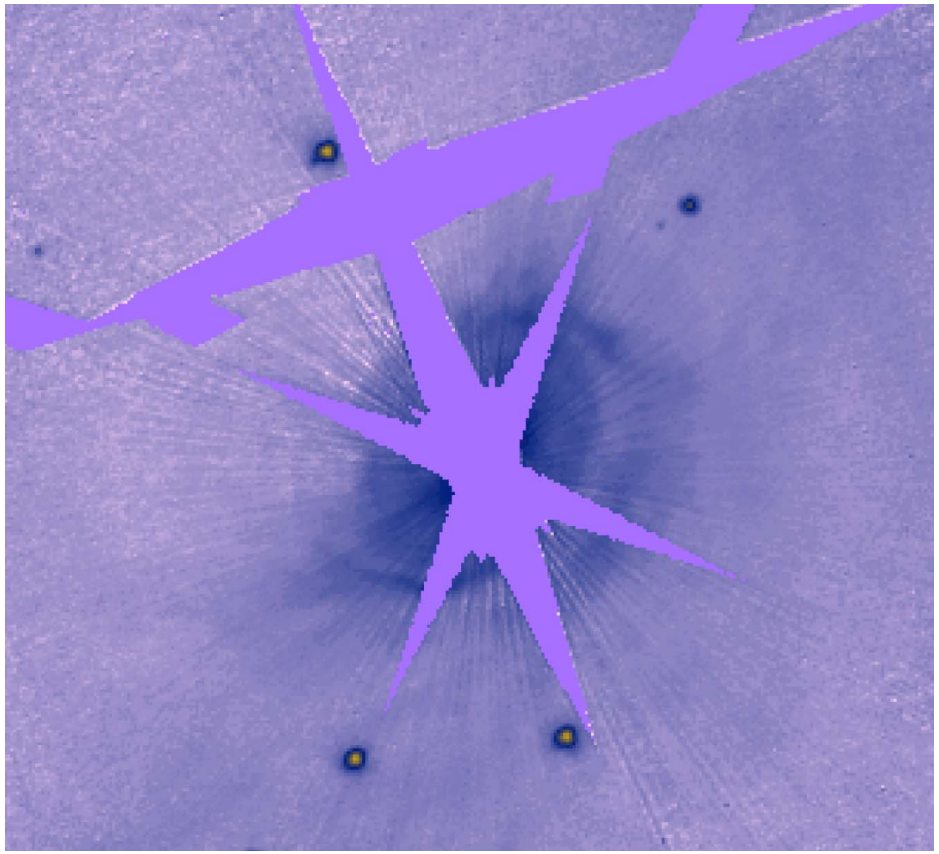
Caught in the Act: Observation of a Forming Planet?

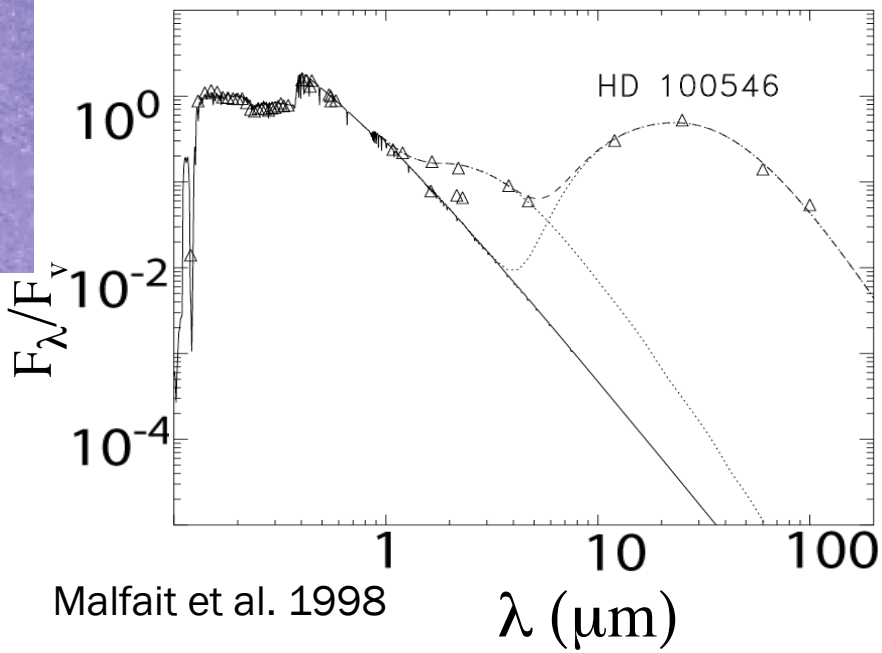
Sean Brittain (Clemson), Joan Najita (NOAO), John Carr (NRL), Joseph Liskowsky (Clemson)

HD 100546: A Transitional Disk



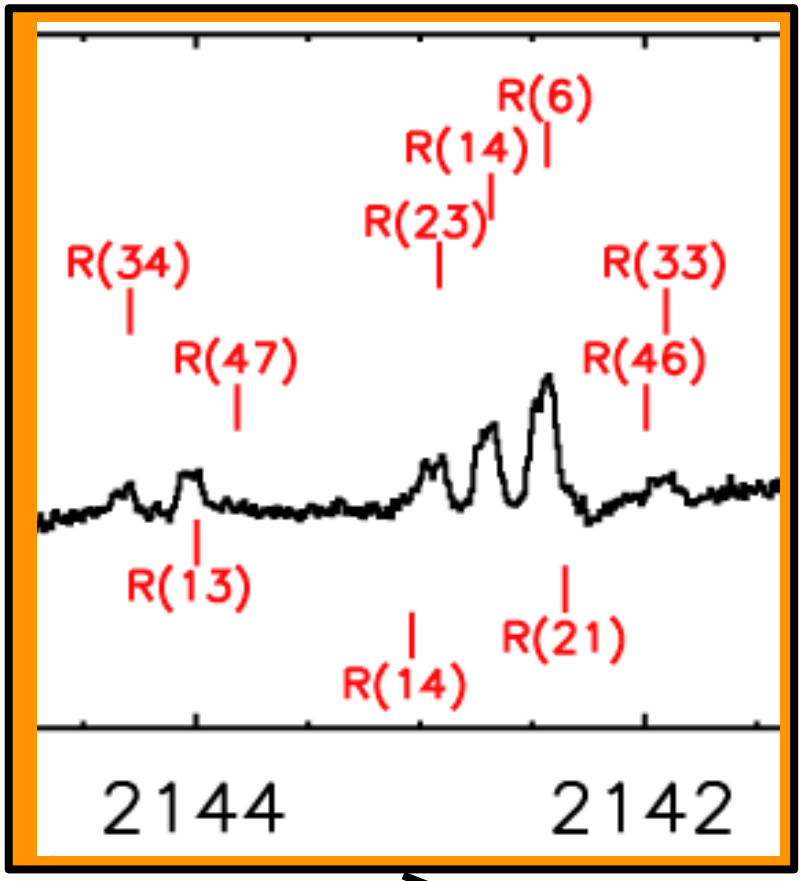
Grady et al. 2005

- ~10Myr
- SpT=B9/B9.5Ve
- d=103±6pc
- $M_{Disk}=0.05M_{Sun}$
- R_{in}(dust)= ~10 AU
- Accreting ~10^{-9}Msun yr^{-1}

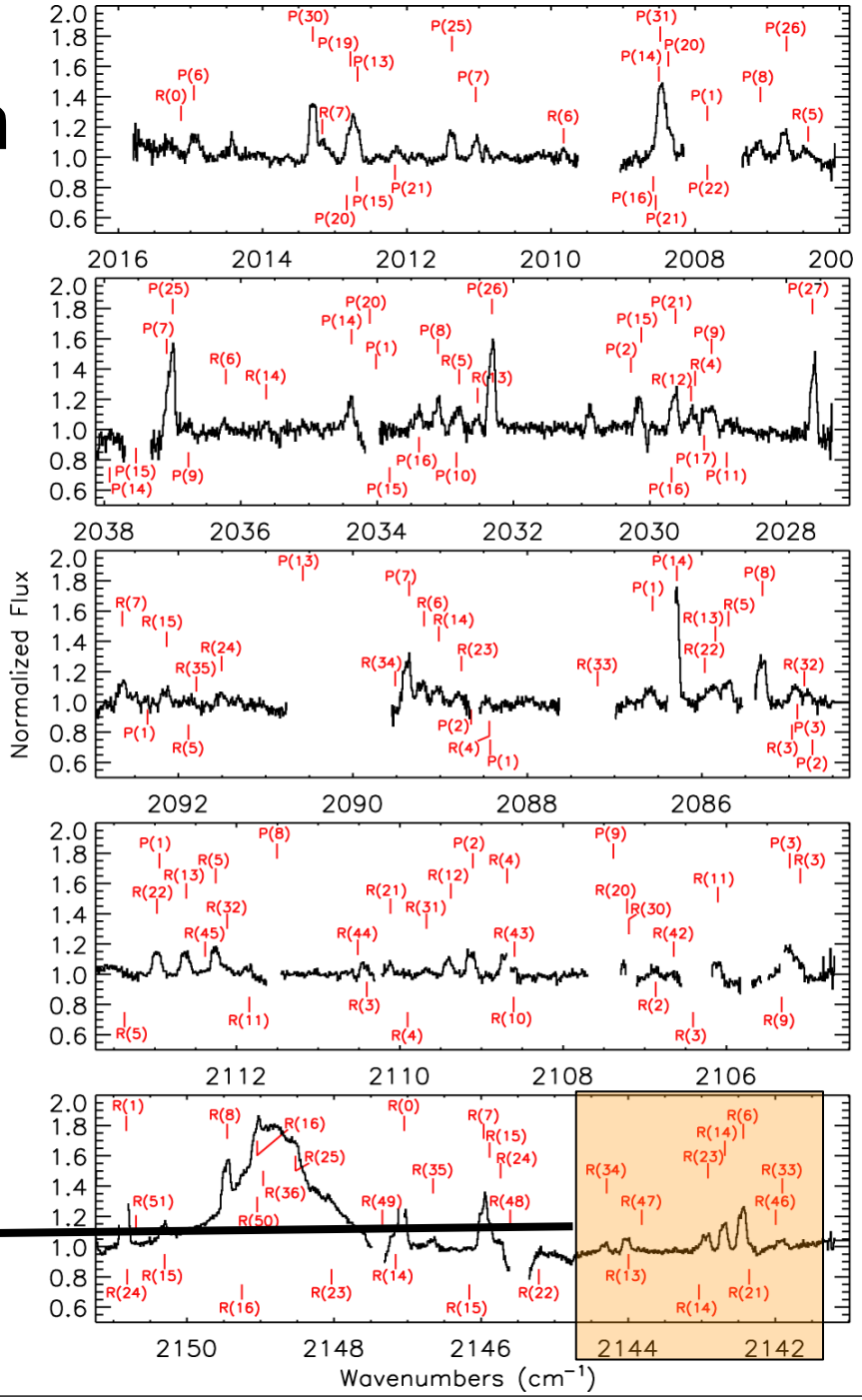


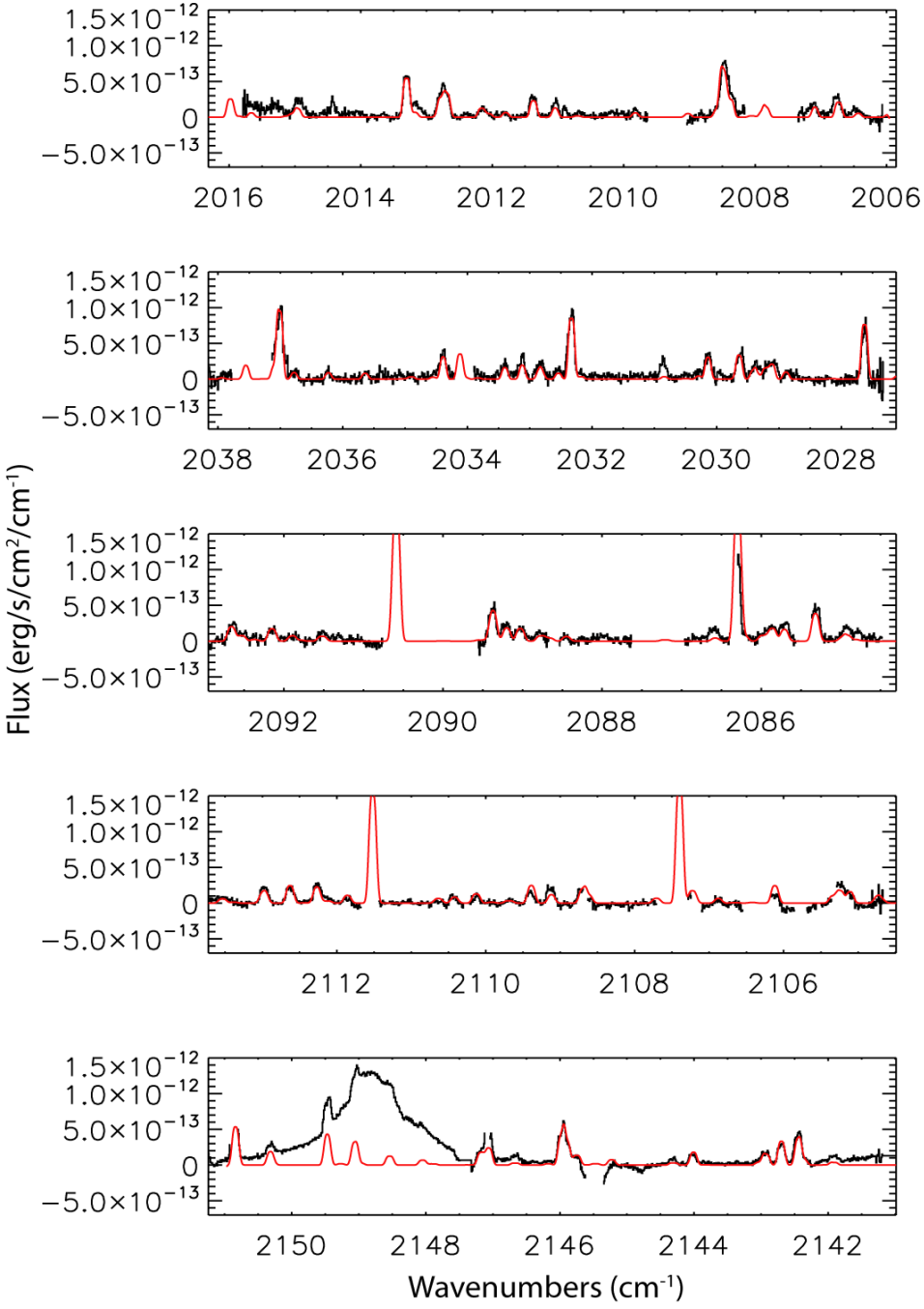
Malfait et al. 1998

HD 100546: CO emission



Brittain et al. 2009



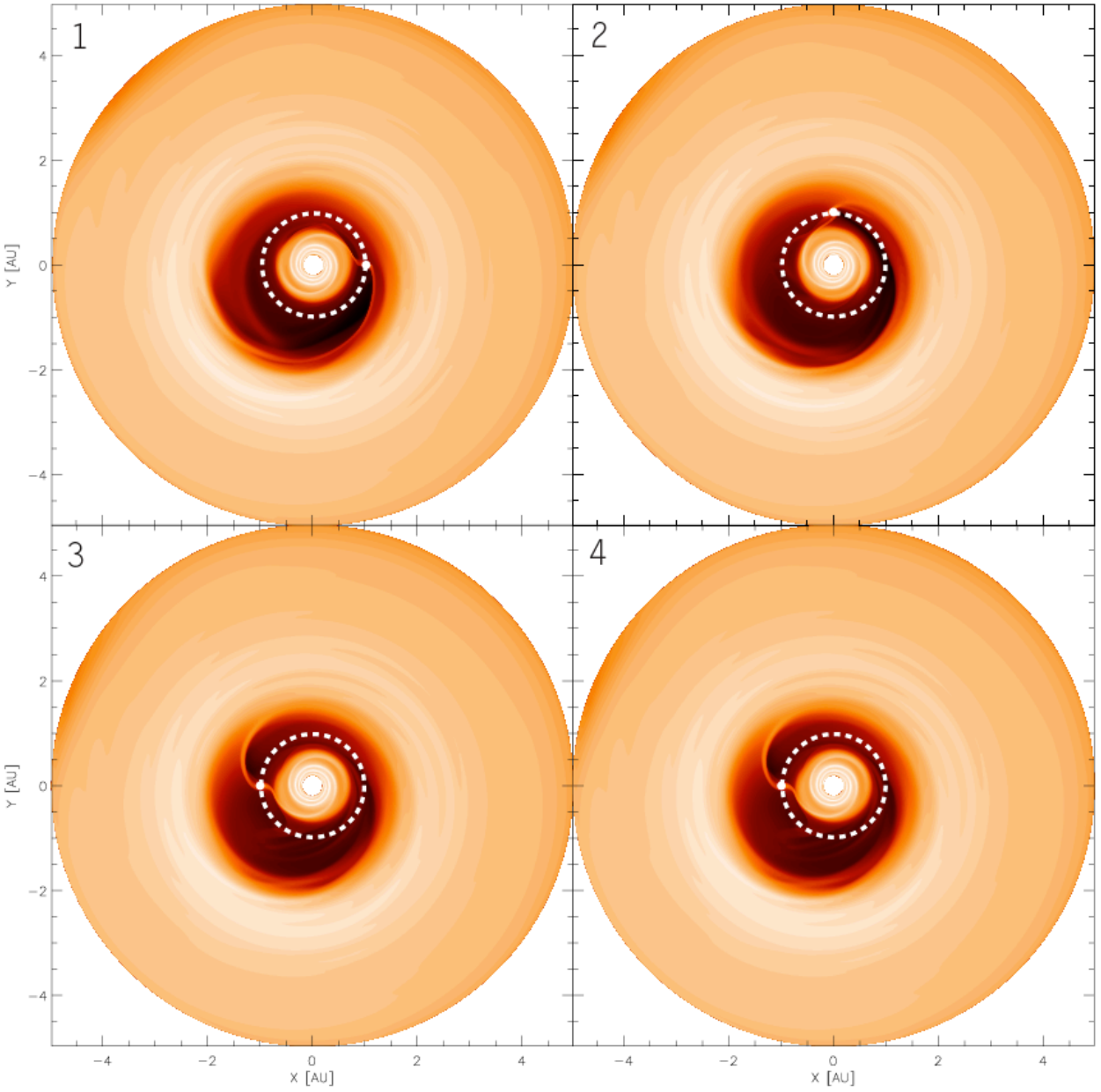


HD 100546

- $R_{in}(CO)=13$ AU
- $R_{out}(CO)\sim100$ AU
- $T(r)=1400\ (r/13AU)^{-0.35}$ K
- CO hot bands UV fluoresced
- CO fundamental has thermal component (excited by collisions)

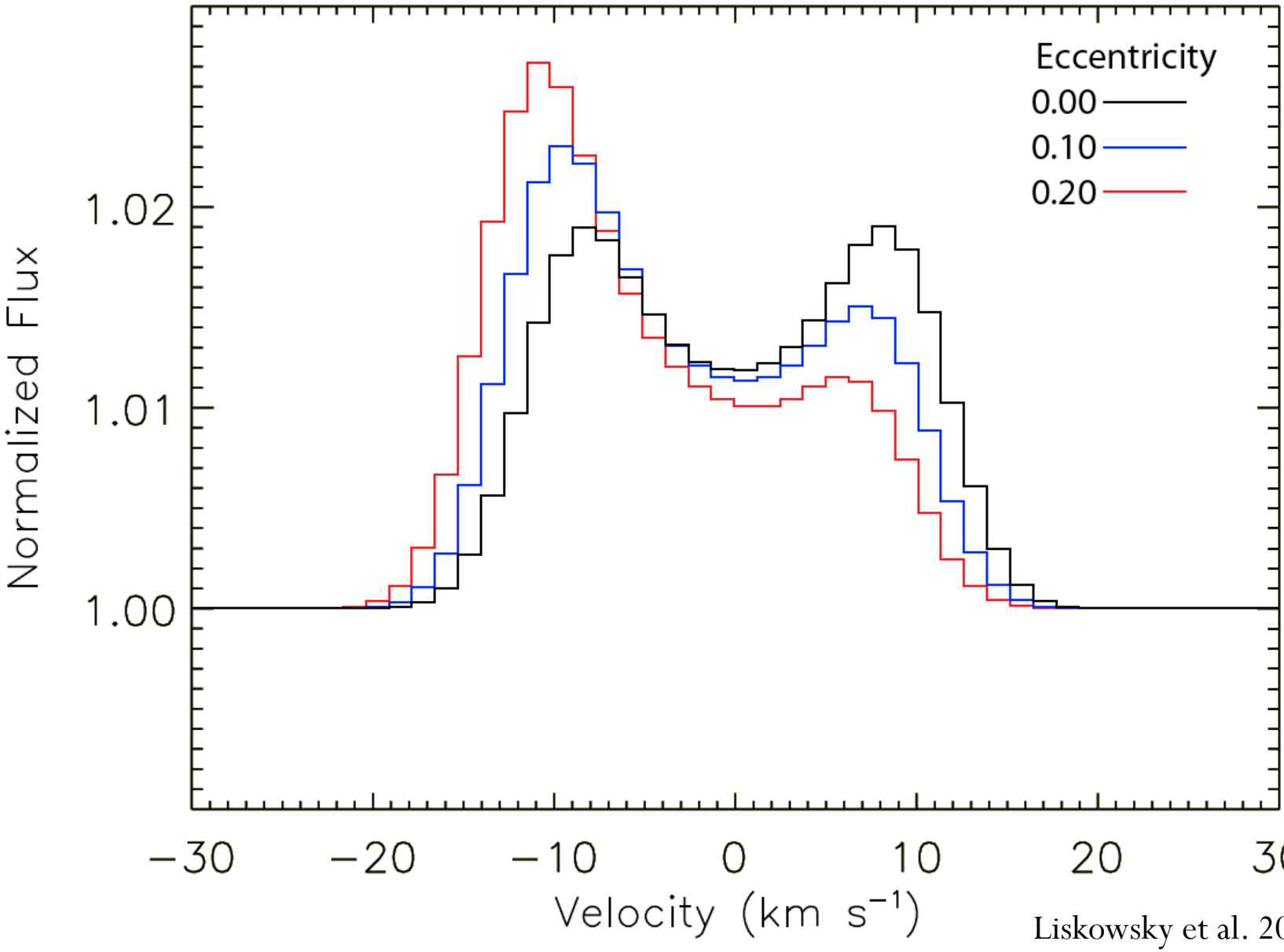
Brittain et al. 2009

The Sculpting of a Planet Forming Disk



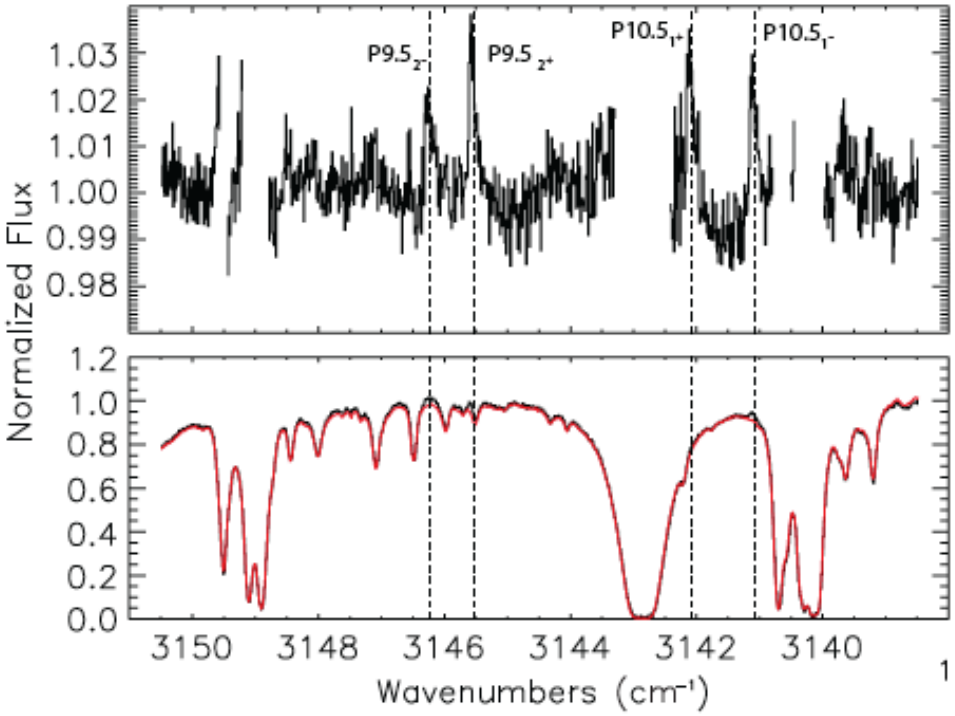
Regaly et al. 2011
(see also Kley &
Dirksen 2006;
Papaloizou et al. 2001)

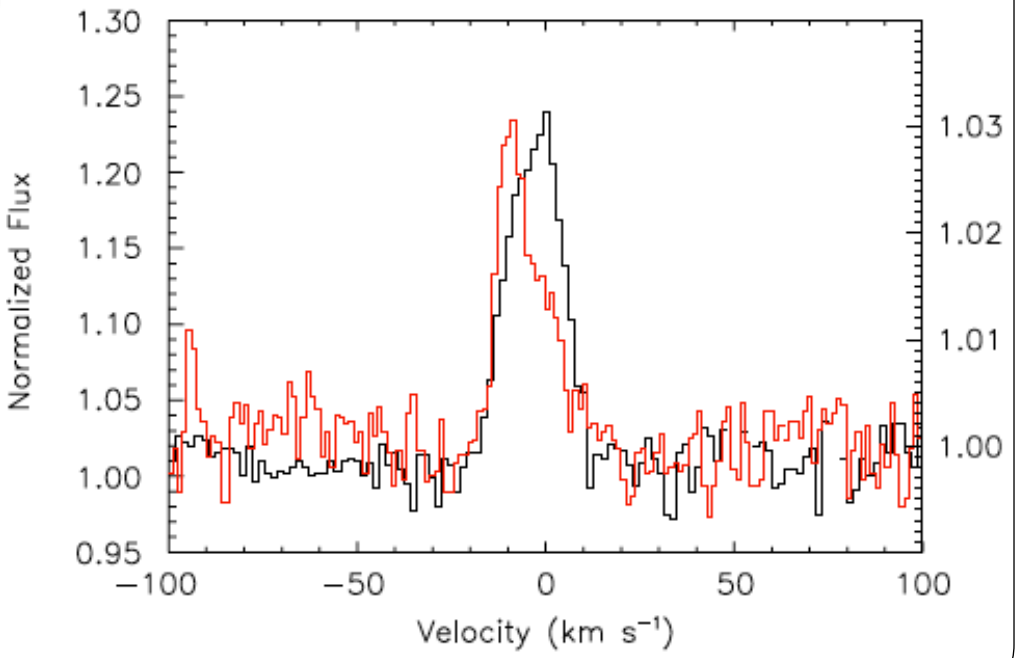
Emission from an Eccentric Ring



Liskowsky et al. 2012

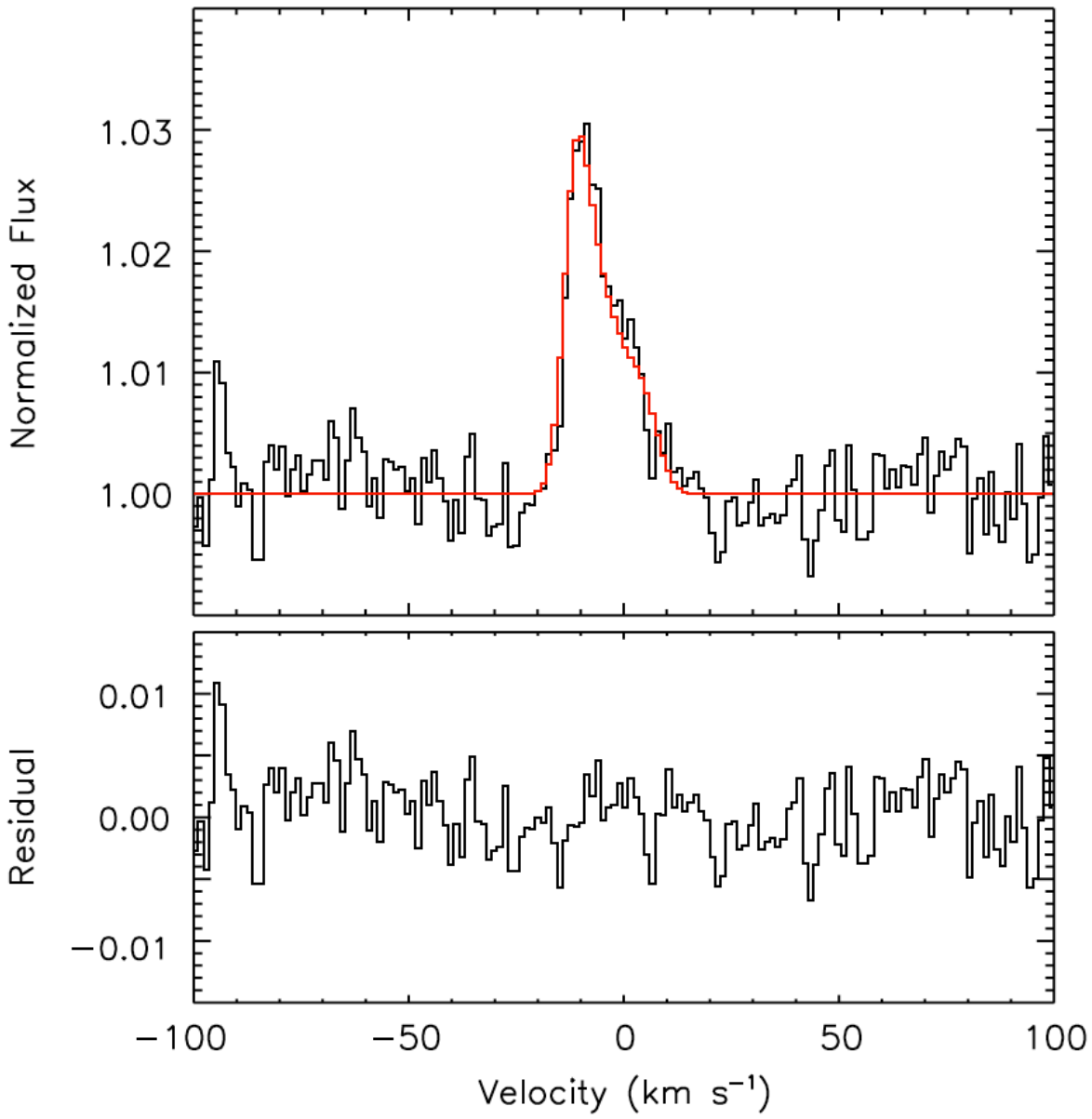
HD100546: OH Emission





Liskowsky et al. 2012

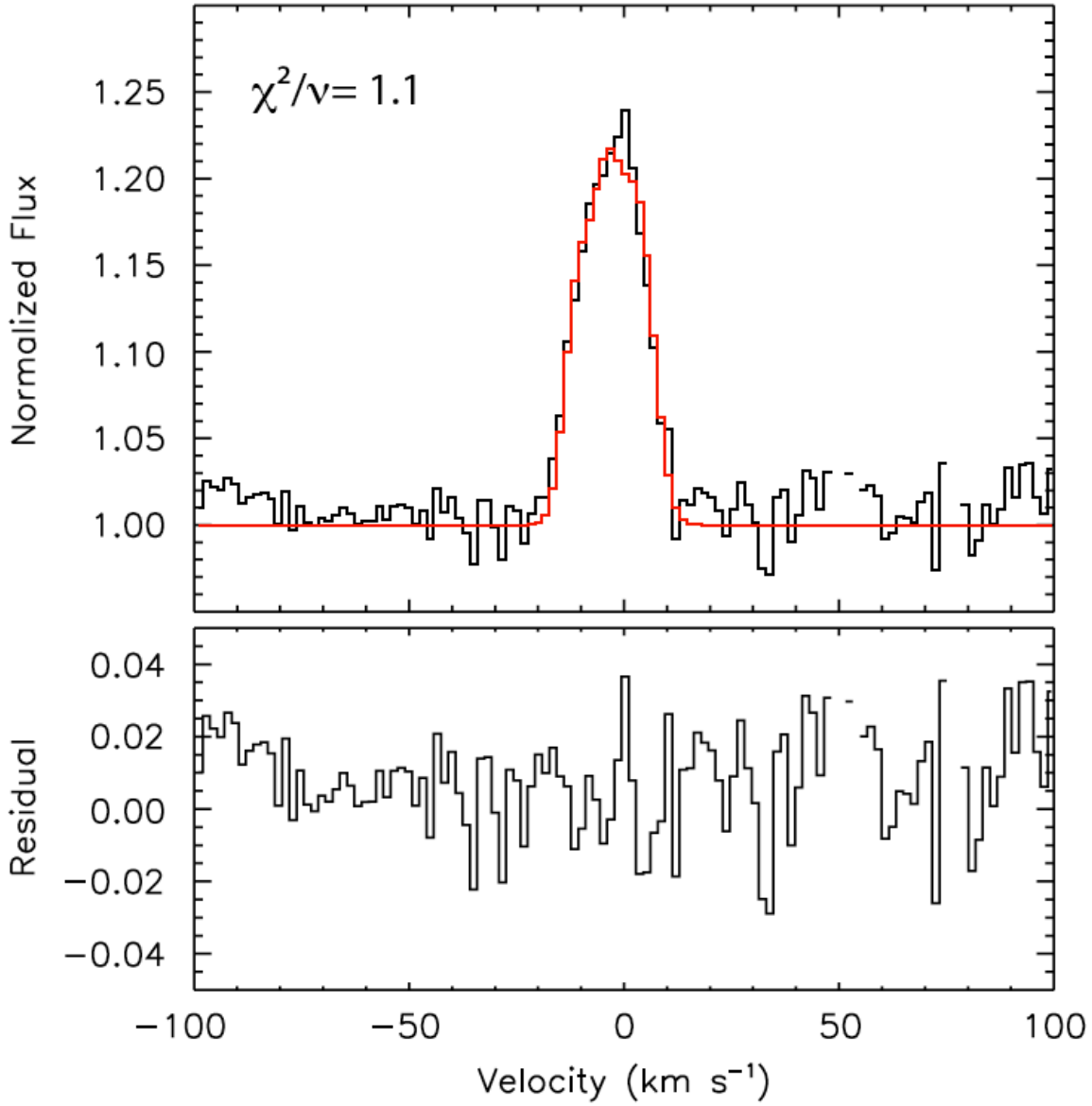
Fit with e=0.18 disk



- 75% of flux arises from inner wall
- Eccentricity of the outer disk is 0
- The radial profile of the OH emission matches the CO in the outer disk

Liskowsky et al. 2012

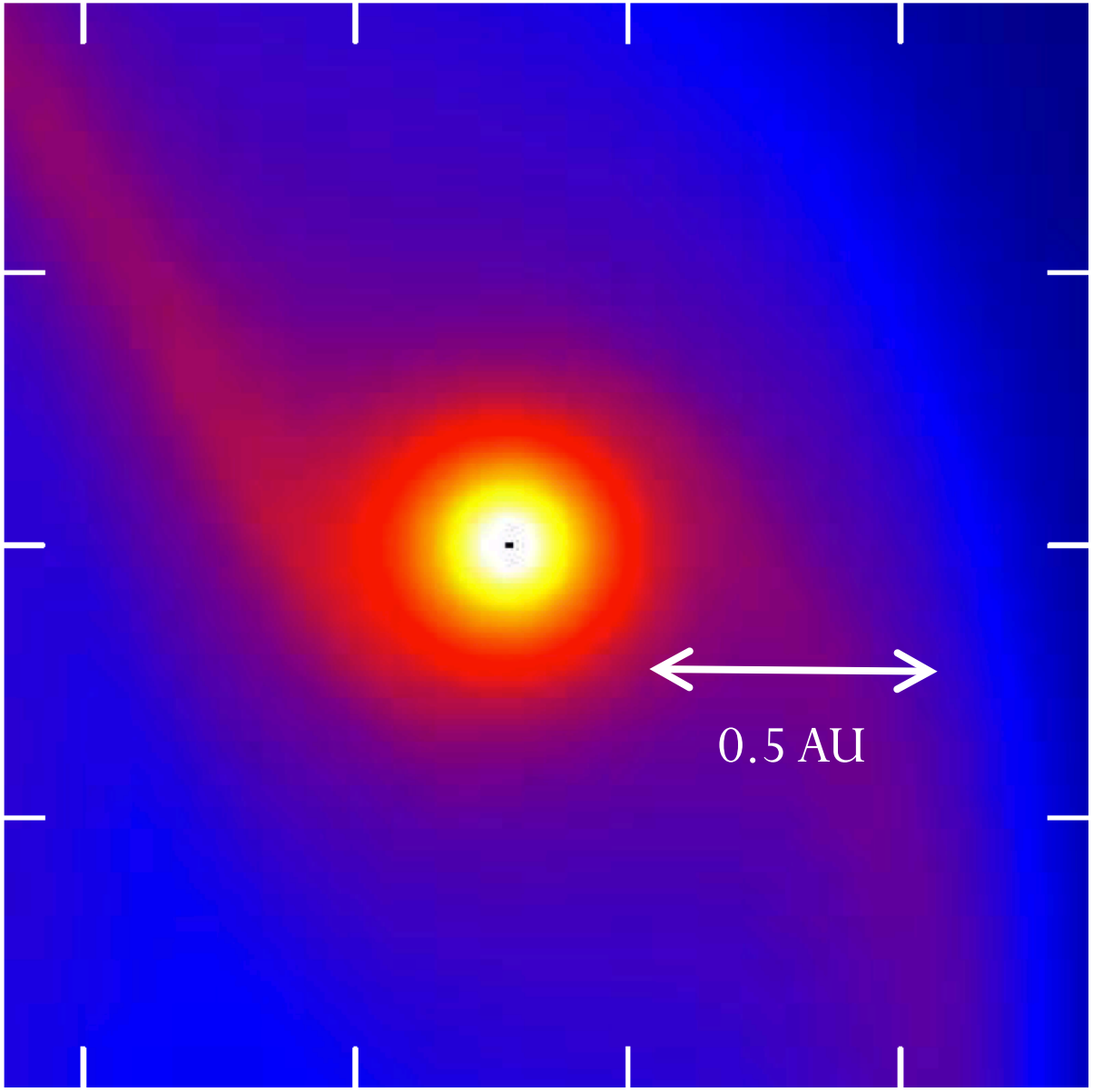
Fit with e=0.18 disk



- 20% of flux arises from inner wall
- Eccentricity of the outer disk is 0
- The radial profile of the CO emission comes from fluorescent modeling

Liskowsky et al. 2012

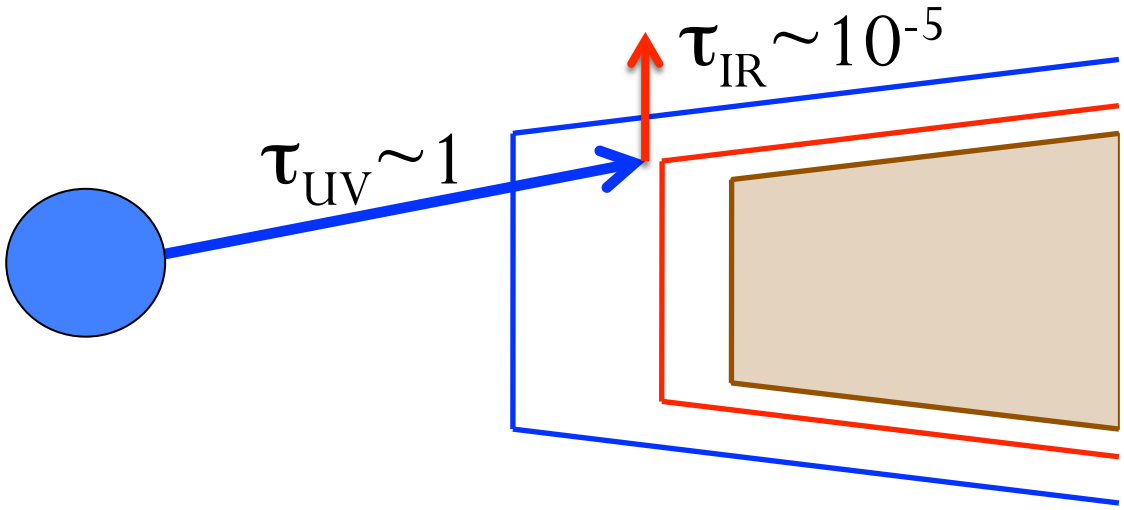
Signposts of Planet formation: Circumplanetary Disks?



Emission lines from a circumplanetary disk will be Doppler shifted relative to the star.

Ayliffe & Bate 2009 (see also Quillen & Trilling 1998; Lubow et al. 2011).

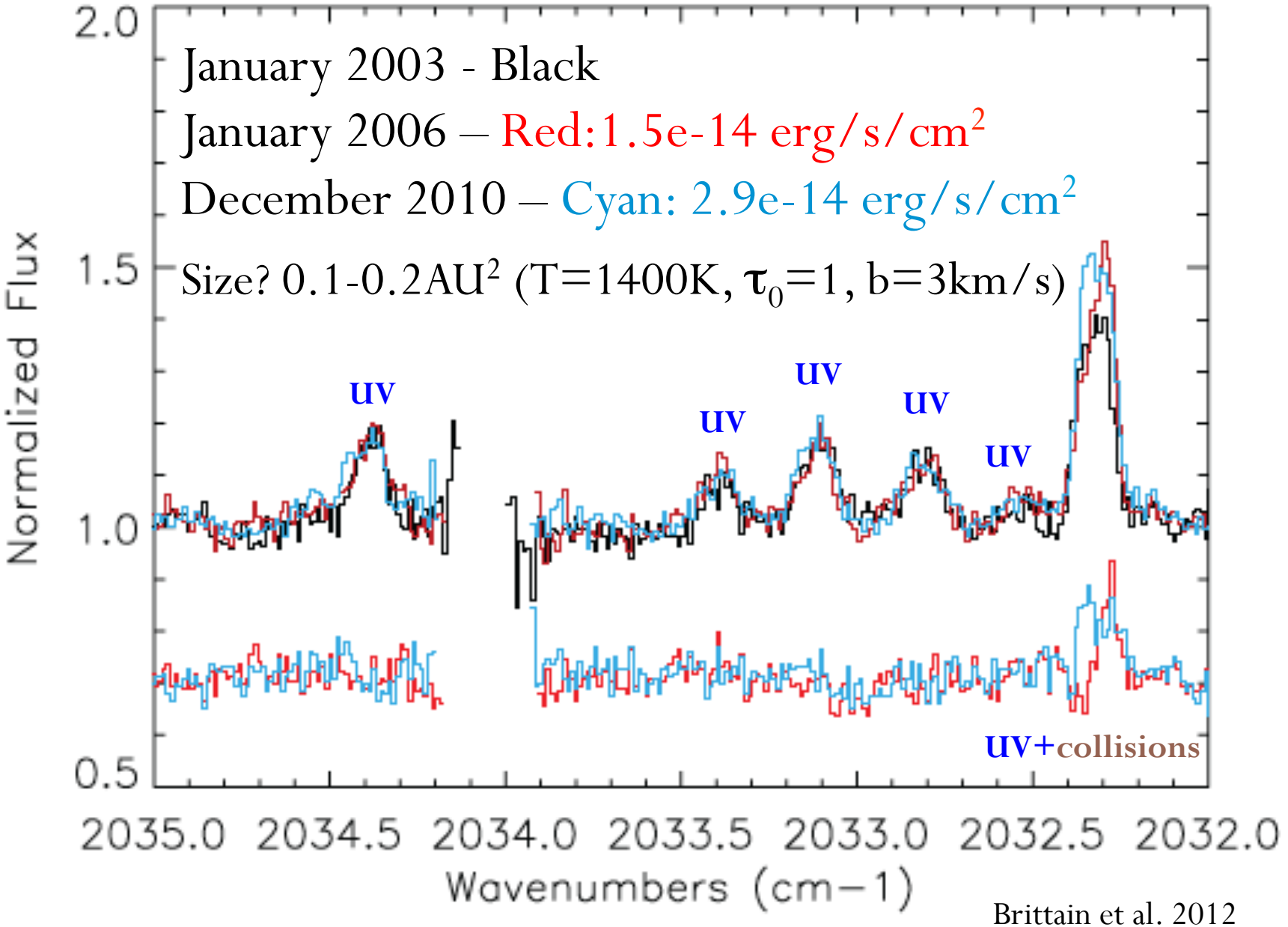
Excitation of gas in disks: UV



$$L \propto \tau * Area$$

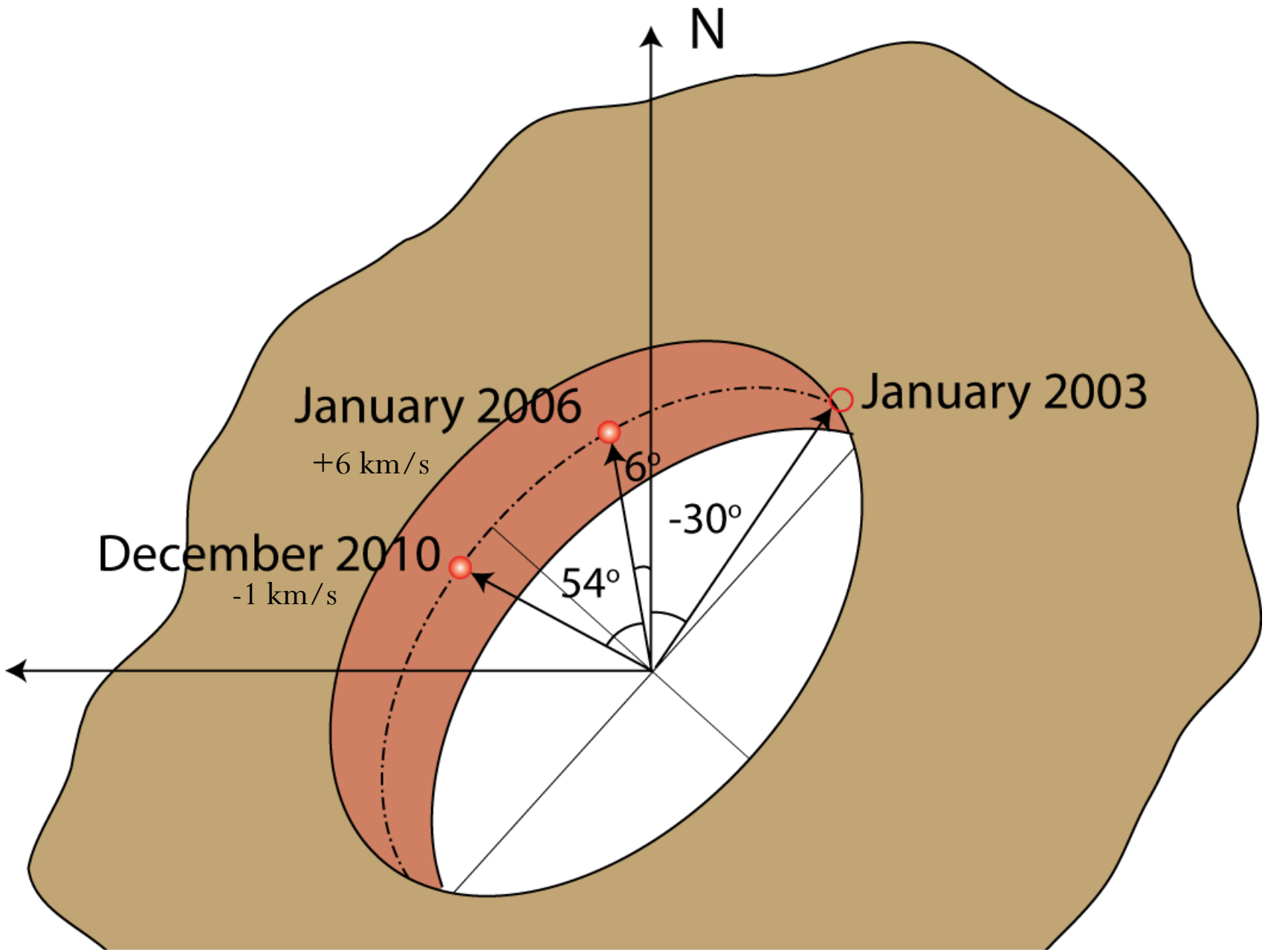
- Can we detect it?
- $5M_J$ => Area of ~0.1 AU^2
- $\tau \sim 1$ (circumplanetary disk)
- $\tau \sim (10^{-5}$ UV fluoresced outer disk)
- Disk Area ~ 10^4 AU^2

The Circumplanetary Disk?

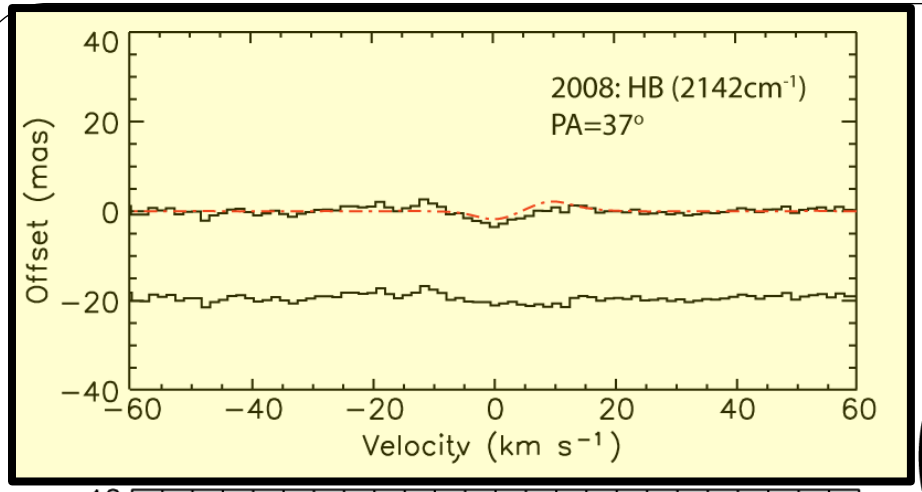


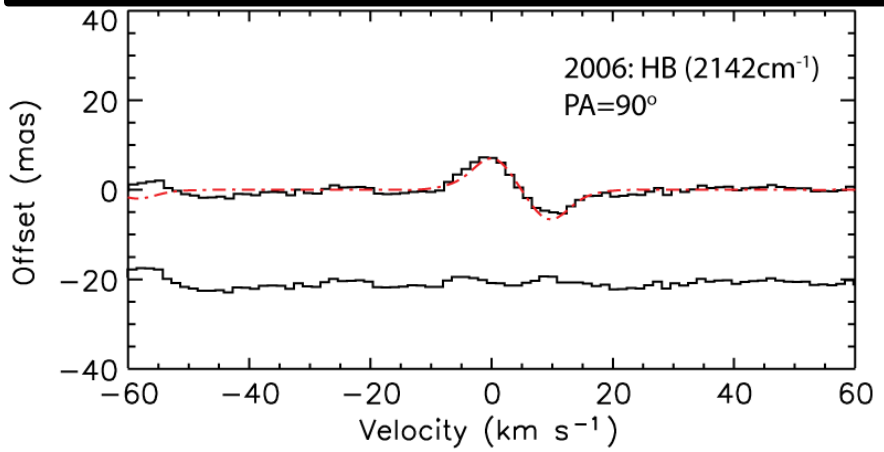
Brittain et al. 2012

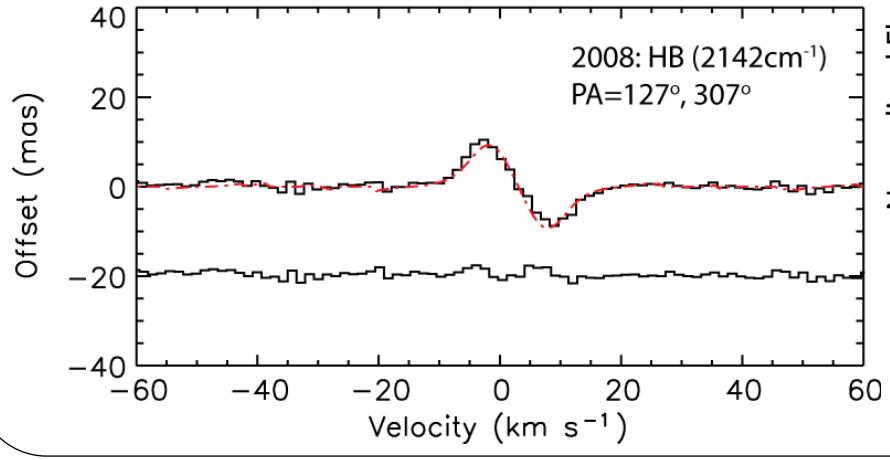
The Circumplanetary Disk?

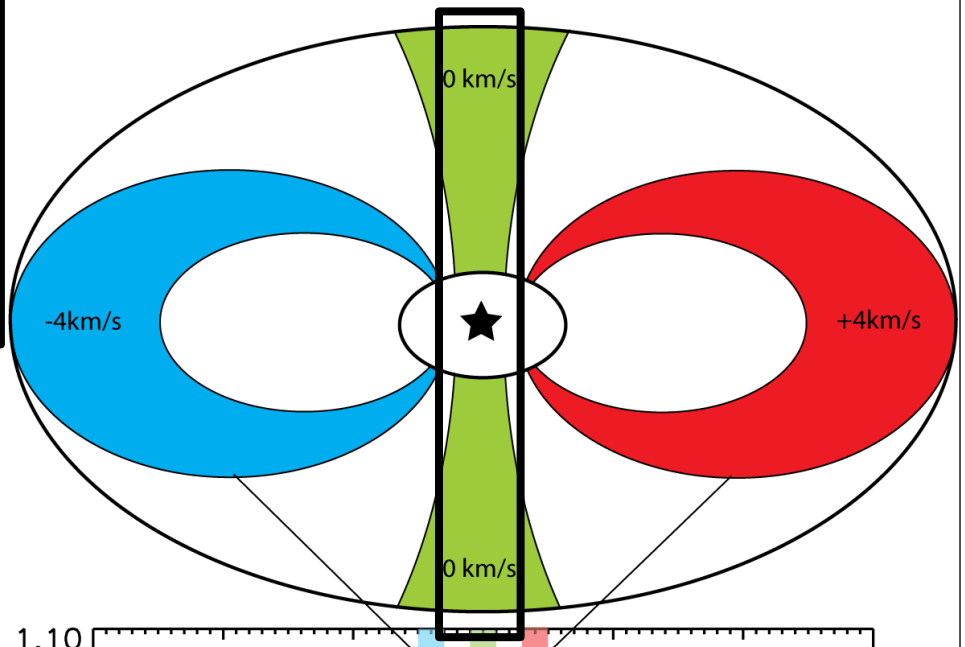


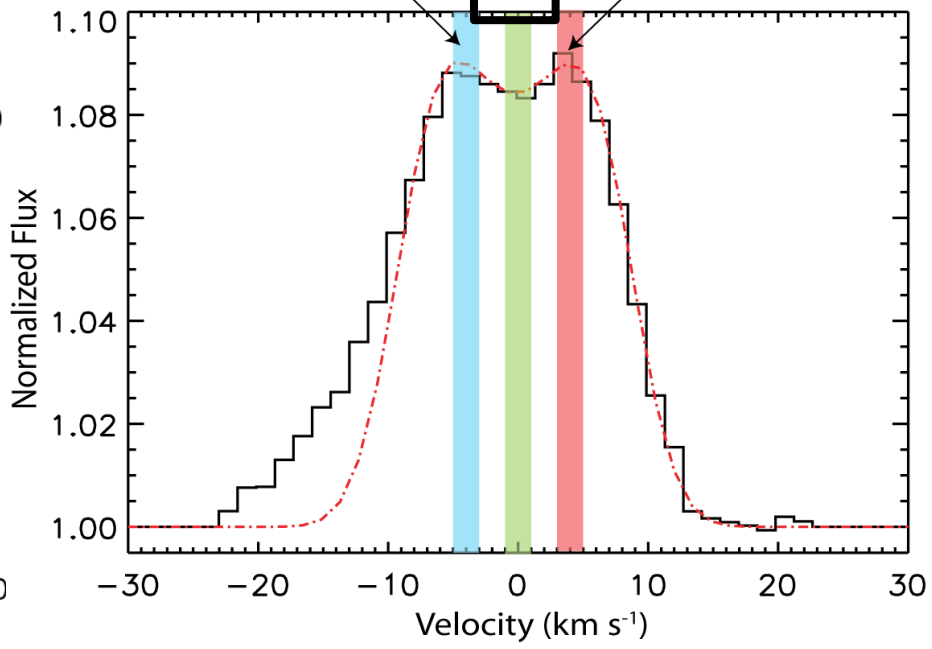
Spectro-Astrometry in Action



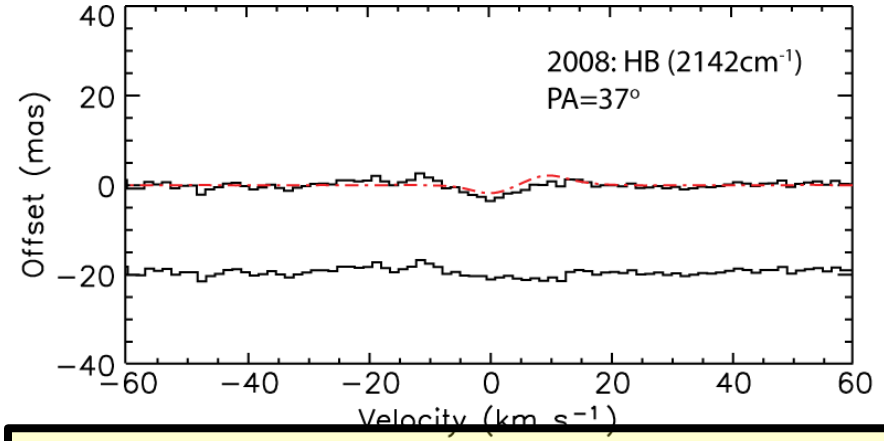


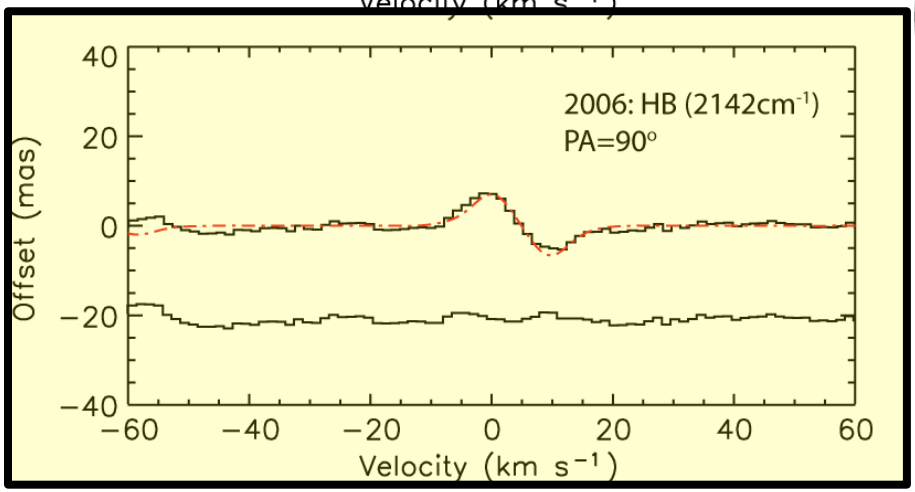


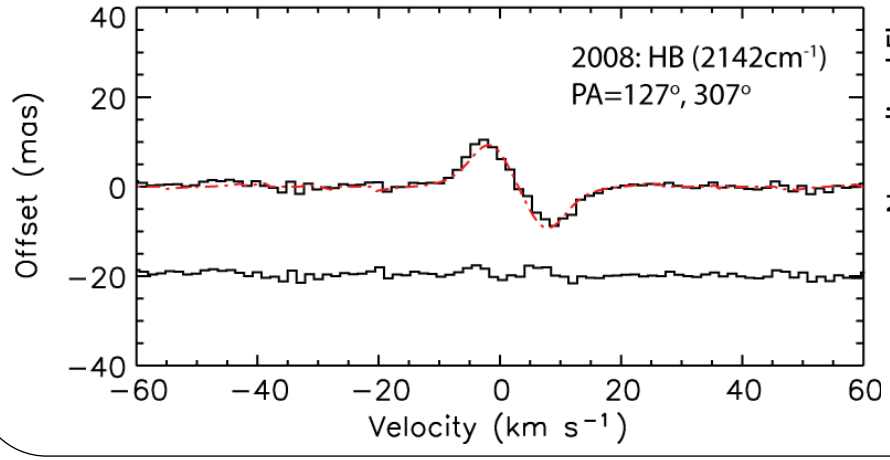


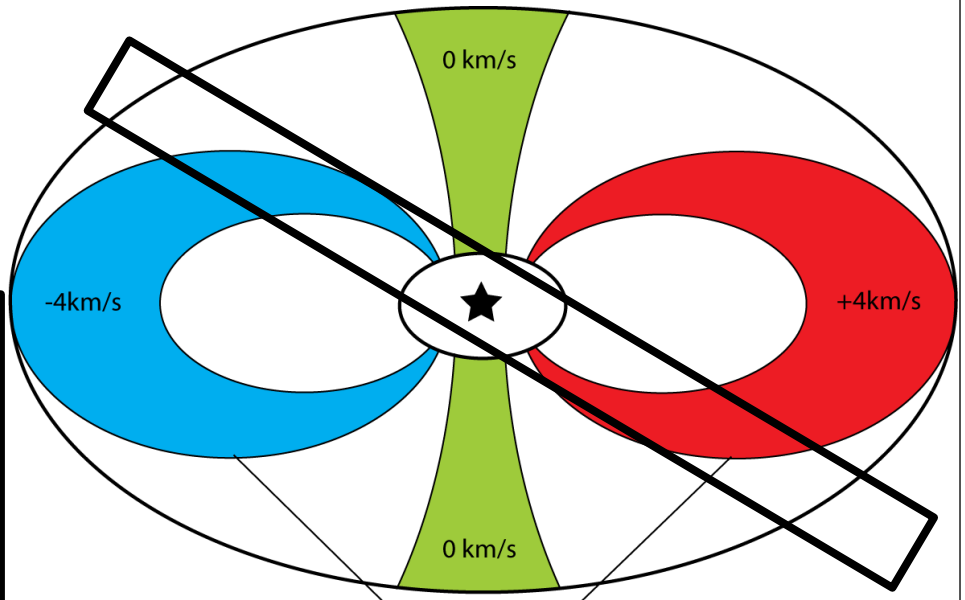


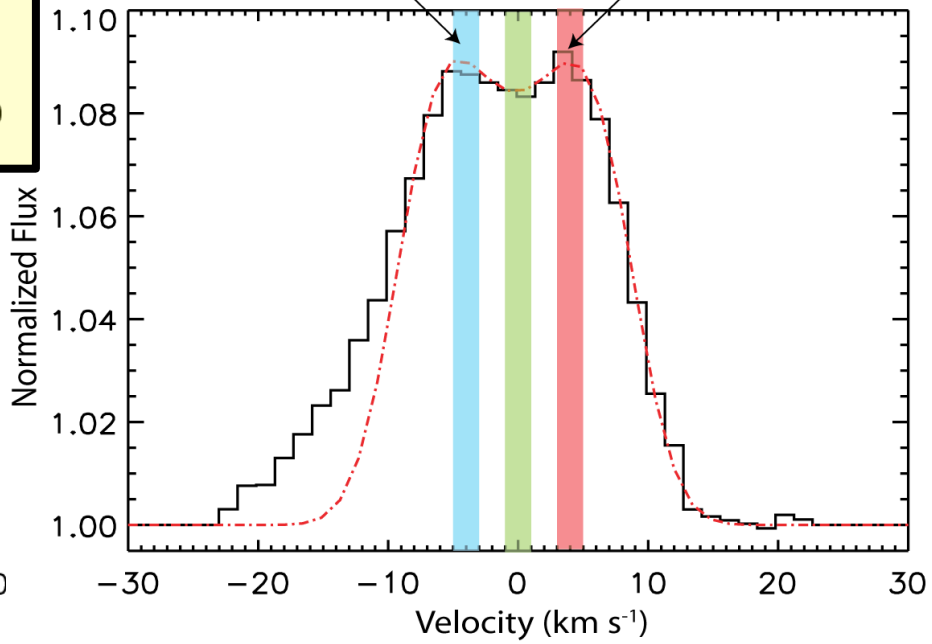
Spectro-Astrometry in Action



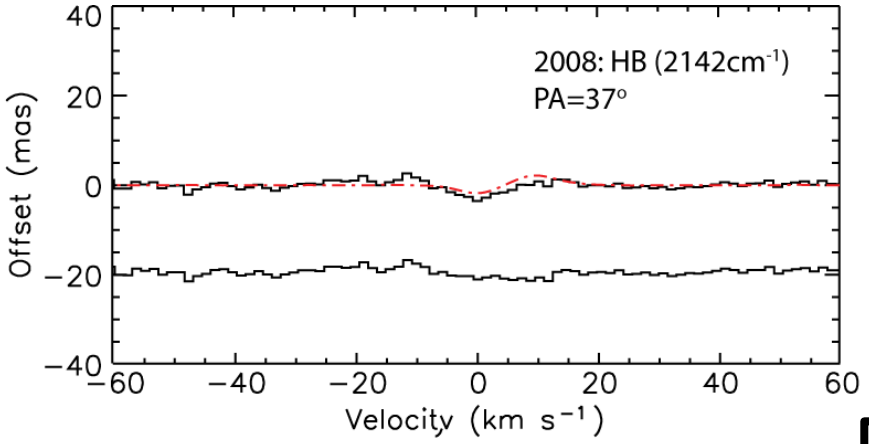


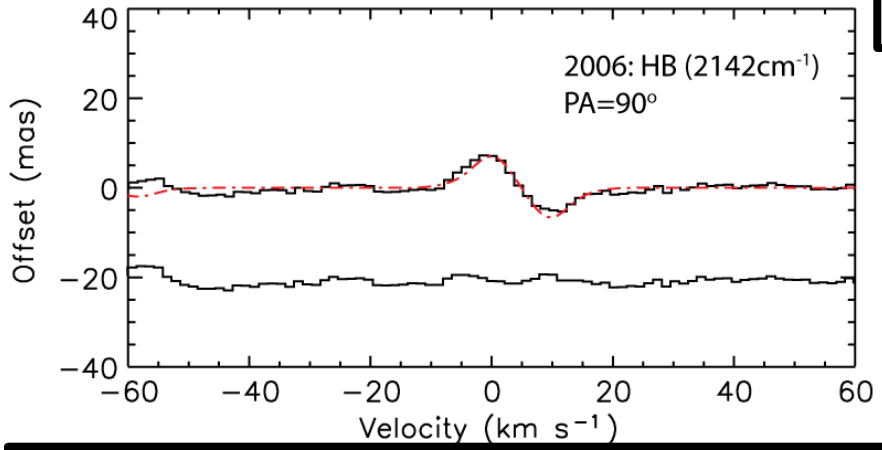


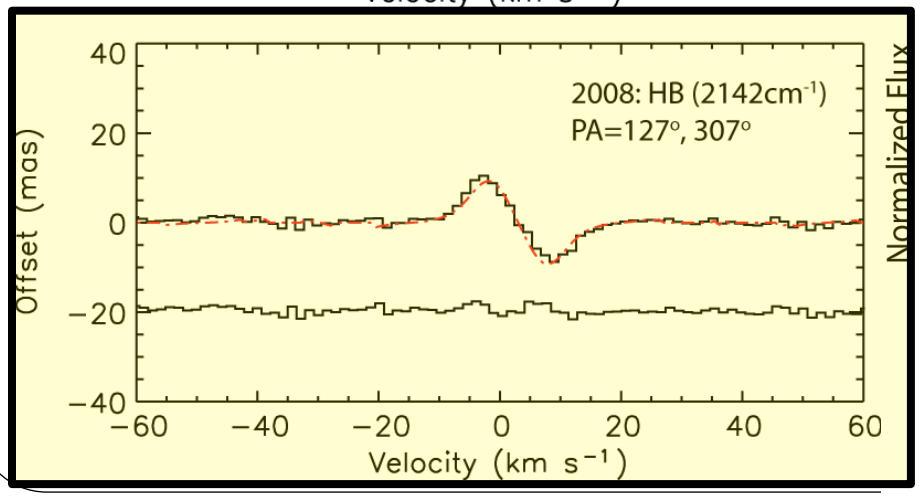


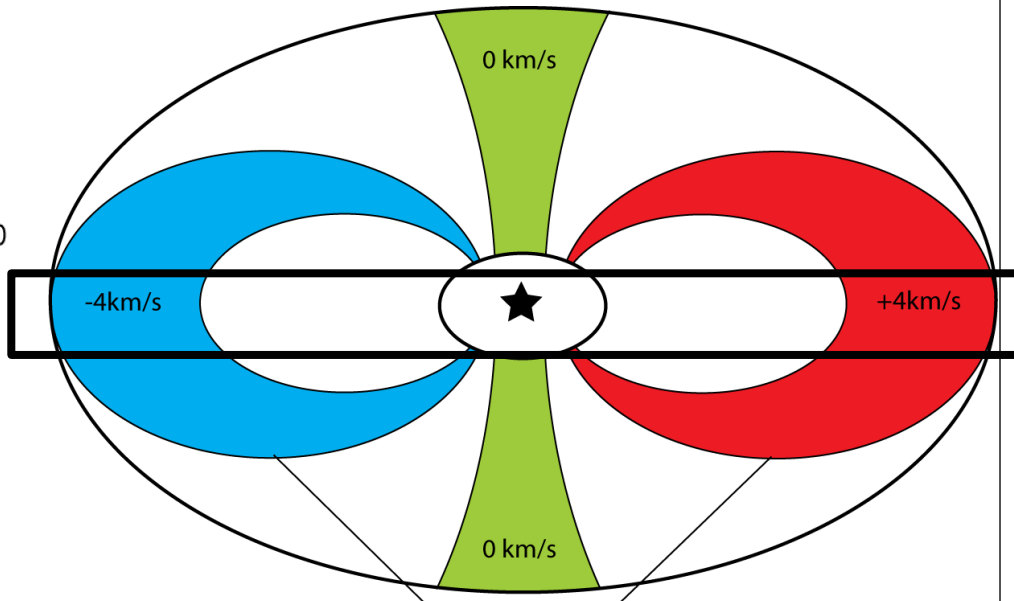


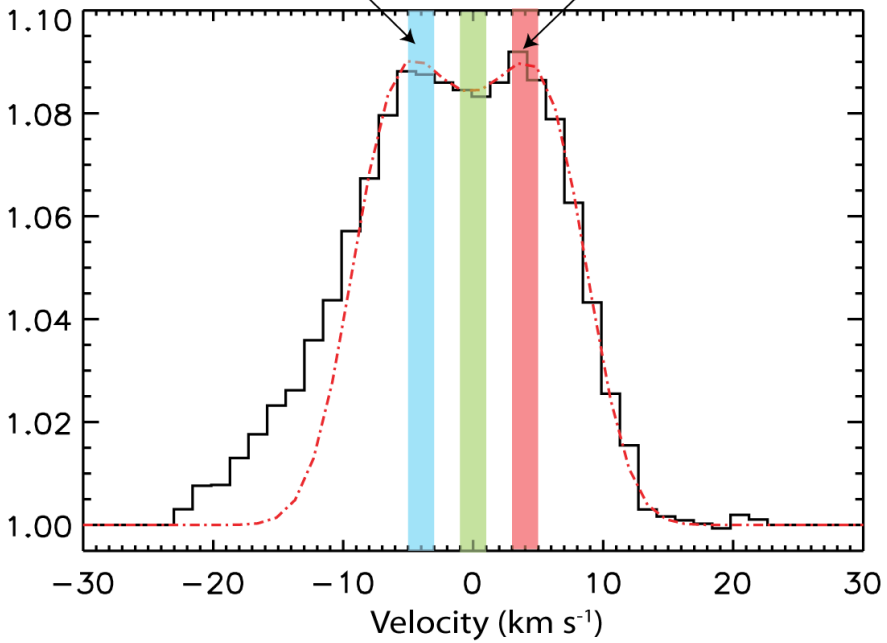
Spectro-Astrometry in Action



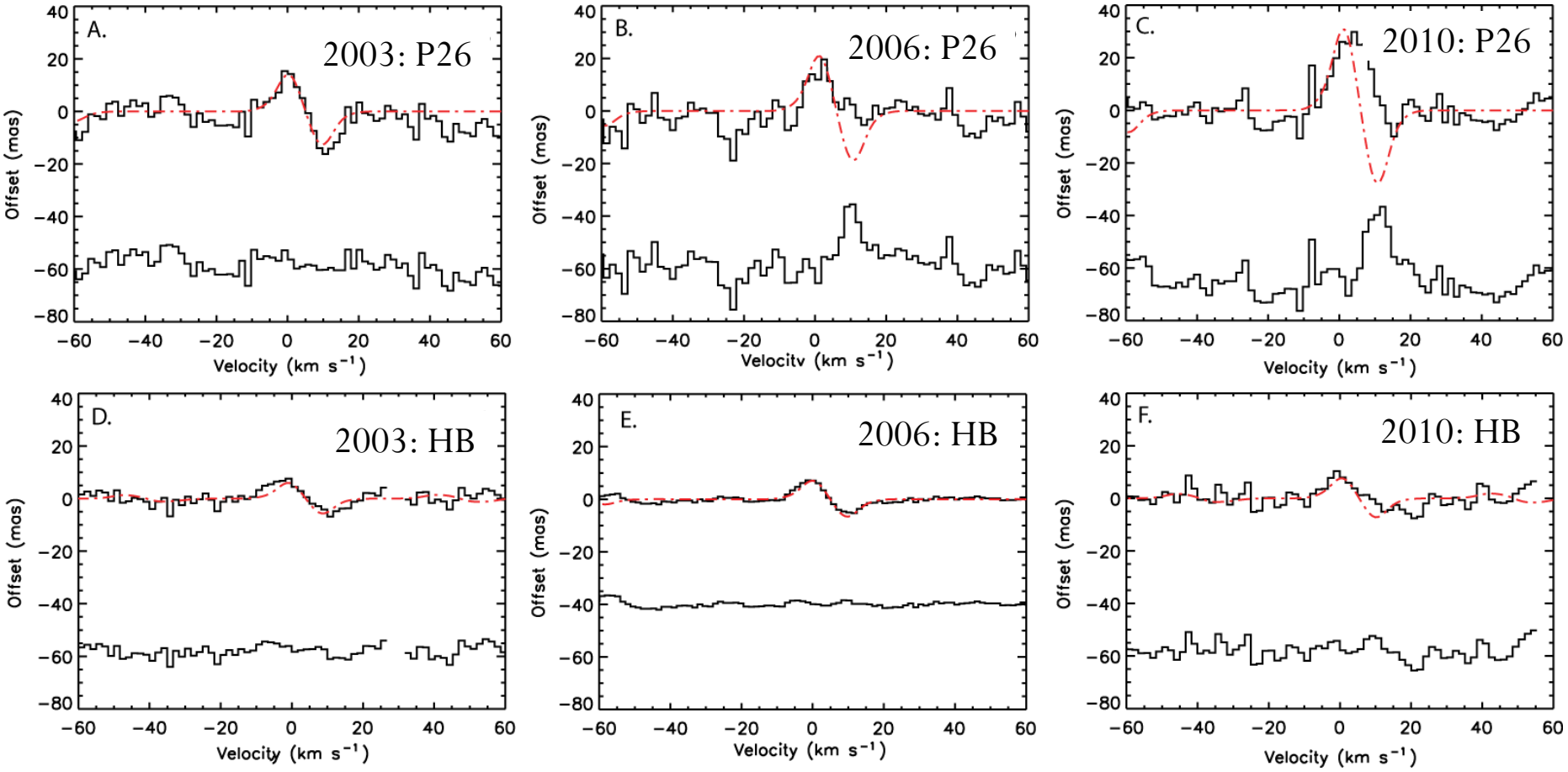






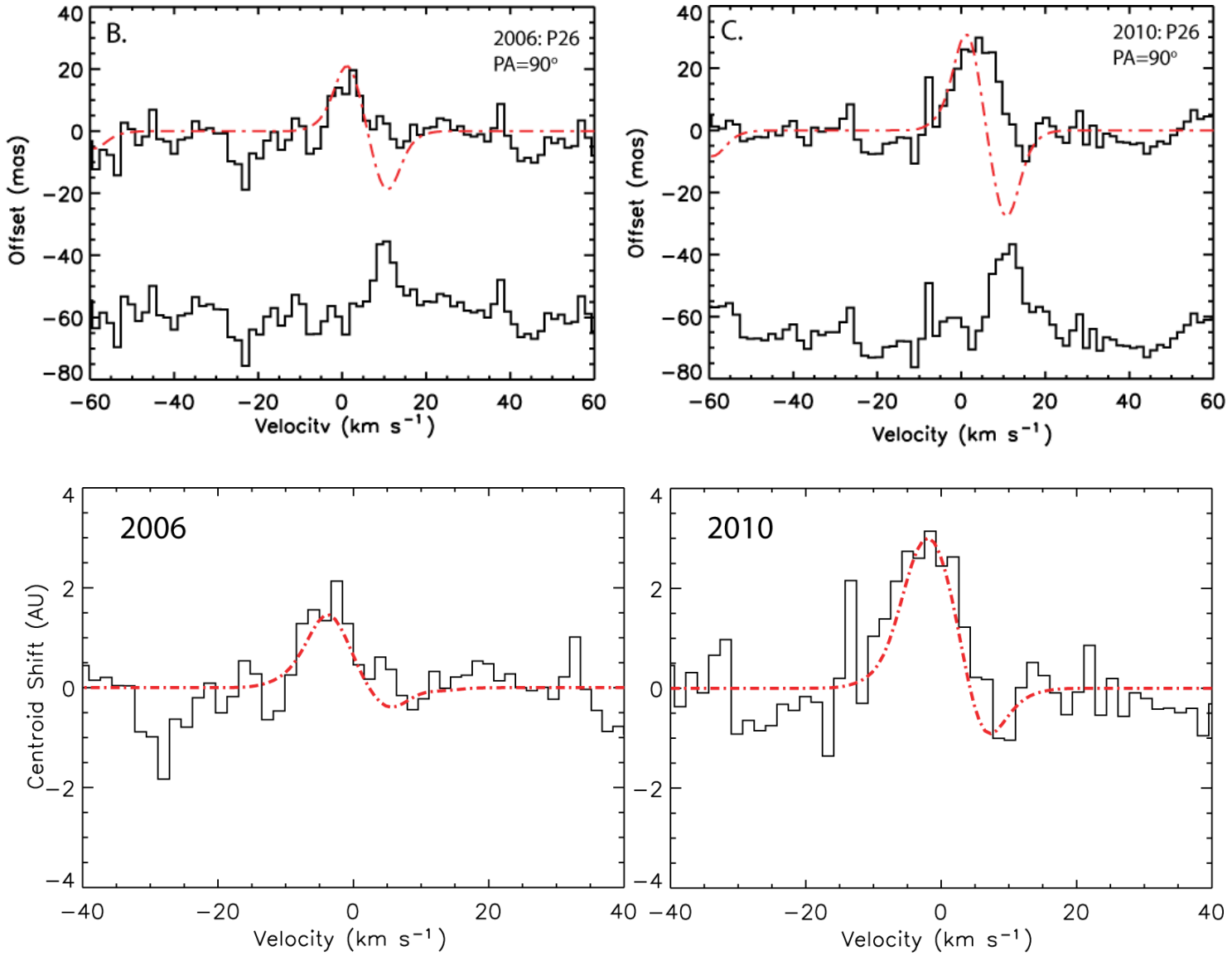


Evolution of Spectro-Astrometric Signal



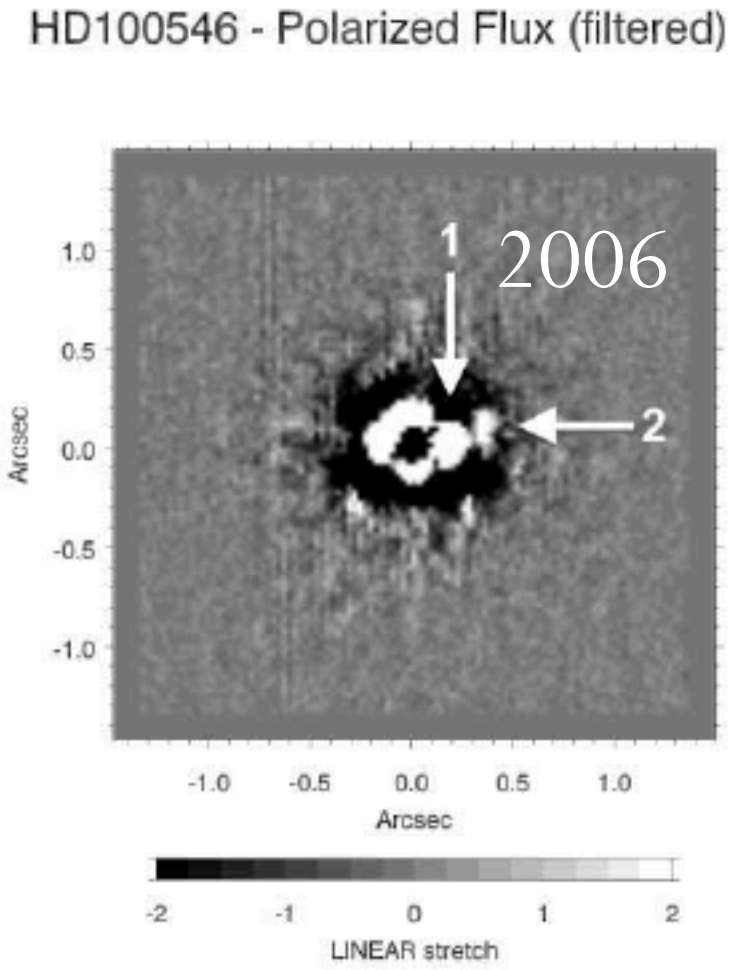
Brittain et al. 2012

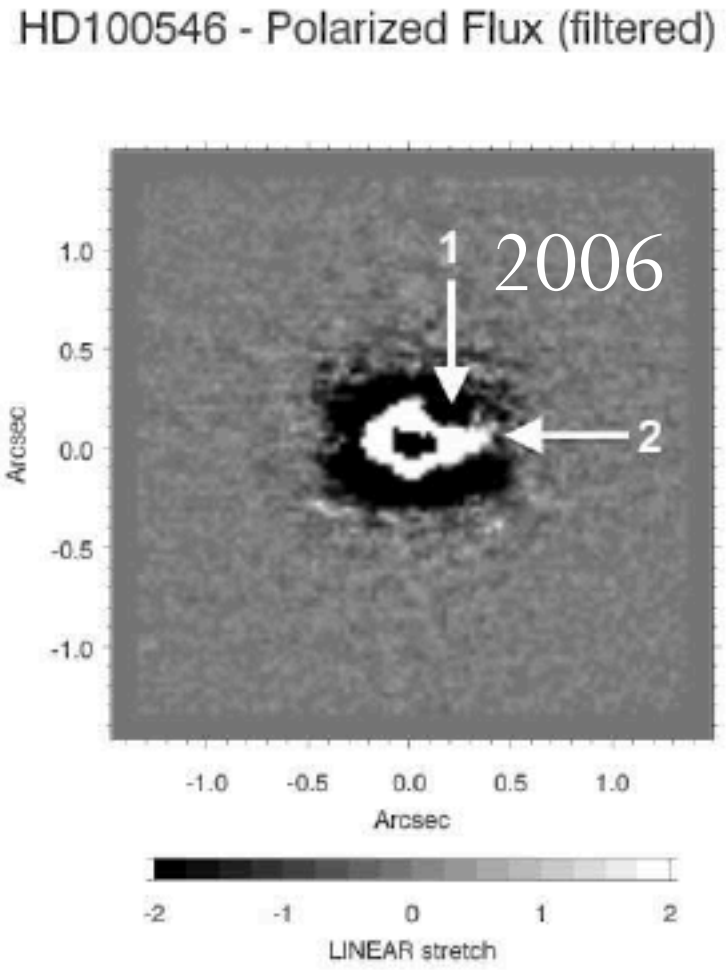
Spectro-Astrometry with a Circumplanetary Disk



Brittain et al. 2012

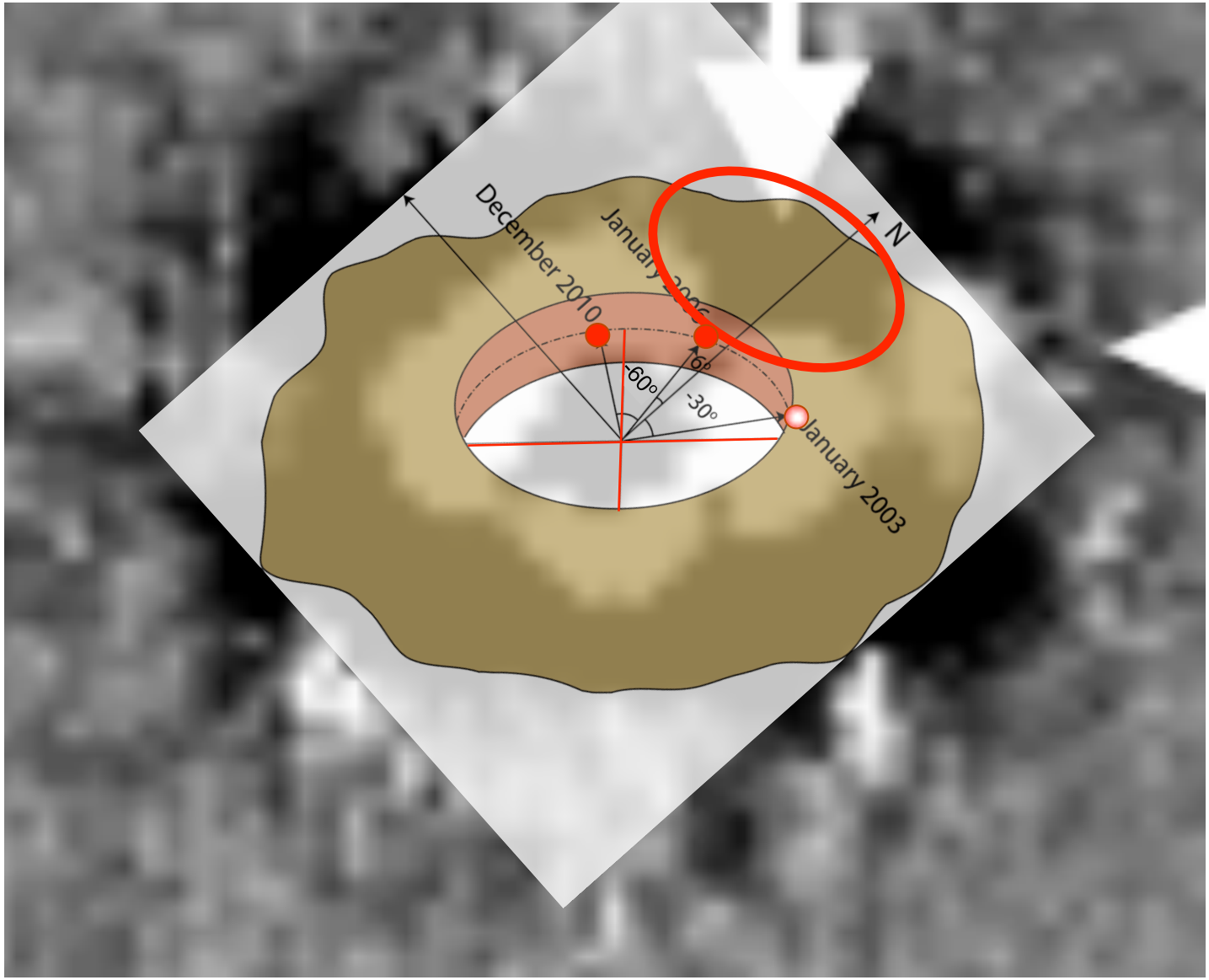
Confirmation?





Quanz et al. 2011

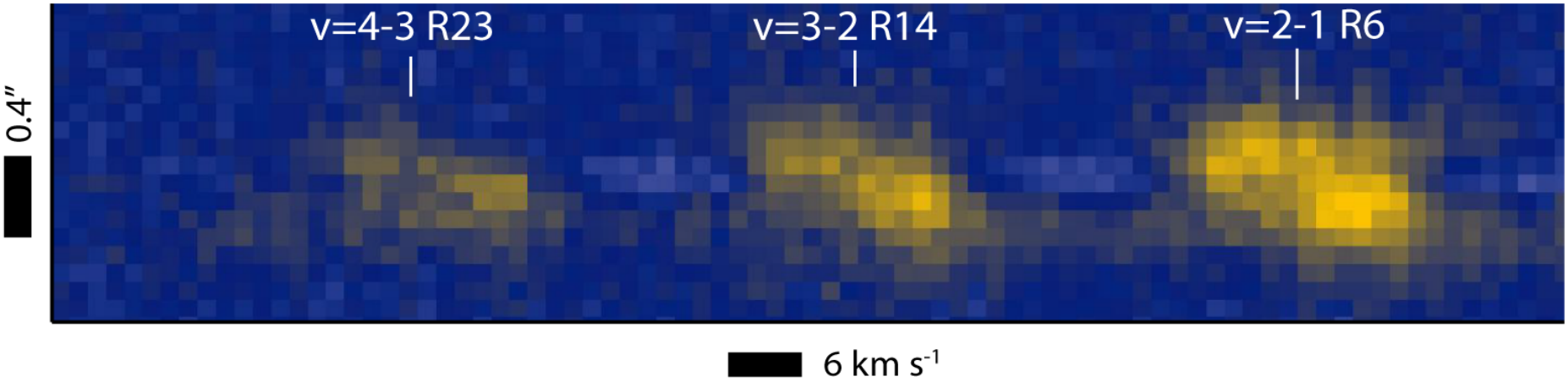
Confirmation?



Detection of a Forming Planet?

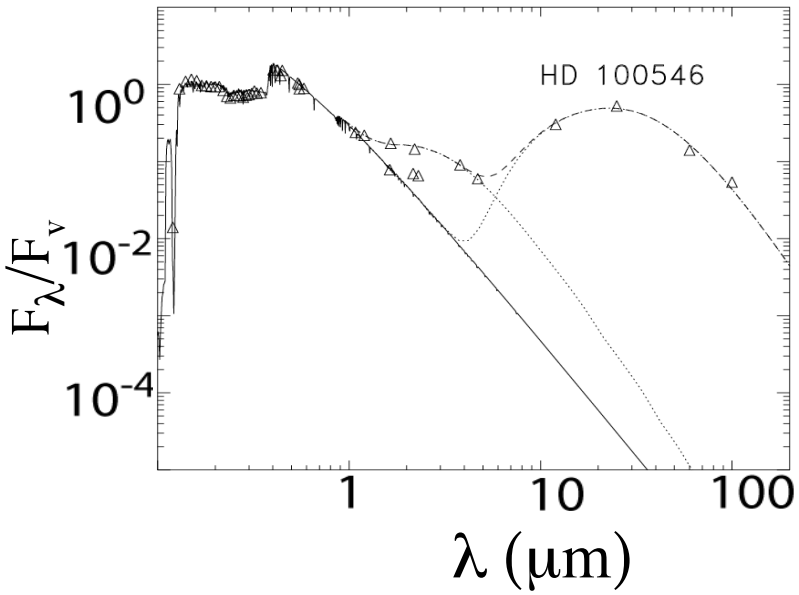
1. Accreting Transition Disk
2. Inner region cleared of molecular gas
3. Inner rim is eccentric
4. Excess emission in orbit in inner region of disk
5. Excess emission is consistent with a 0.1-0.2AU^2 emitting region at temperature of 1400K
6. Excess emission is consistent with SA measurement
7. Location of emission in 2006 agrees with PDI result

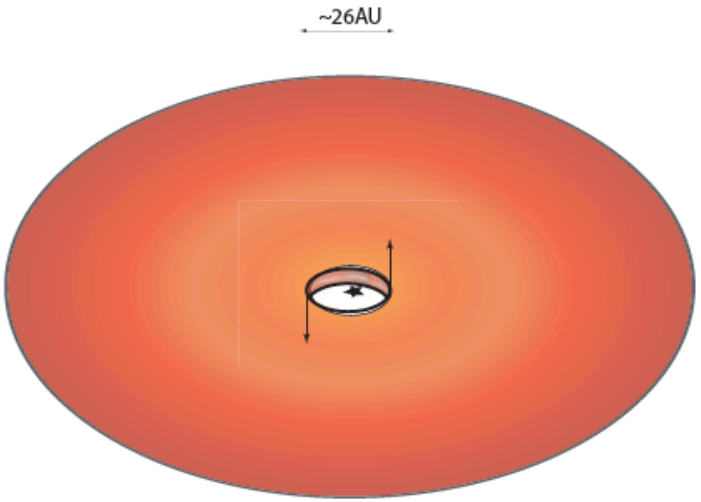
Spatially Resolved Emission

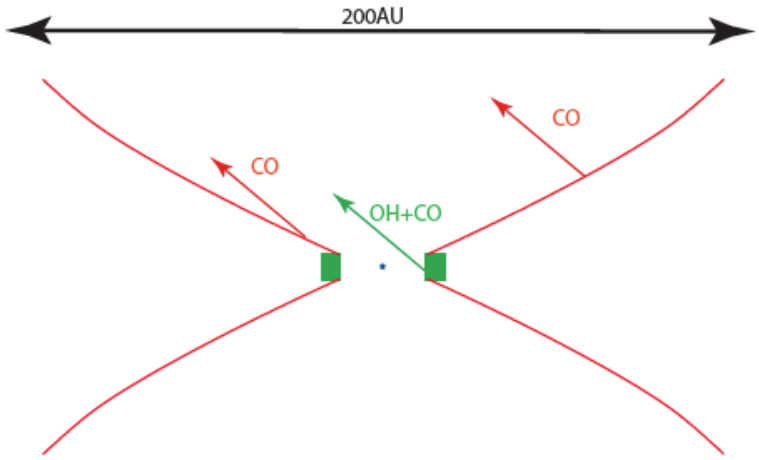


Brittain et al. 2009

Companion in a Transitional Disk?







Liskowsky et al. 2012

Spectro-Astrometry: Effect of a Planet