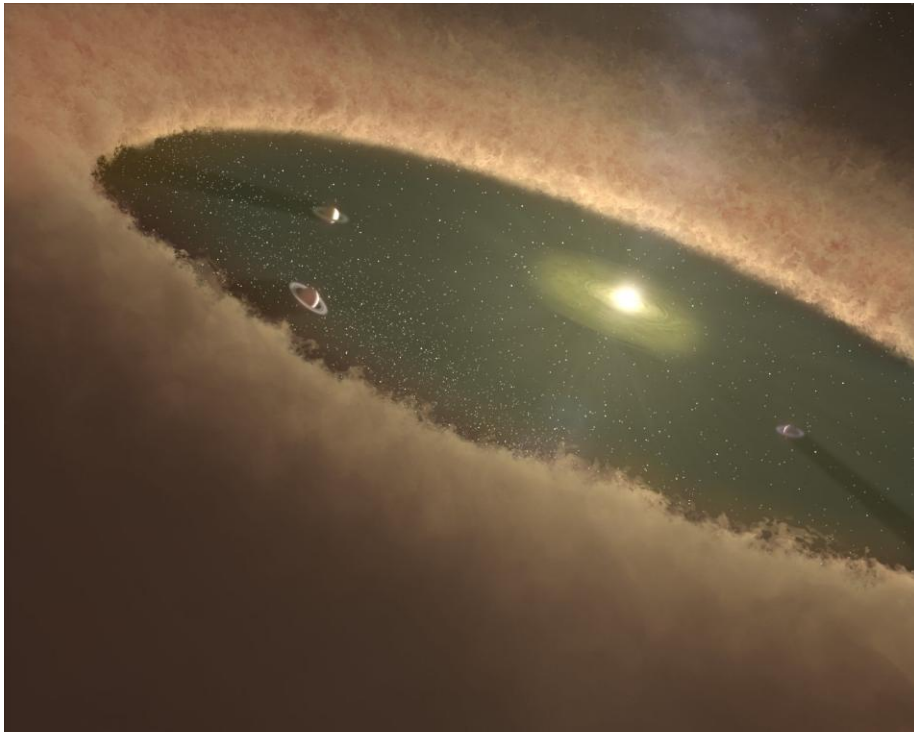
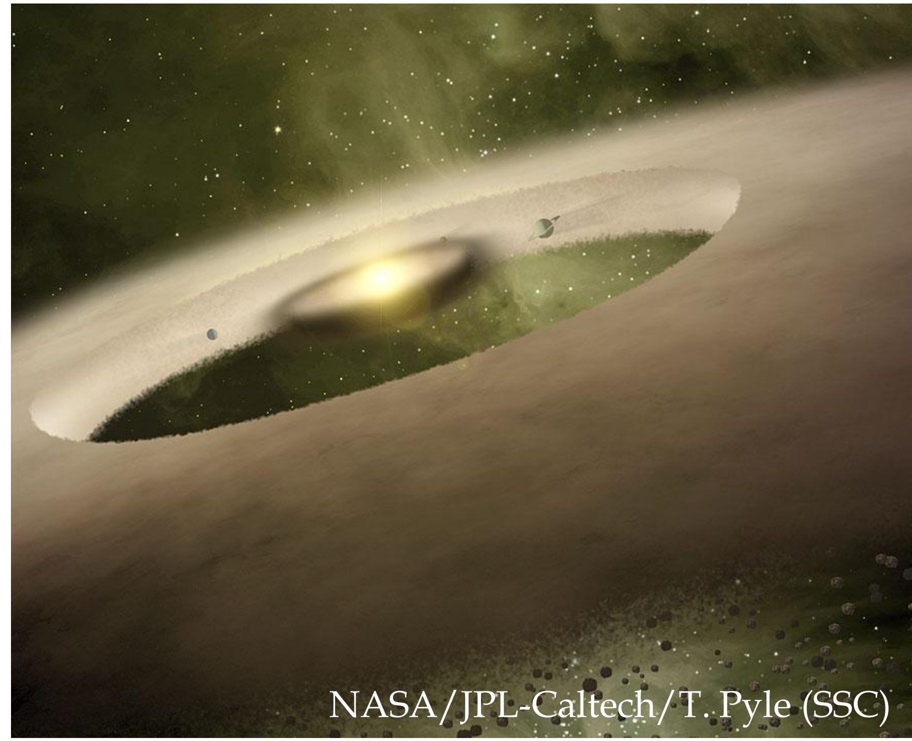
A Clue to the Formation of Transitional Disks: Mass Accretion Rates





Kyoung Hee Kim (U of Rochester)

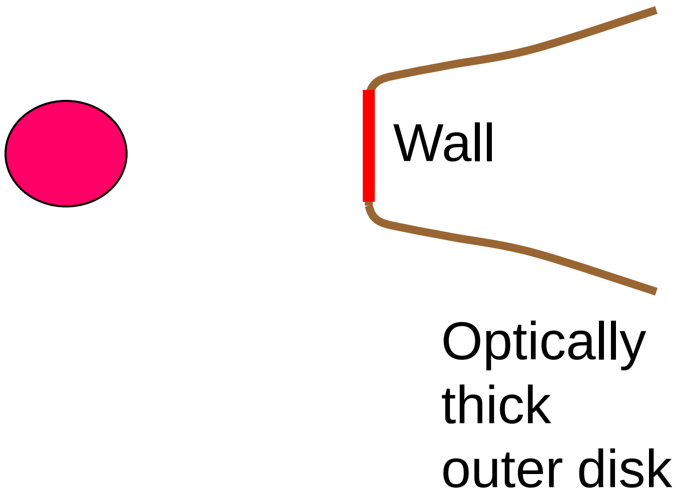
Dan Watson, Manoj P., Bill Forrest and the IRS_Disks Team

Kim et al. 2009, ApJ, 700, 1017
Kim et al. 2010, in preparation

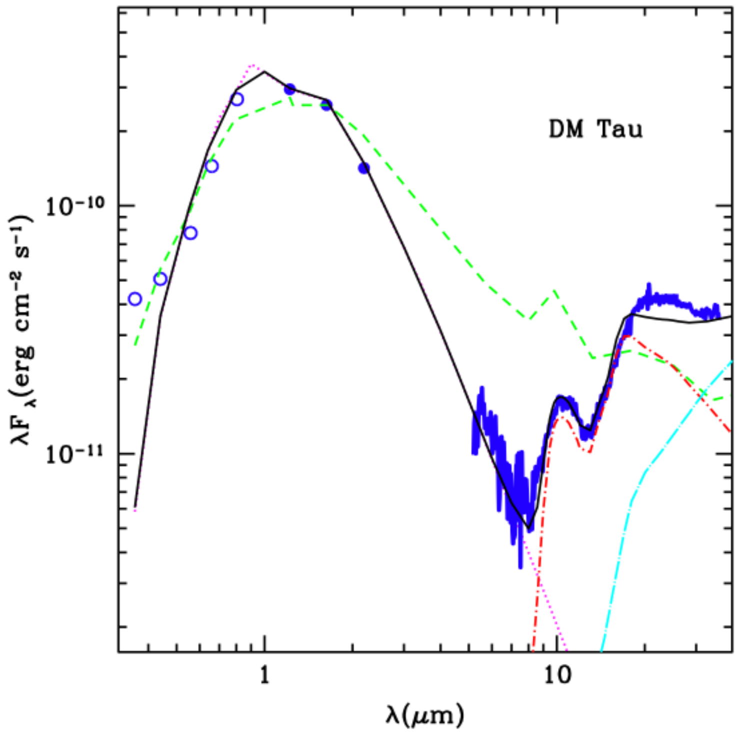
Definition of Transitional Disk

A disk around a young star, which is optically thick and gas rich, and has an AU-scale **inner disk clearing** or **radial gap** evident in its SED.

TD : Transitional Disk with **zero** excess at 5-8 μm



Archetype: **DM Tau**
Calvet et al. 2005

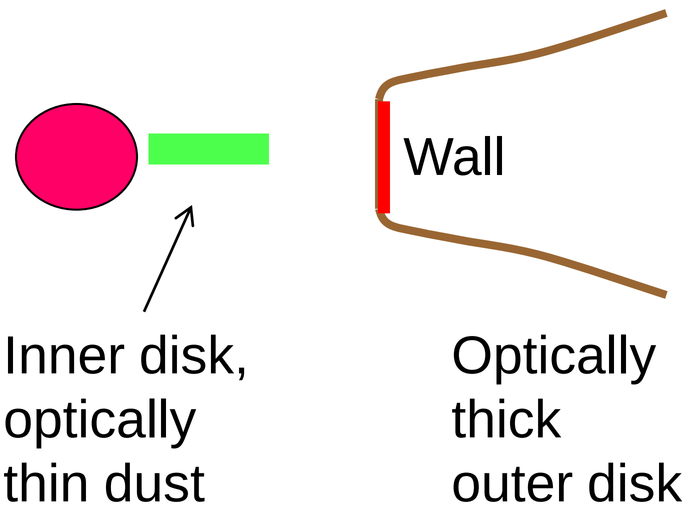


Kim et al. 2009, ApJ, 700, 1017
Kim et al. 2010, in preparation

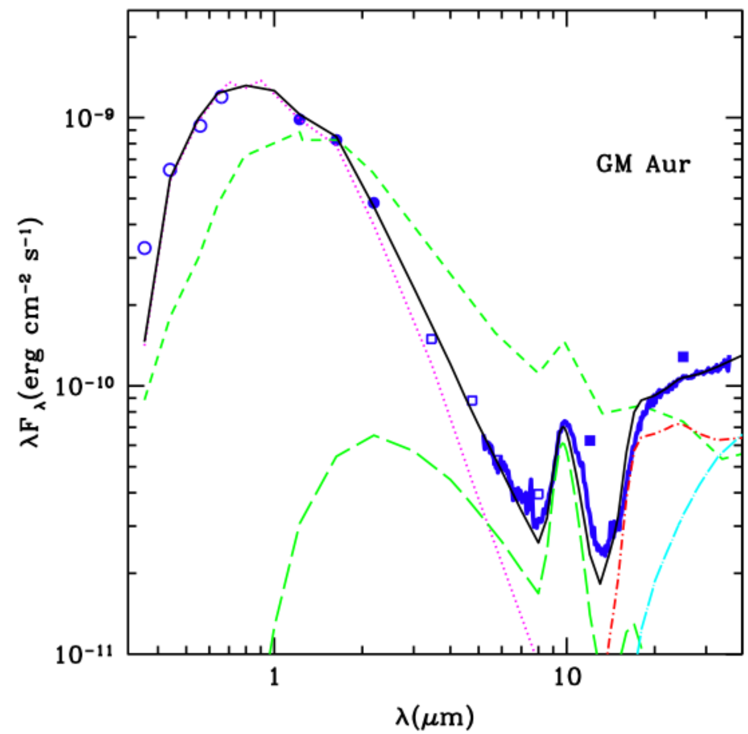
Definition of Transitional Disk

Protoplanetary disk around a young star that is optically thick and gas rich, with AU-scale **inner disk clearing** or a **radial gap** evident in the SED.

WTD : Transitional Disk with **Weak** excess at 5-8 μm



Archetype: **GM Aur**
Calvet et al. 2005

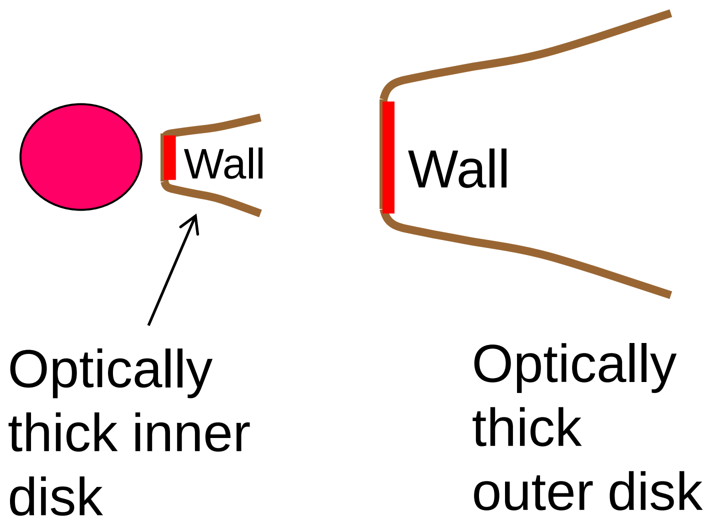


Kim et al. 2009, ApJ, 700, 1017
Kim et al. 2010, in preparation

Definition of Transitional Disk

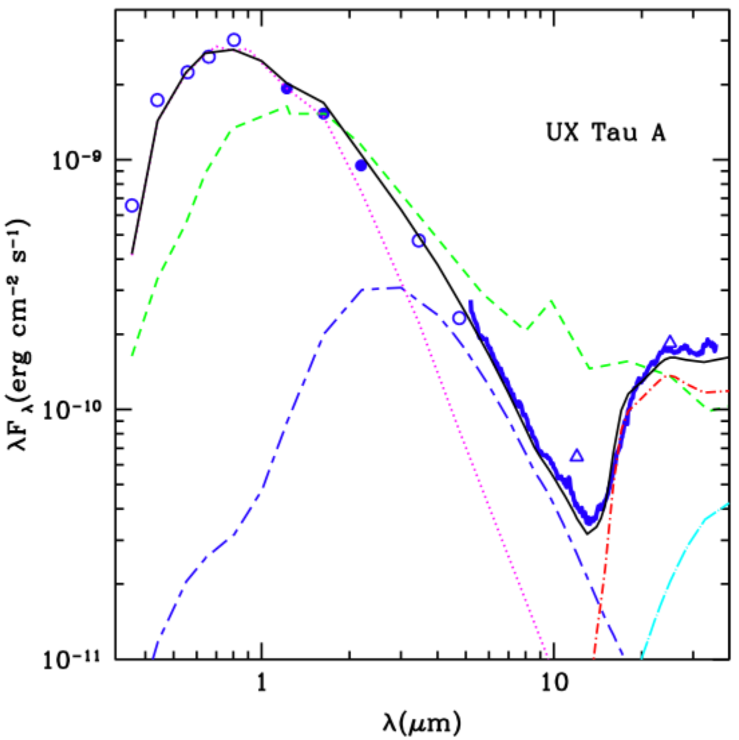
Protoplanetary disk around a young star that is optically thick and gas rich, with AU-scale **inner disk clearing** or a **radial gap** evident in the SED.

PTD : **Pre**-Transitional Disk, moderate excess at 5-8 μm



Archetype: **UX Tau A**

Espaillat et al. 2007, 2010

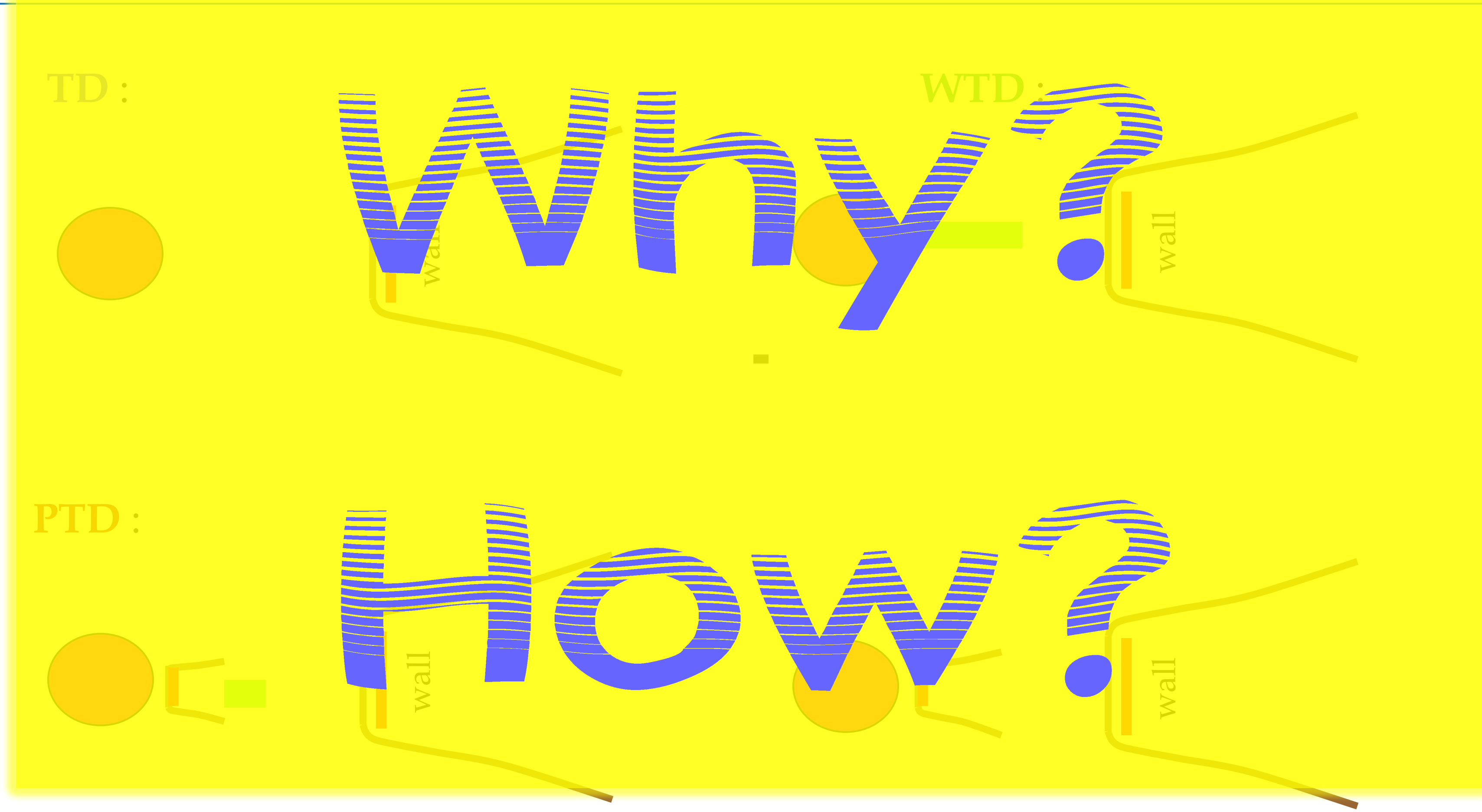


Kim et al. 2009, ApJ, 700, 1017

Kim et al. 2010, in preparation

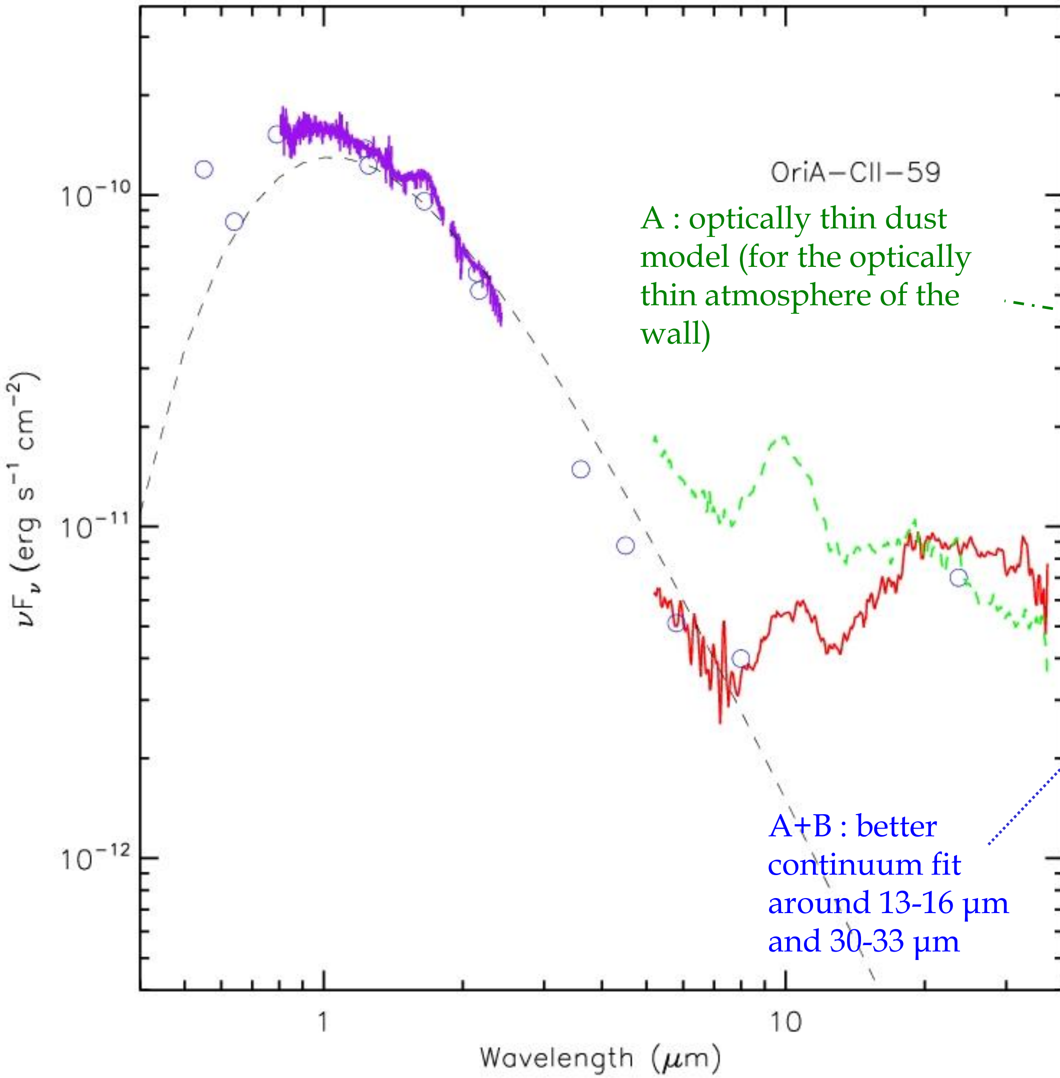
Definition of Transitional Disk

Protoplanetary disk around a young star that is optically thick and gas rich, with AU-scale inner disk clearing or a radial gap evident in the SED.

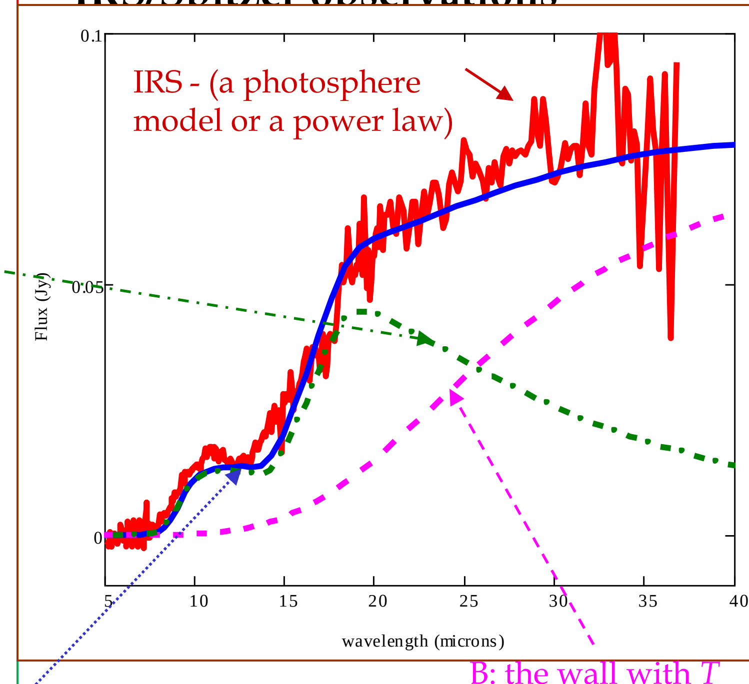


Kim et al. 2009, ApJ, 700, 1017
Kim et al. 2010, in preparation

From *Spitzer*-IRS: dimensions of gap (R_{wall})



- IRS/Spitzer observations



24(L1641), 20(ONC)

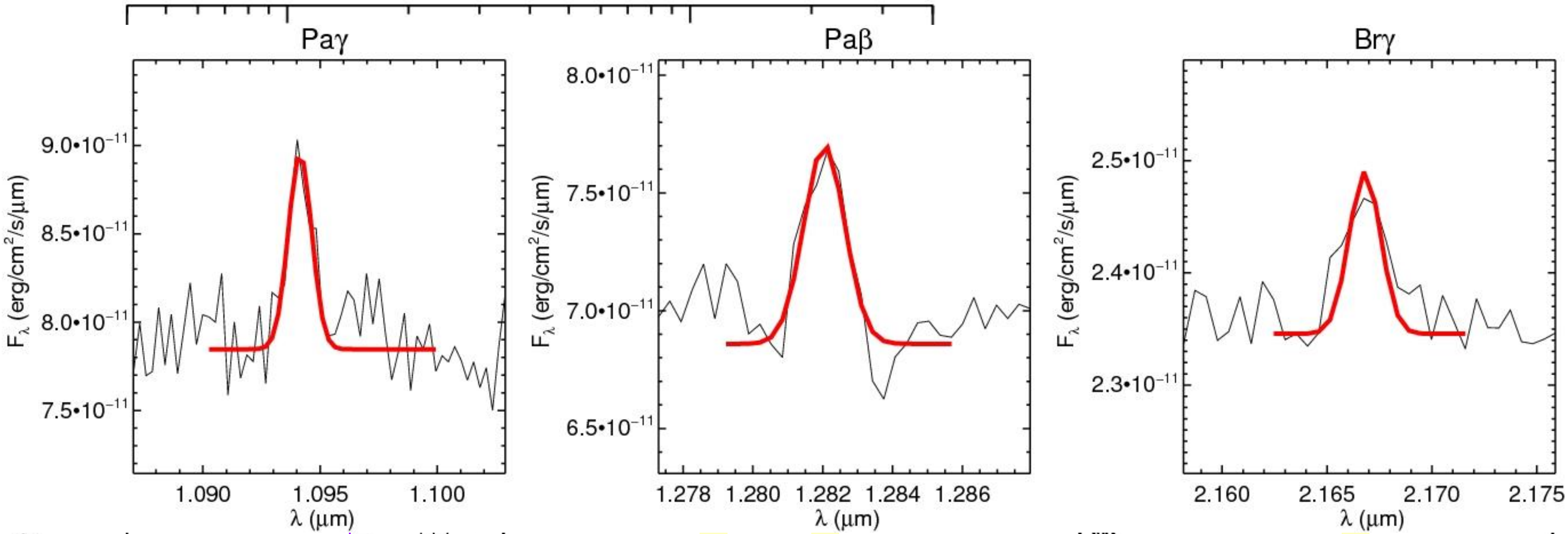
$$\frac{L_*(1-A_{UV})}{4\pi R_{wall}^2} a = \sigma T^4 \varepsilon_{IR} a$$

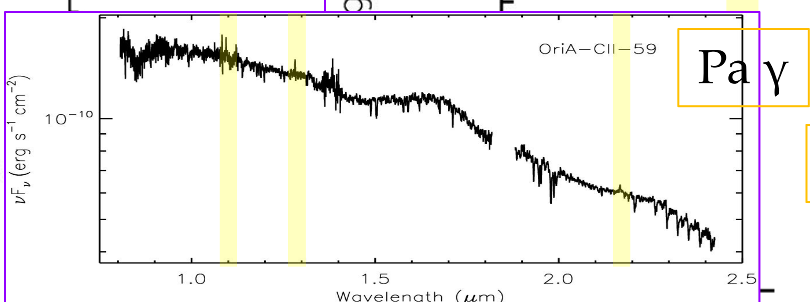
$$R_{wall} = \sqrt{\frac{L_*(1-A_{UV})}{4\pi\sigma T^4 \varepsilon_{IR}}}$$

See, Kim et al. (2009) for detail

Kim et al. 2009, ApJ, 700, 1017
Kim et al. 2010, in preparation

From IRTF-SpeX: accretion rate

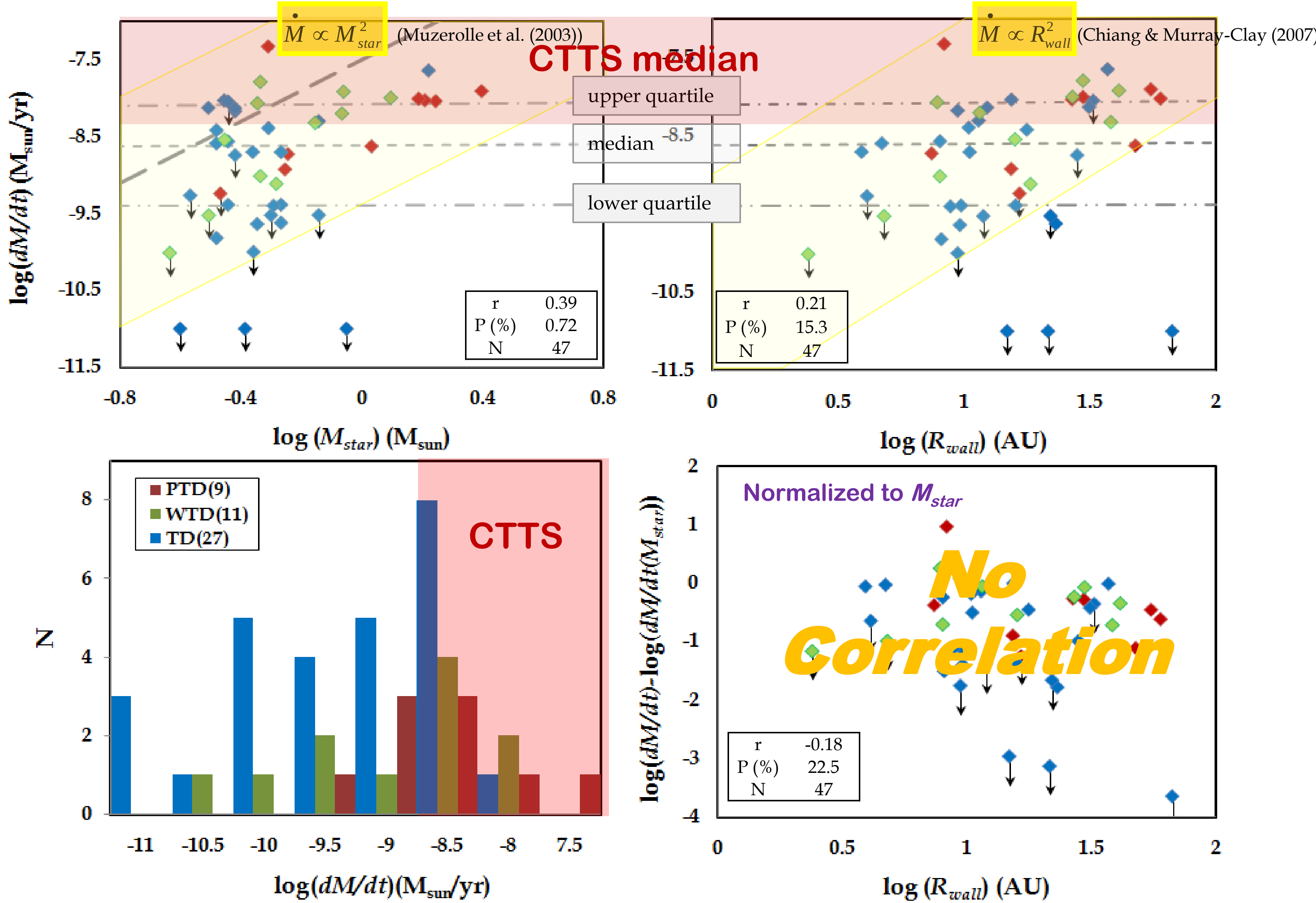




- **Mass accretion rate measurement**
  - L_{acc} from luminosity of hydrogen recombination lines
    - -Pa γ (1.094 μm) (Natta et al. (2004));
    - - Pa β (1.282 μm) (Muzerolle et al. (1998))
    - - Br γ (2.166 μm) (Muzerolle et al. (1998))

$$\dot{M}_{acc} = \frac{L_{acc} R_*}{G M_*}$$

Kim et al. 2009, ApJ, 700, 1017
Kim et al. 2010, in preparation



Kim et al. 2009, ApJ, 700, 1017

Kim et al. 2010, in preparation

Summary

1. *dM/dt* of TDs are less than *dM/dt* of PTDs; *dM/dt* of PTDs are still high (similar to or about factor of 10 lower to that of CTTS). ➔ Much too large to be explained by photoevaporative disk clearing, or by companions with masses as large as stars.

2. Trends: no correlations among *dM/dt*, R_{wall}, and L_x with normalization to M_{star}. ➔ This cannot be explained by inside-out clearing by MRI.

			Photo-	MRI	massive	giant planet formation
						Y
						Y
						Y
						Y
						Y
						Y
						Y
						Y

norm. to M_{star}

Giant Planet formation

can explain all features of transitional disks!!

3. Giant Planet formation is suitable to explain our results!

Kim et al. 2009, ApJ, 700, 1017
Kim et al. 2010, in preparation