Resolving Structure in Transition Disks: Inner Holes

A. Meredith Hughes

David J. Wilner

Harvard-Smithsonian Center for Astrophysics

Collaborators:

Nuria Calvet (U. Michigan), Paola D'Alessio (UNAM), Chunhua Qi (CfA), Mark Claussen (NRAO), Michiel Hogerheijde (Leiden Observatory), Sean Andrews (U. Hawaii IfA), Jonathan Williams (IfA)
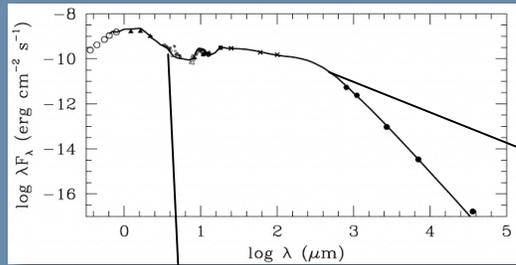
Objective:

To confirm, by means of direct imaging, the SED-based inference of an inner hole in transition disks
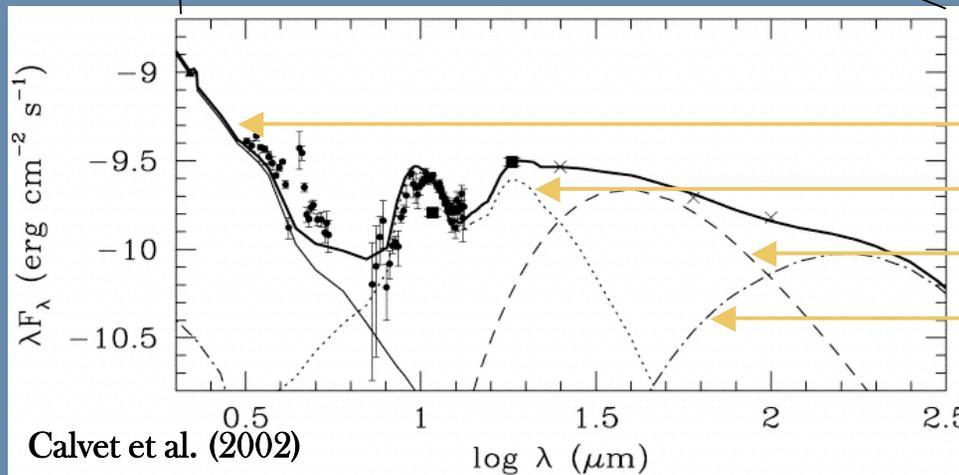
(specifically, TW Hydrae and GM Aurigae)

TW Hydrae

- Closest known T Tauri star (51 pc)
- Face-on disk of gas and dust
- SED indicates inner hole of radius 4 AU
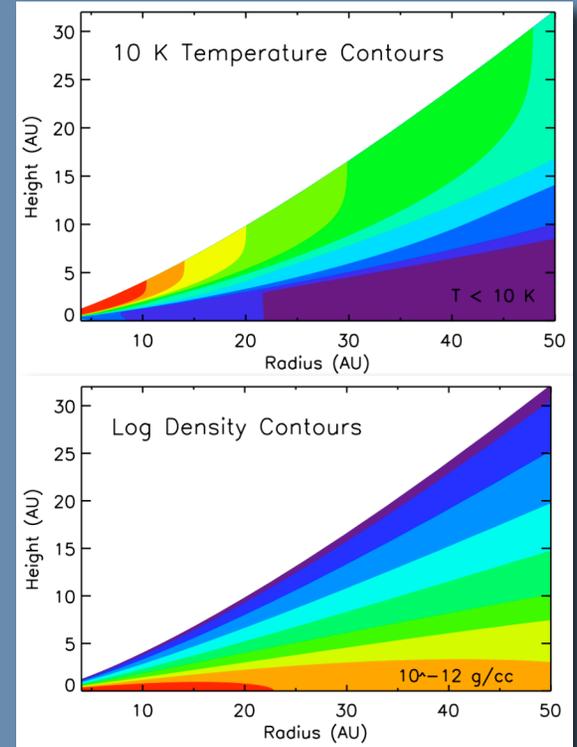
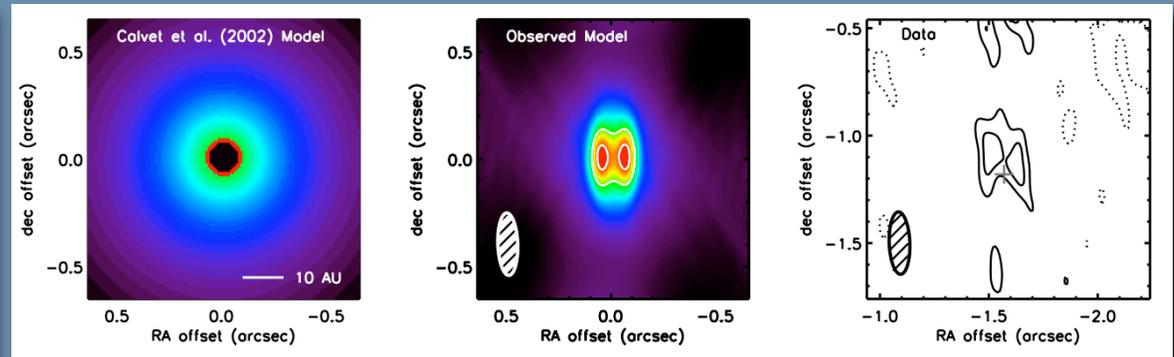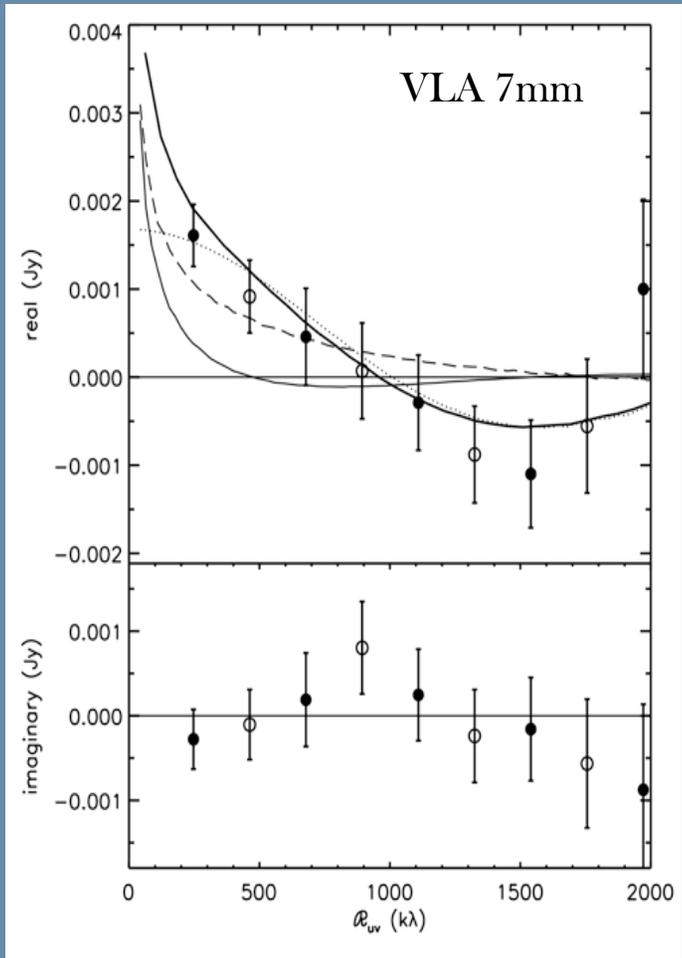SED from Calvet et al. (2002)

Zooming in on the mid-IR...

Stellar photosphere

Inner disk

Wall

Outer disk

Calvet et al. (2002)

TW Hya Observations: Disk + Wall

VLA 7mm

Calvet et al. (2002) Model   Observed Model   Data

Inner radius: 4.3 AU
Wall flux: 1.7 mJy

At this resolution/ wavelength, continuum emission is dominated by the *wall*

Hughes et al. 2007

Null Position

Flat, optically thin disk radiating in **R-J** limit:

$$R_{null}(k\lambda) = \left(\frac{1AU}{r_{hole}}\right)\left(\frac{D_{source}}{100\,pc}\right)[2618 + 1059 \times (p + q)]$$
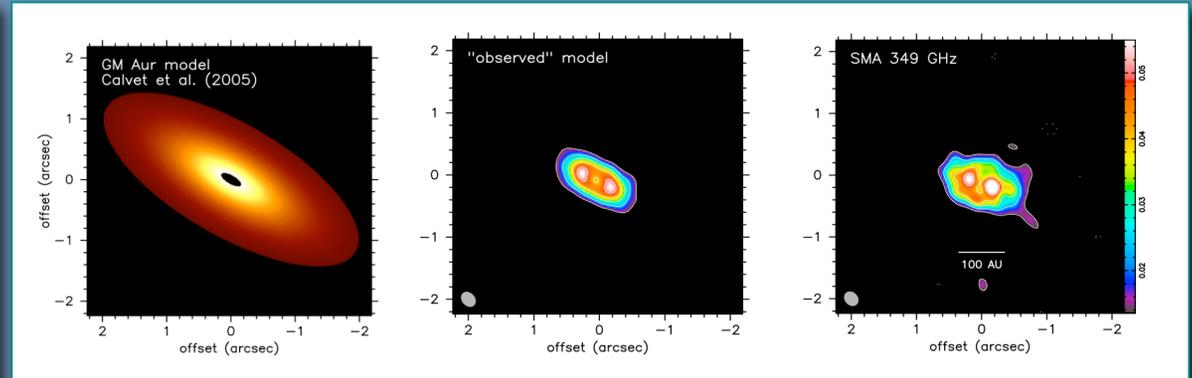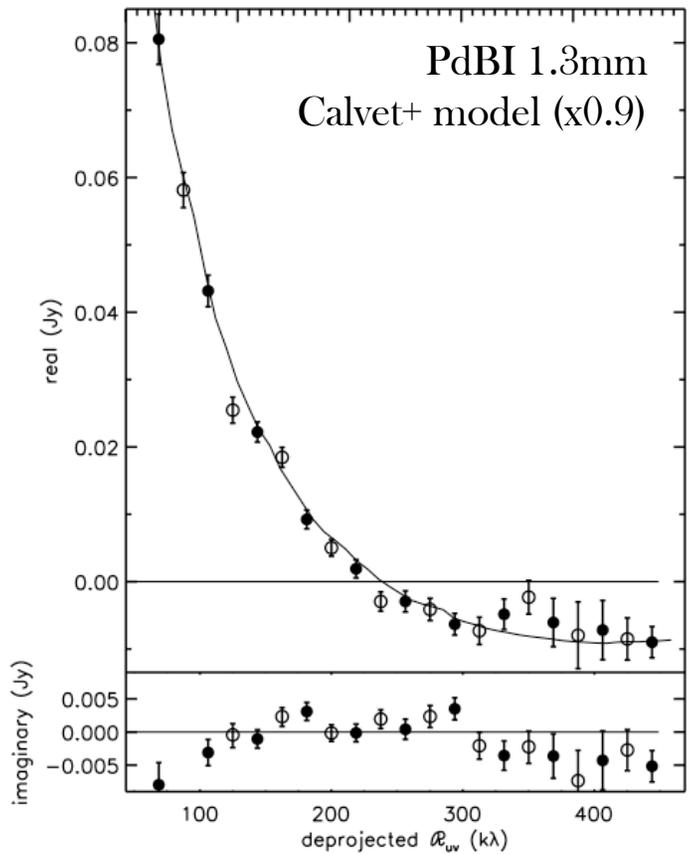
Thin wall (Bessel function):

$$R_{null}(k\lambda) = \frac{77916}{\pi^2}\left(\frac{D_{source}}{100\,pc}\right)\left(\frac{1AU}{r_{hole}}\right)$$

Given p+q and D_{source},

null position therefore depends on

1) Radius of hole

2) Wall/disk flux ratio

A Similar Case: GM Aurigae

PdBI 1.3mm
Calvet+ model (x0.9)

SMA 349 GHz

Calvet et al (2005) model Spitzer IRS spectrum and infer hole of radius 24 AU.

Observations with SMA and PdBI match model prediction well.

Summary

- We have confirmed through direct imaging the SED-based inference of inner holes in the disks of TW Hya and GM Aur

- The TW Hya 7mm emission is dominated by the directly illuminated "wall"