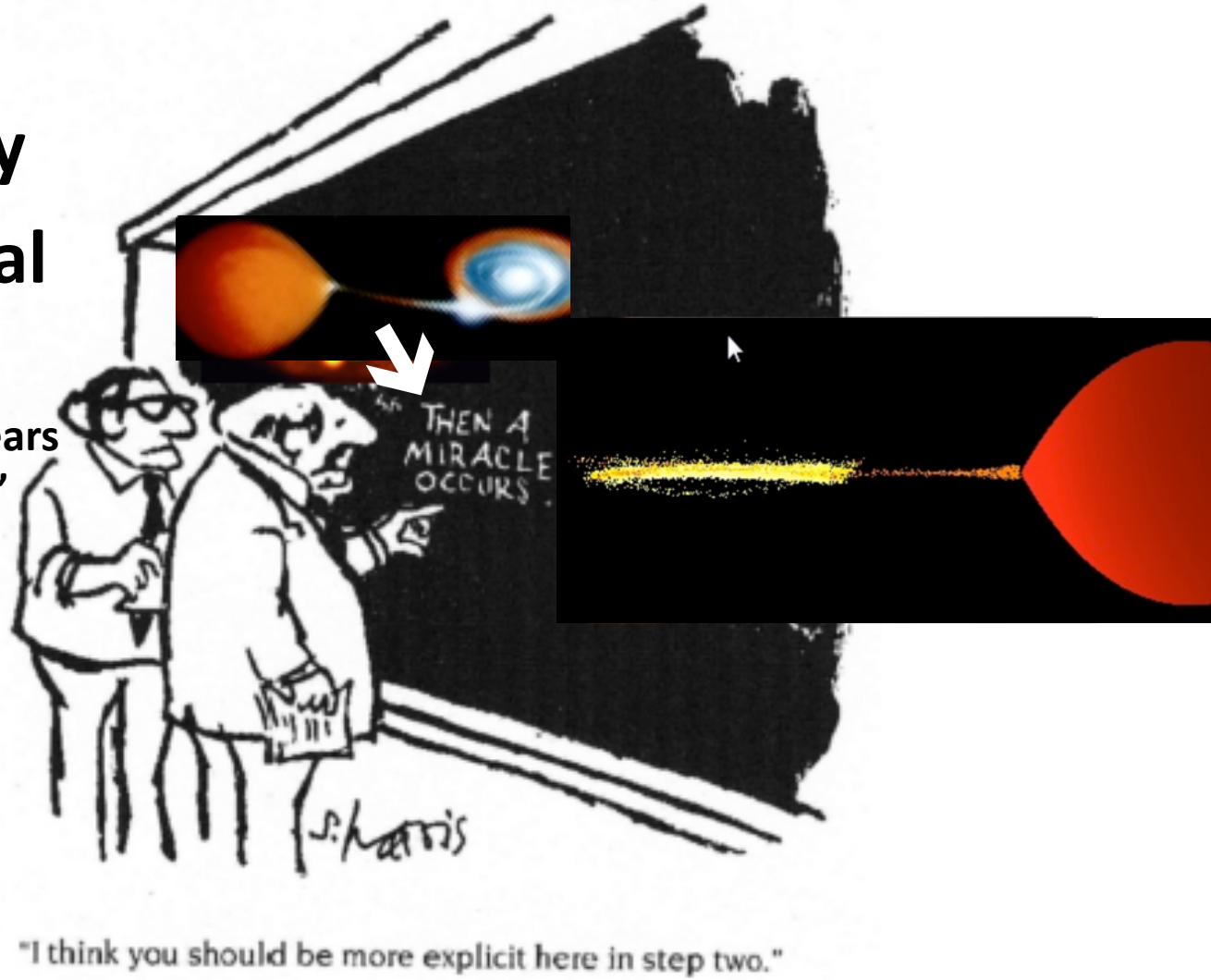
SPH Simulations of Naturally Tilted Disks in Close Binary Systems

M.M. Montgomery

University of Central Florida

"X-ray Binaries, Celebrating 50 Years Since the Discovery of Sco X-1"

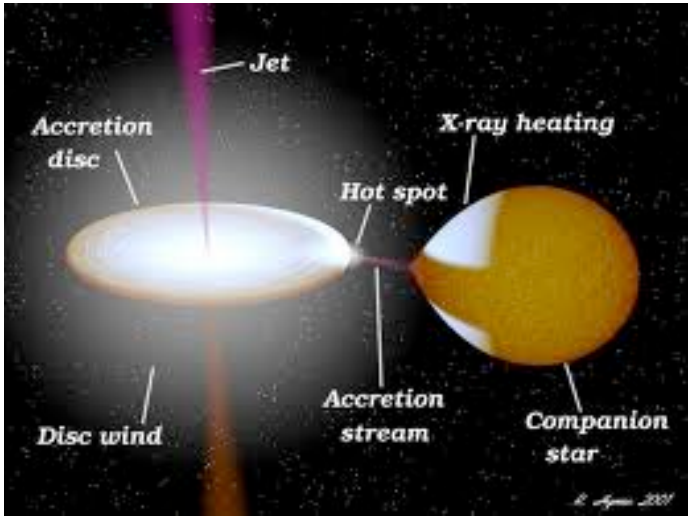
July 12, 2012

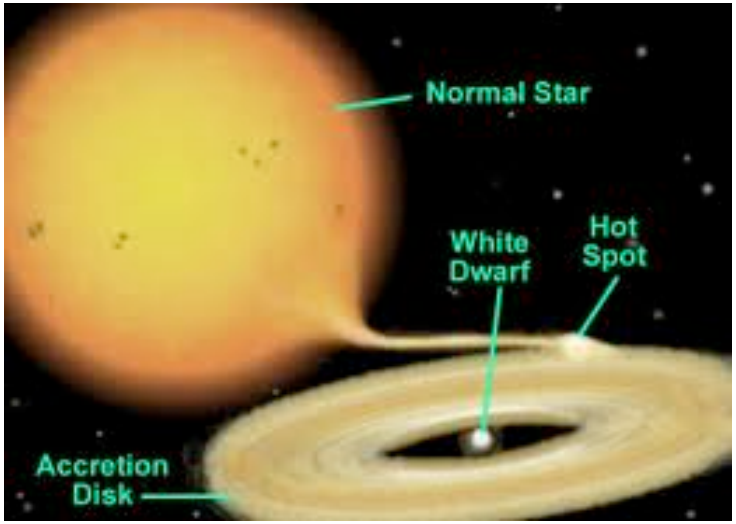


Outline

- **Connections Between WD, NS, BH compact binary systems**
- Tilted Disks in Non-Magnetic Systems
- Tilted Disks in Magnetic Systems

Connections Between WD, NS, BH compact binary systems





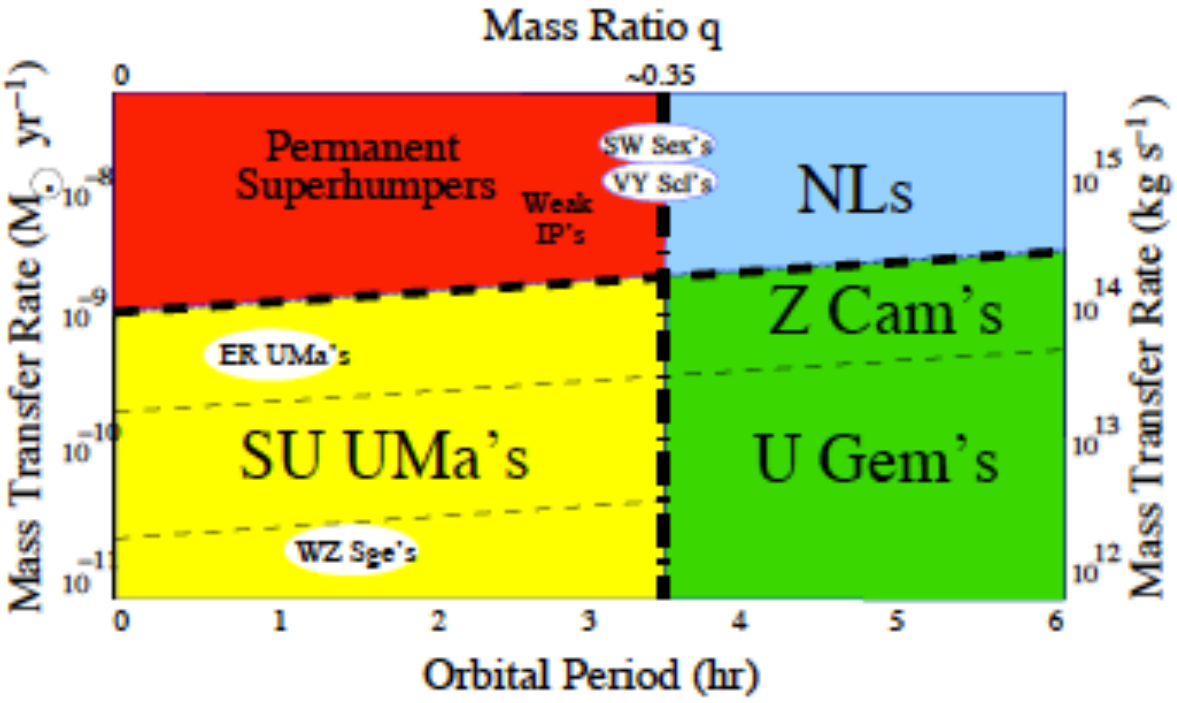
LMXB - Rob Hynes, LSU webpage

CV – NASA

Connections Between WD, NS, BH compact binary systems

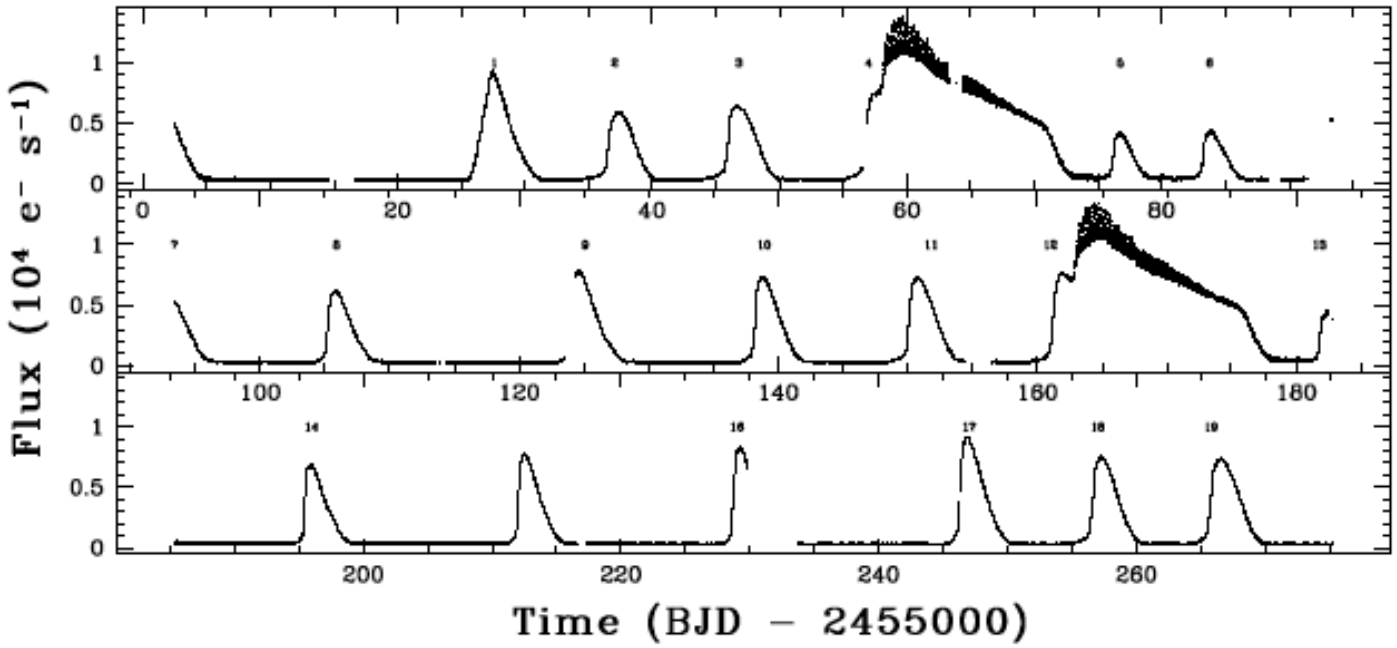
Similar Orbital Period (when < 6hr)

Similar Mass Transfer rates



Montgomery (2009b)

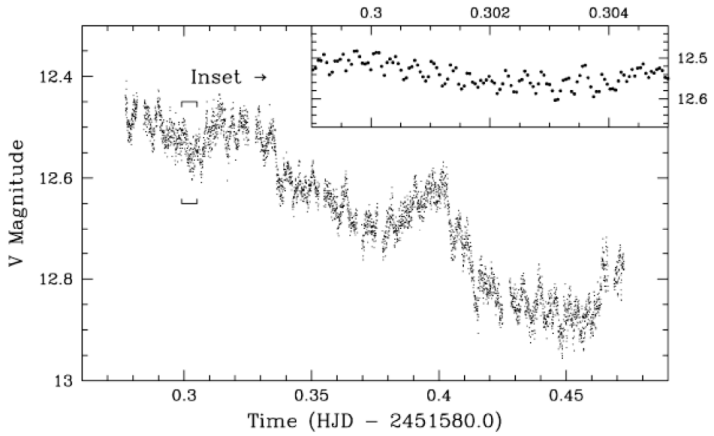
Outbursts



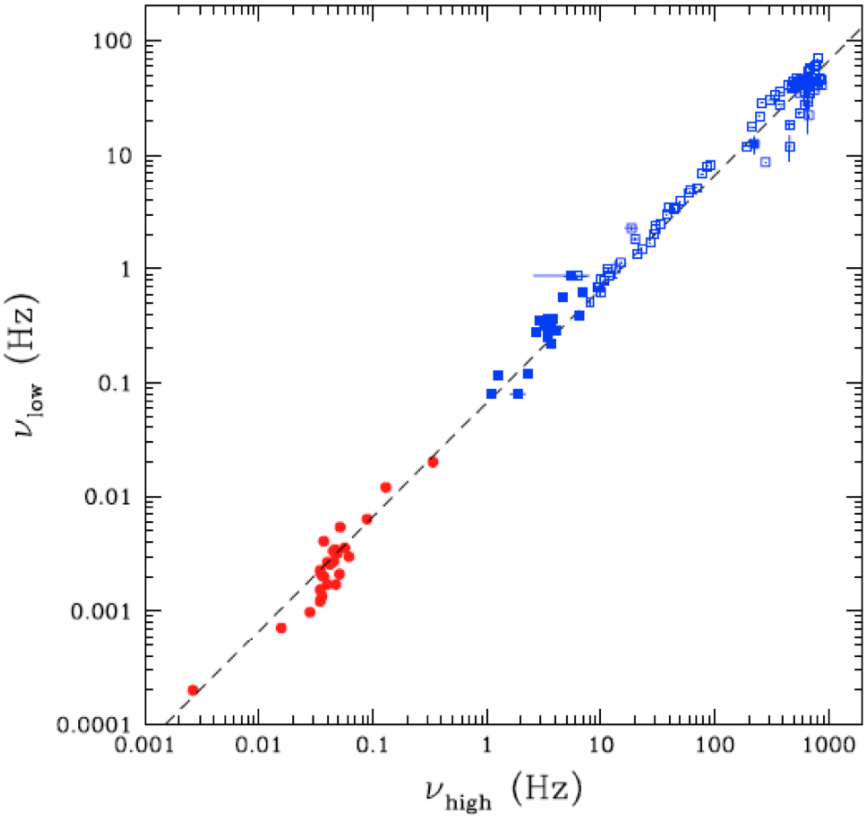
V344 Lyrae (Wood et al., 2011)

Connections Between WD, NS, BH compact binary systems

QPOs

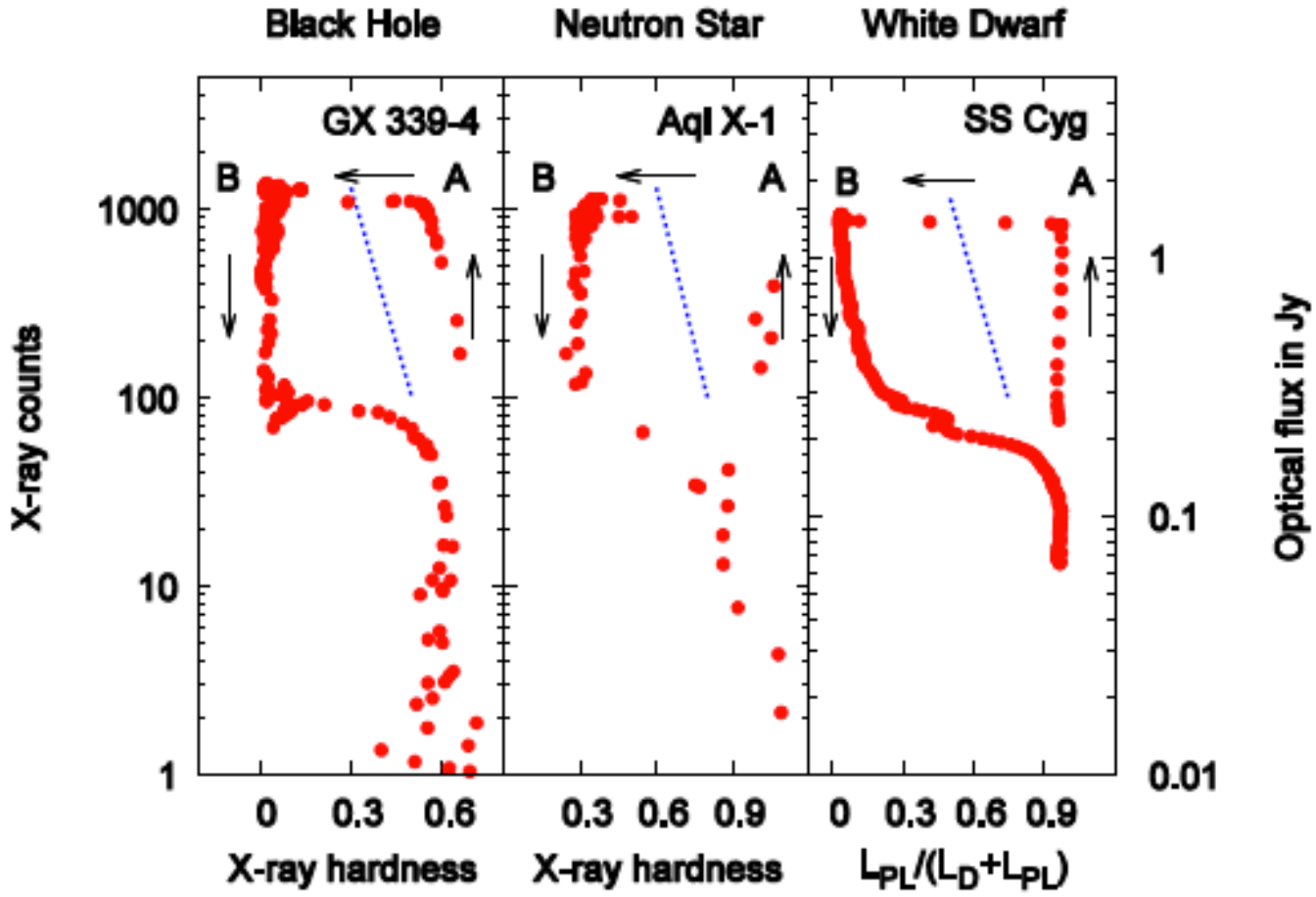


VW Hyi (Woudt & Warner, 2002)



Belloni et al. (2002); Warner et al. (2003),

Connections Between WD, NS, BH compact binary systems



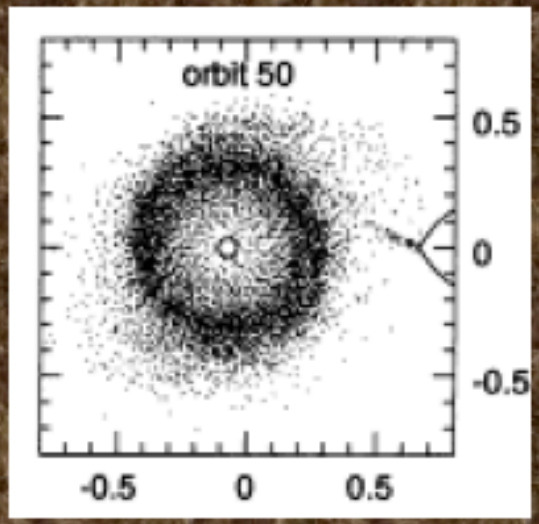
Körding et al. (2008)

Outline

- **Connections Between WD, NS, BH compact binary systems**
- **Tilted Disks in Non-Magnetic Systems (SPH code)**
  - **Montgomery (2012a), ApJ, 745, L25 (Jan)**
  - Montgomery (2012b), ApJ, 753, L27 (June)
- Tilted Disks in Magnetic Systems (3D HD, MHD Grid code)

3D SPH Code Basics (Simpson, 1995)

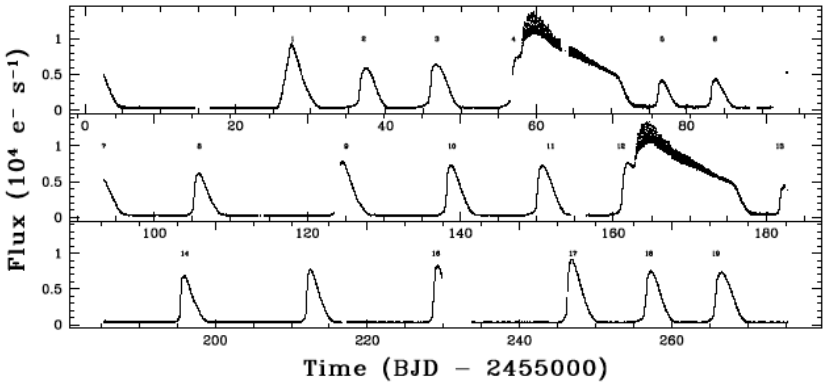
- Inertial frame
- Keplerian orbits
- No radiative cooling
  - Ideal gas $P=(\gamma-1)\rho u=\rho kT/m$
  - low adiabatic cooling $\gamma=1.01$
- No magnetic fields



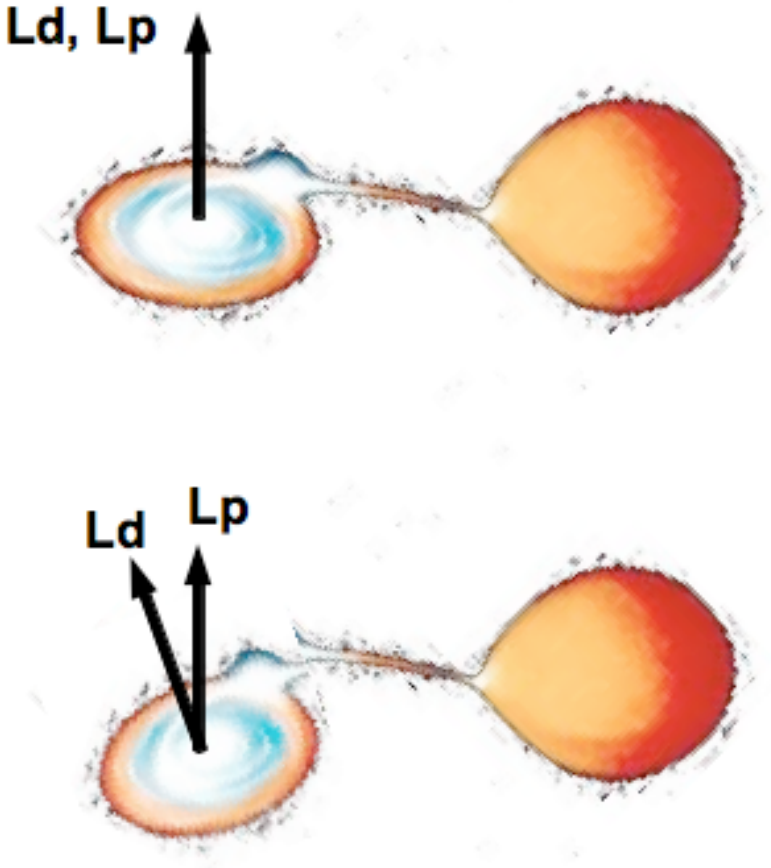
- Number of Particles in Disk maintained
- Particles: equal size, mass, shape; particle mass arbitrary and does not affect dynamics in disk
- Particles injected at gas thermal speed
- Numerical Viscosity (Monaghan, 1992, ARA&A, 30, 543) acts both on *approaching* and *receding* particles (Shakura & Sunyaev 1973 α disk, α~0.05)

Evolution of Tilted Disk

t=0 (form disk)

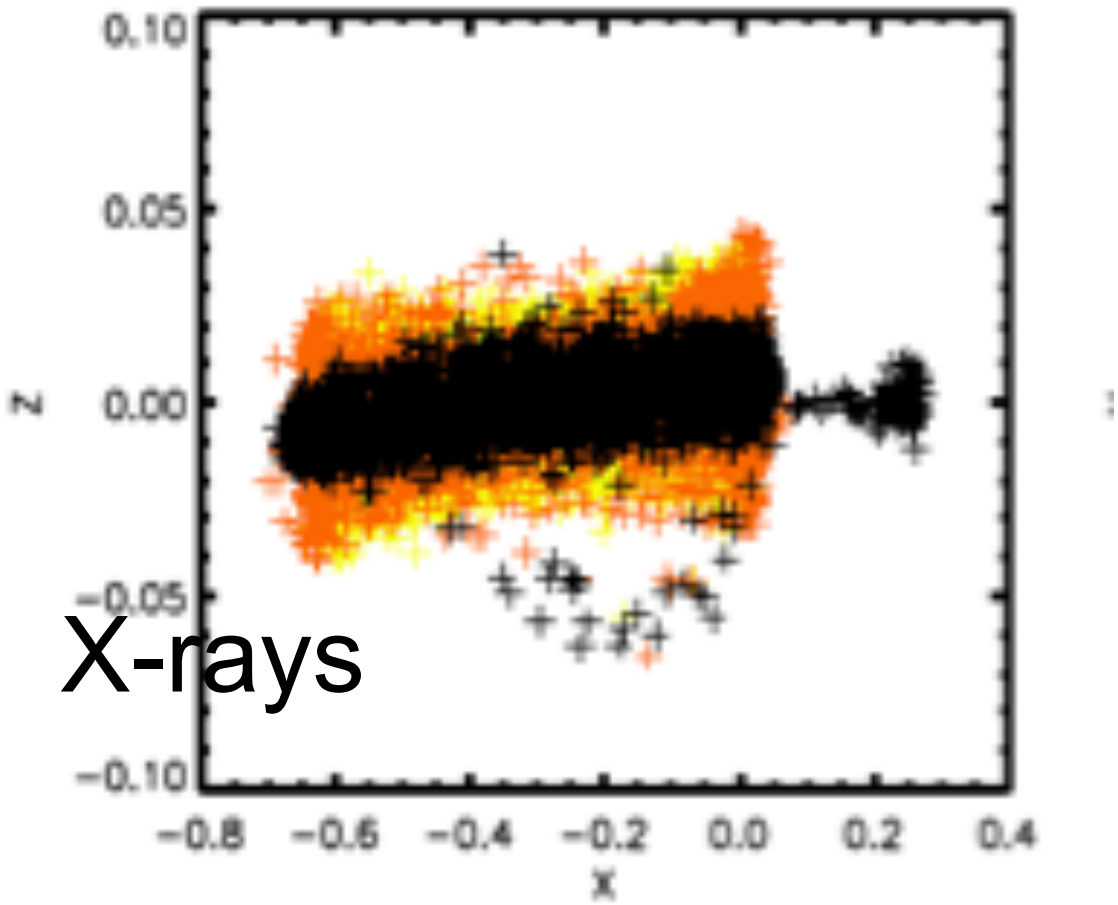


t~fortnight

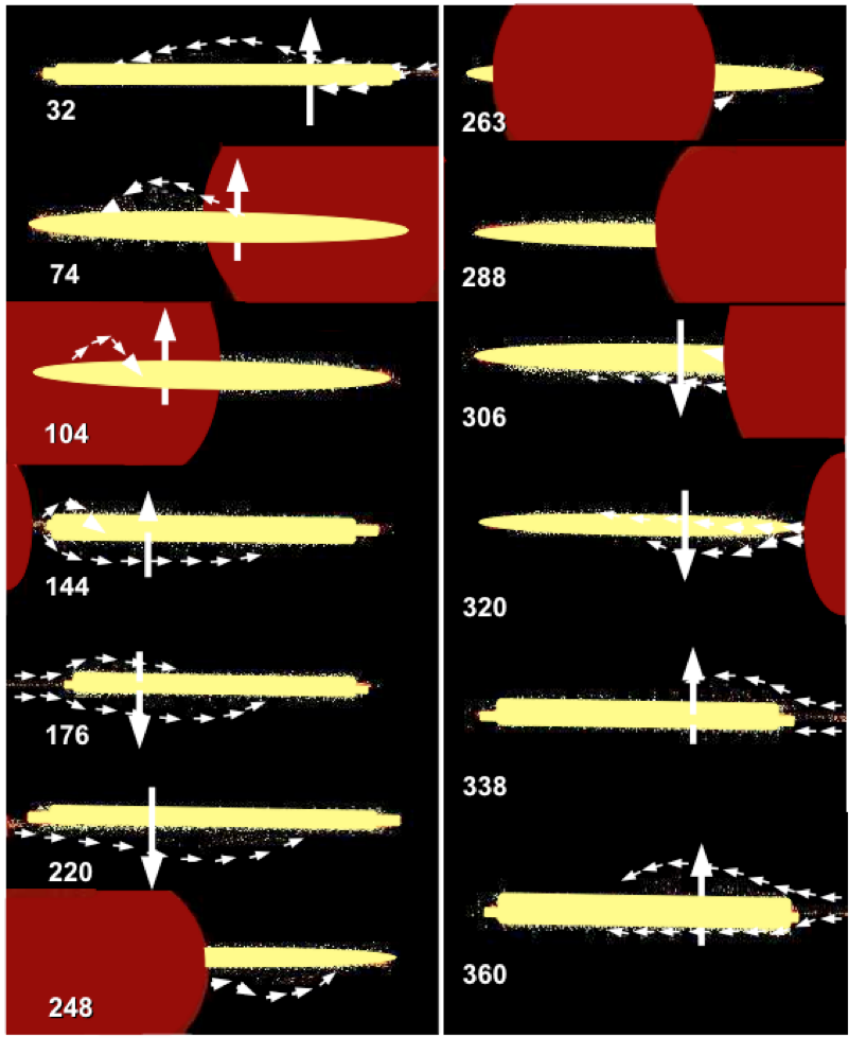


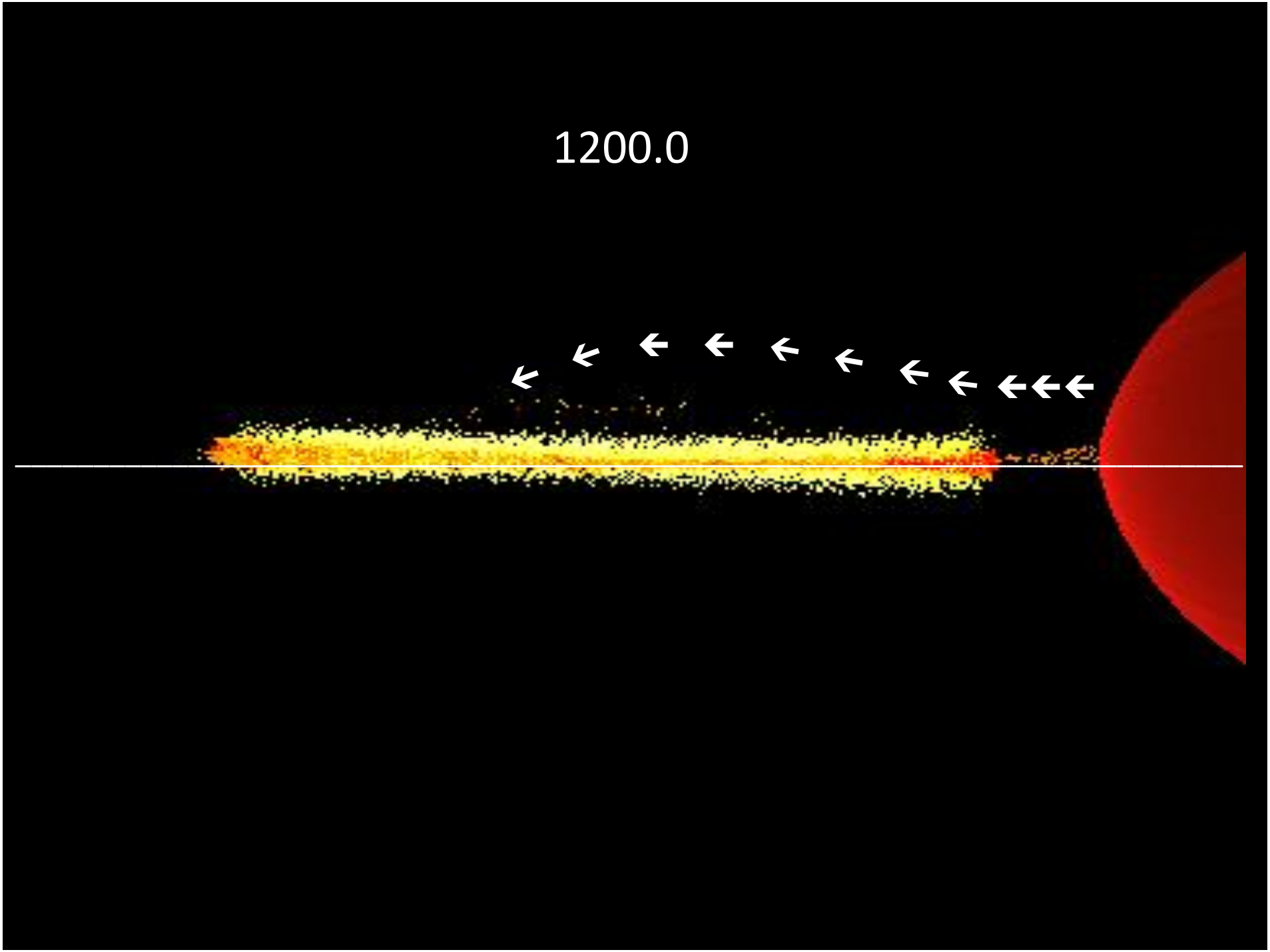
Ed Sion, Villanova webpage

Montgomery (2012b, ApJ, 753, L27)

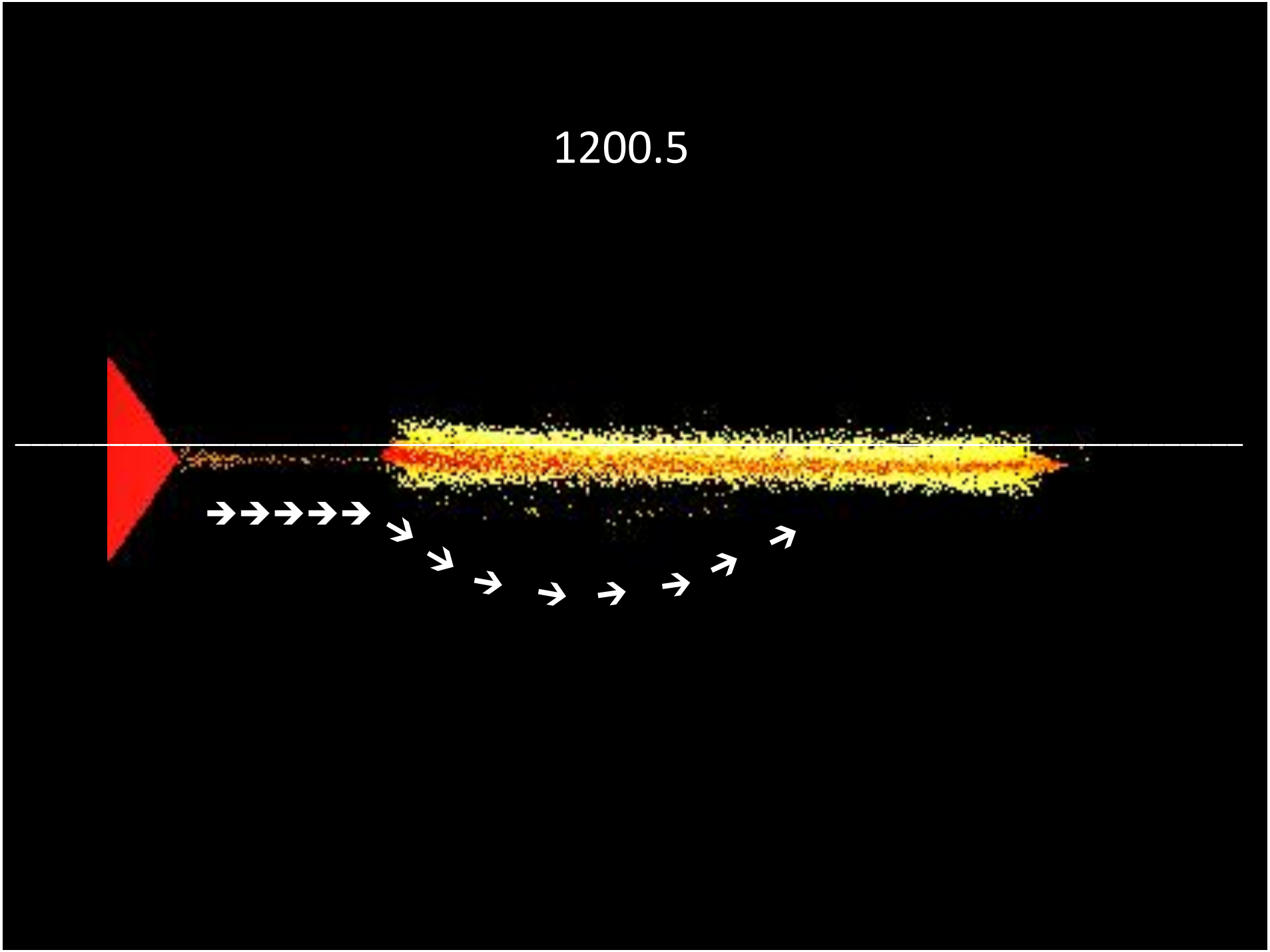


Montgomery (2012a, ApJ, 745, L25)

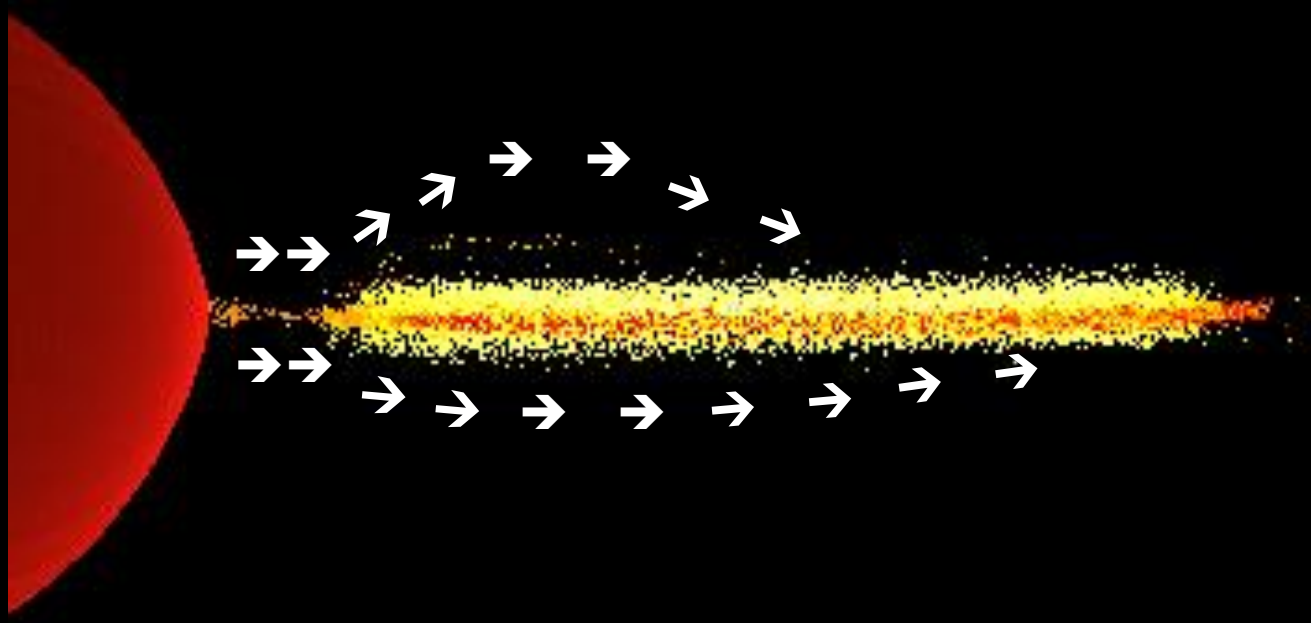



1200.0

1200.5



1215.5

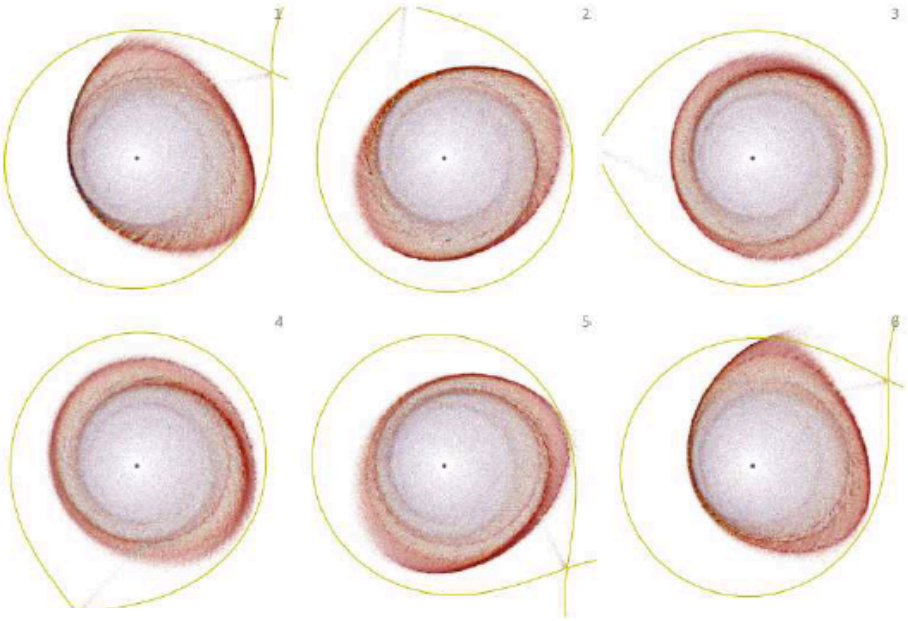


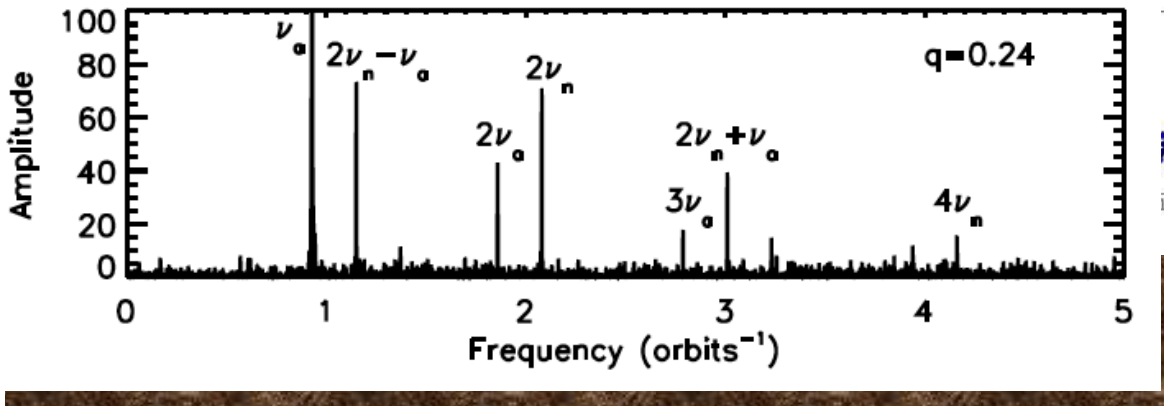
Montgomery & Martin (2010)

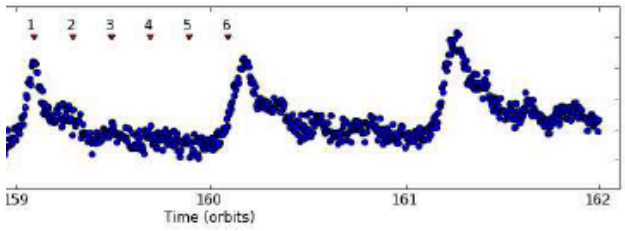
Fluid Effects – Disk simultaneously progradely and retrogradely precesses

V344 Lyrae

(Wood et al., 2011)

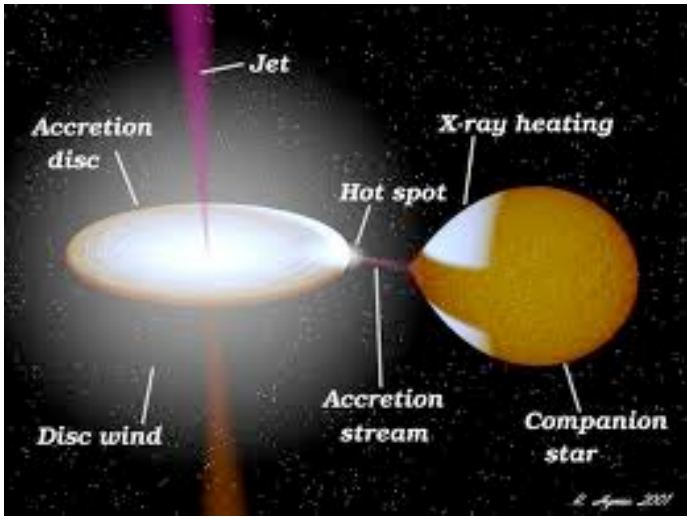


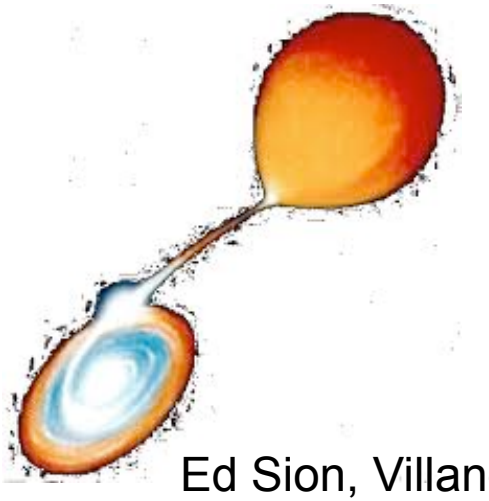




Outline

- Background
- Tilted Disks in Non-Magnetic Systems (All non-**B** disks have the potential to tilt)
- **Tilted Disks in Magnetic Systems**





Ed Sion, Villanova webpage

Conclusions

With the right mass transfer rate, a disk has the potential to tilt.

Gas stream overflows disk rim, transferring mass and angular momentum directly to inner annuli.

Both disk faces are struck once each ½ orbital period.

Questions?