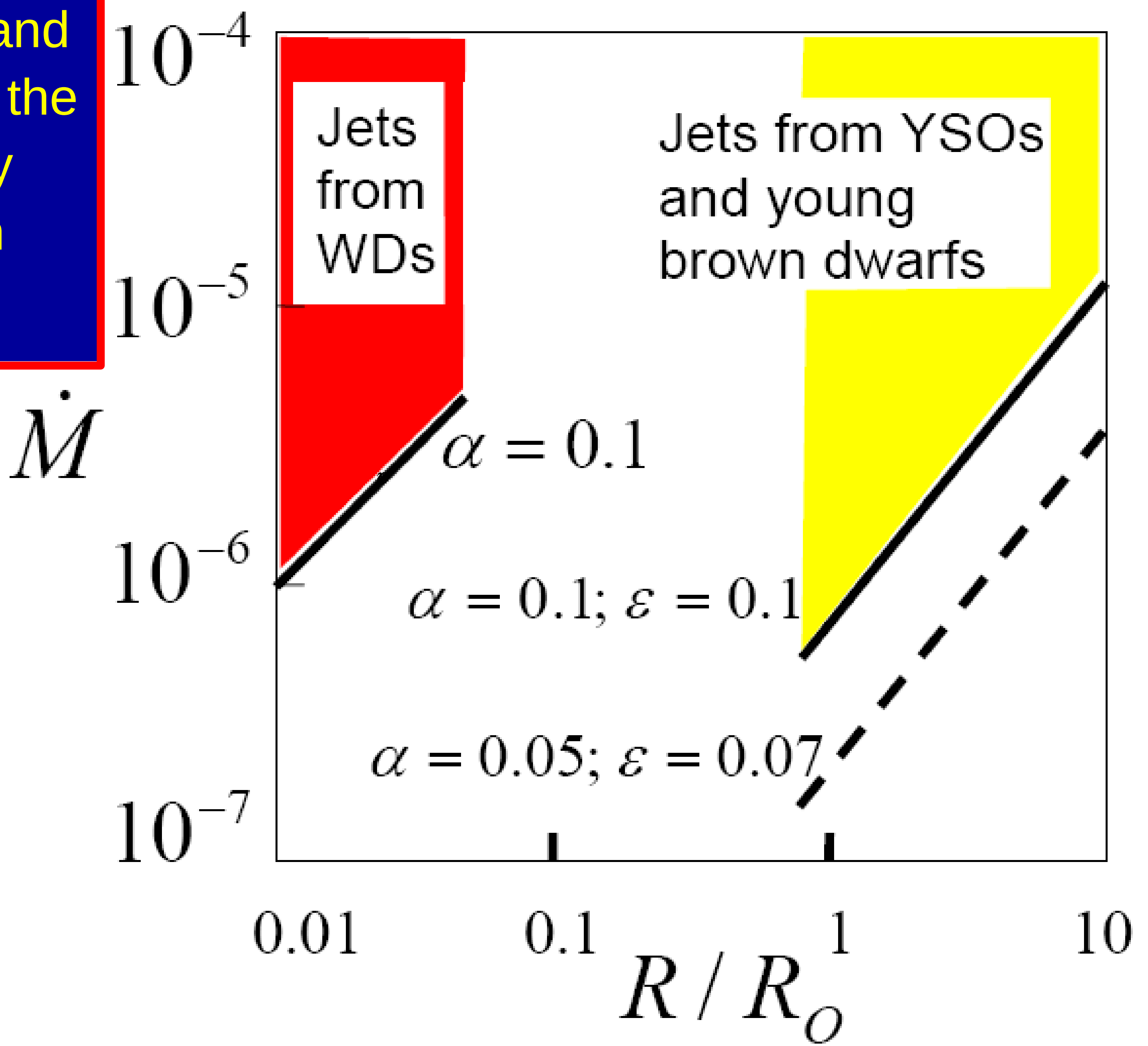
$$\dot{M}_{\mathrm{acc}} > 7\times10^{-7}\left(\frac{R}{R_O}\right)^{1.2}\left(\frac{\varepsilon}{0.1}\right)^{1.4}\left(\frac{\alpha}{0.1}\right) M_O\,\mathrm{yr}^{-1}$$

$\varepsilon = \dfrac{H}{r}$, and α is the usual viscosity parameter.

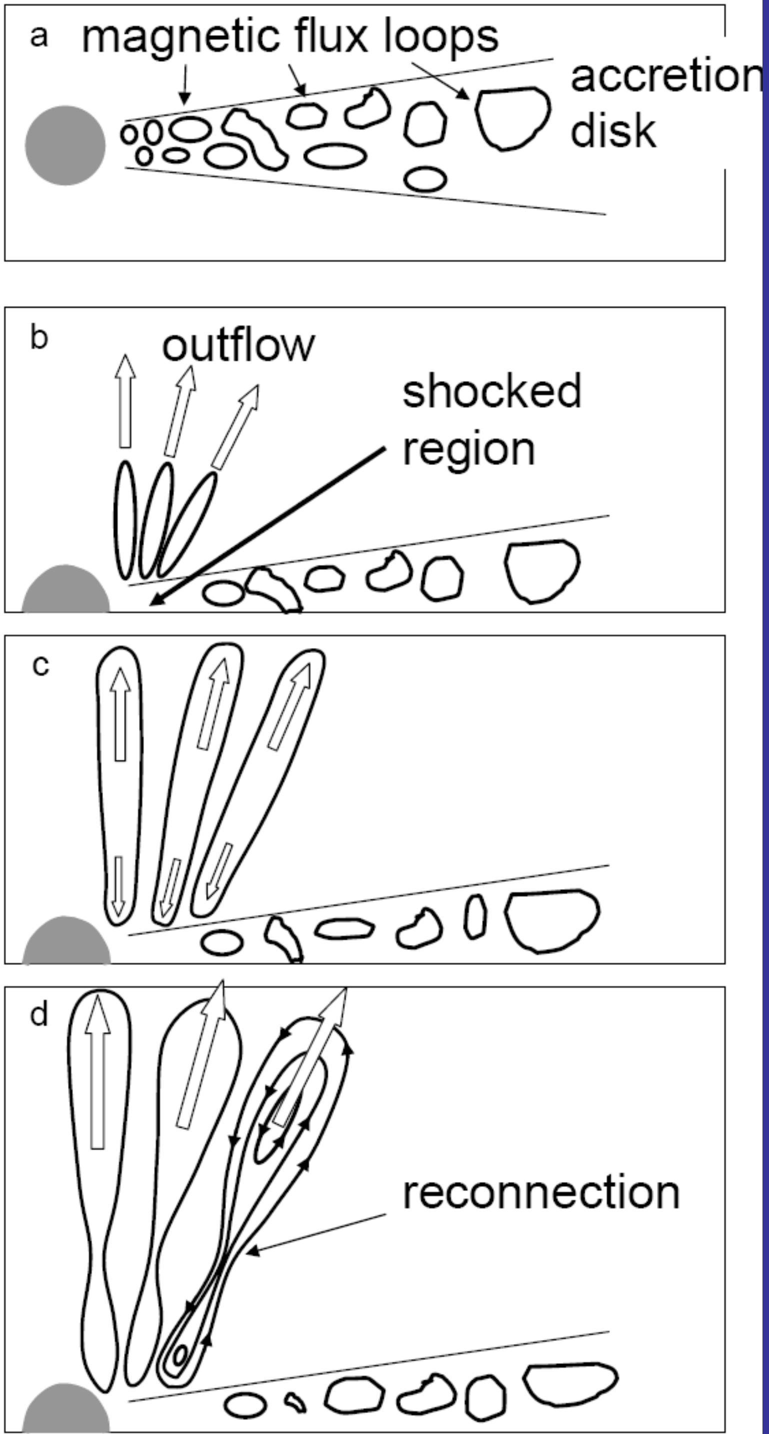
Accretion into WDs and YSOs

The differences between WDs and YSOs is due to the different opacity dependence on T and density.

$$\dot{M} \propto \frac{1}{\kappa}$$



A DOUBLE-STAGE ACCELERATION SCENARIO



Single Stage Acceleration

- Kinetic energy of rotating disk's material
- ↓ Stochastic Shock waves
- Internal (e.g., thermal) energy
- ↓ Pressure gradient
- High velocity outflow (jets)

Double Stage Acceleration

- Kinetic energy of rotating disk's material
- ↓ Stochastic Shock waves
- Internal (e.g., thermal) energy
- ↓ Pressure gradient
- Outflow
- ↓ Stretching magnetic flux loops
- Magnetic energy in loops
- ↓ Magnetic field reconnection
- High velocity outflow (jets)

Solar Flares

- Kinetic energy of solar rotation and convection
- ↓ $\alpha\omega$ Dynamo
- Magnetic fields in the outer envelope
- ↓ Buoyancy of magnetic tubes
- Outflow
- ↓ Stretching magnetic flux loops
- Magnetic energy in loops
- ↓ Magnetic field reconnection
- High velocity ejection

Accretion into Black Holes