A Resolved Molecular Gas Disk around 49 Ceti

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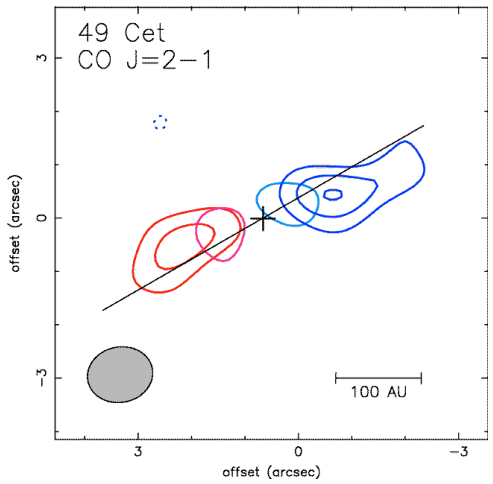
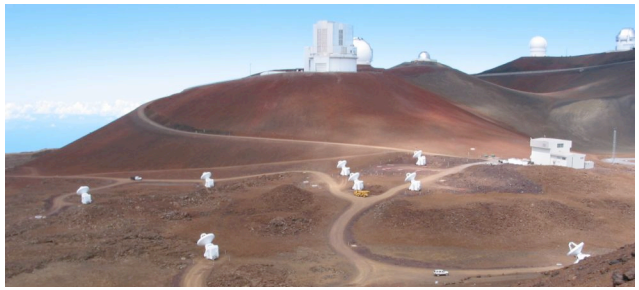
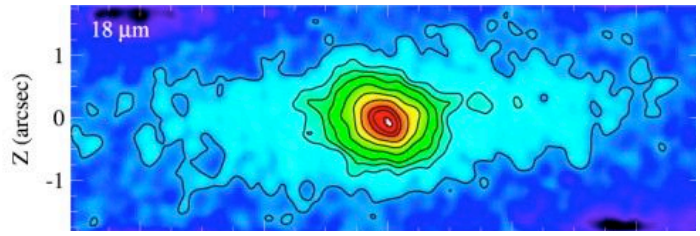




49 Ceti

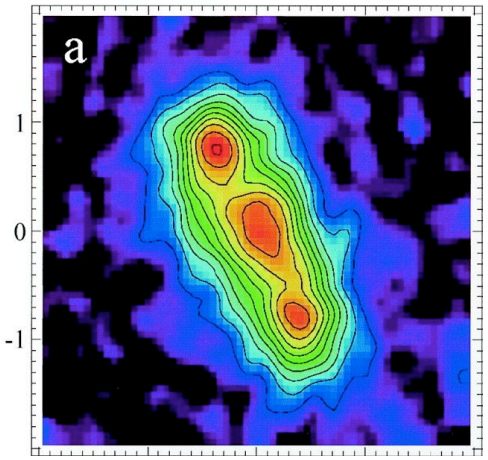
- A1V, distance 61±3 pc (Hipparcos)
- identified as "Vega-like" from IRAS PSC 60 μm vs. Bright Star Catalog (Sadakane & Nishida 1986)
- $L_{IR}/L_{*} \sim 10^{-3}$, one of only three of ~1500 main-sequence A-type stars in Bright Star Catalog (Jura et al. 1993)

β Pic



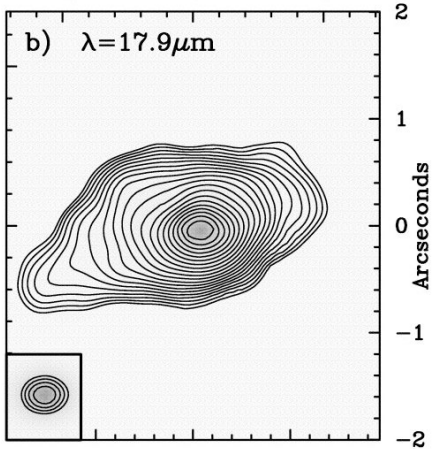
Weinberger et al. 2003

HR4796A



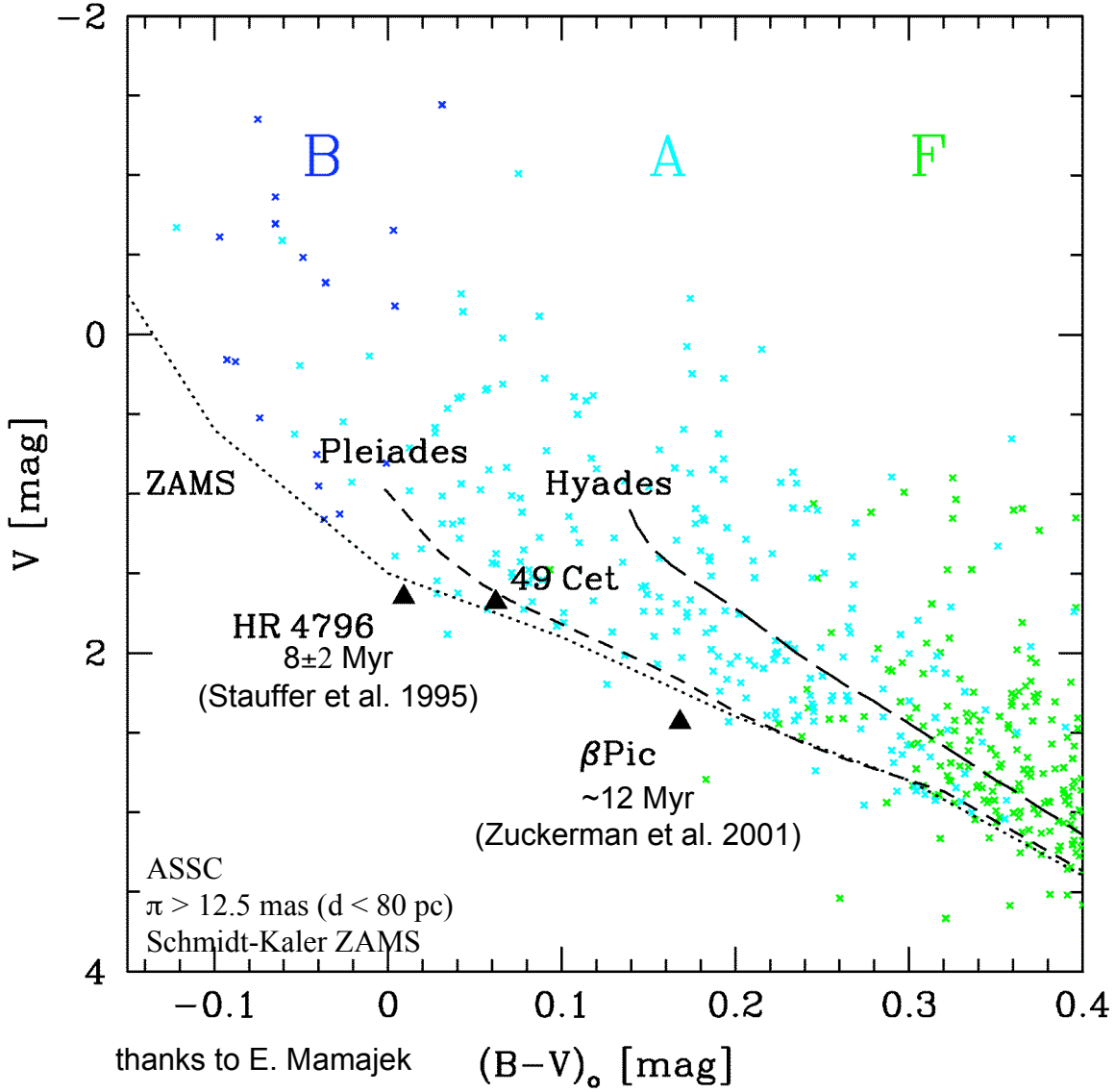
Telesco et al. 2000

49 Cet



Wahhaj et al. 2007

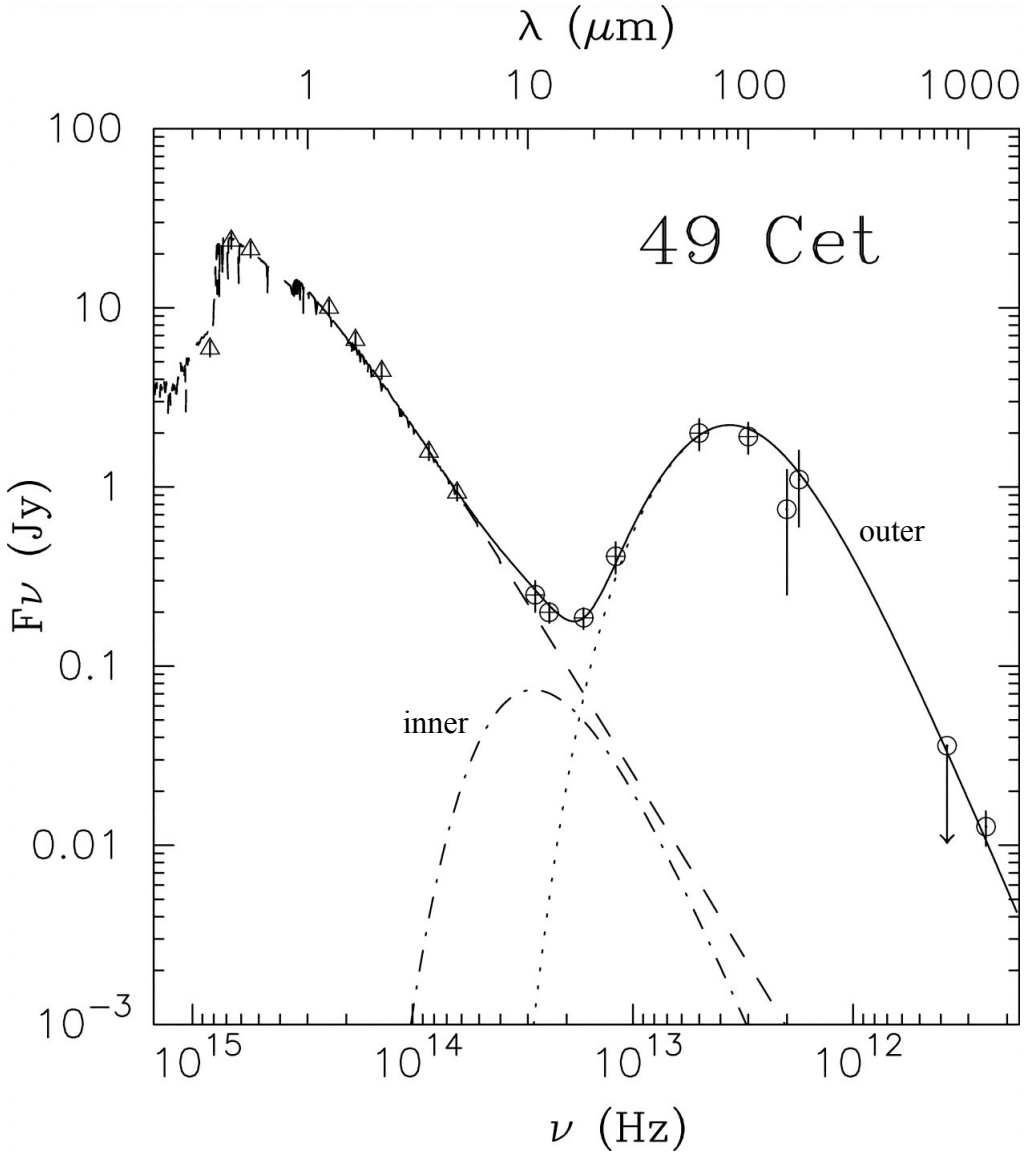
How old is 49 Ceti?

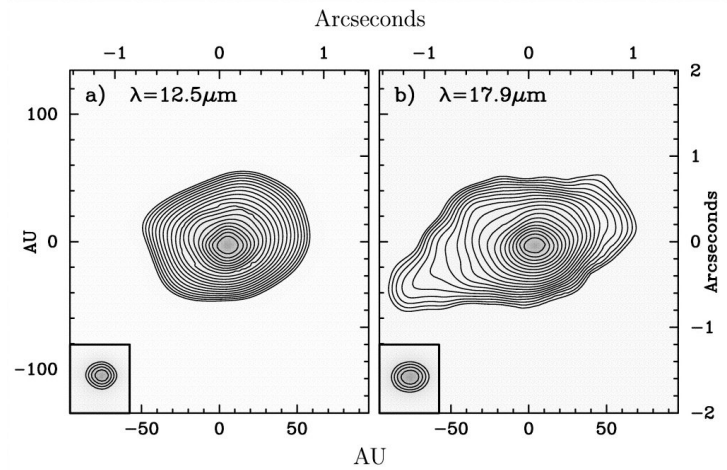


thanks to E. Mamajek

- no associated low mass stars like, e.g.
  - β Pic moving group
  - HR4796b
- HR diagram
  - low luminosity for optical color
  - 10 to 20? Myr (cf. Jura et al. 1998, Thi et al. 2001)

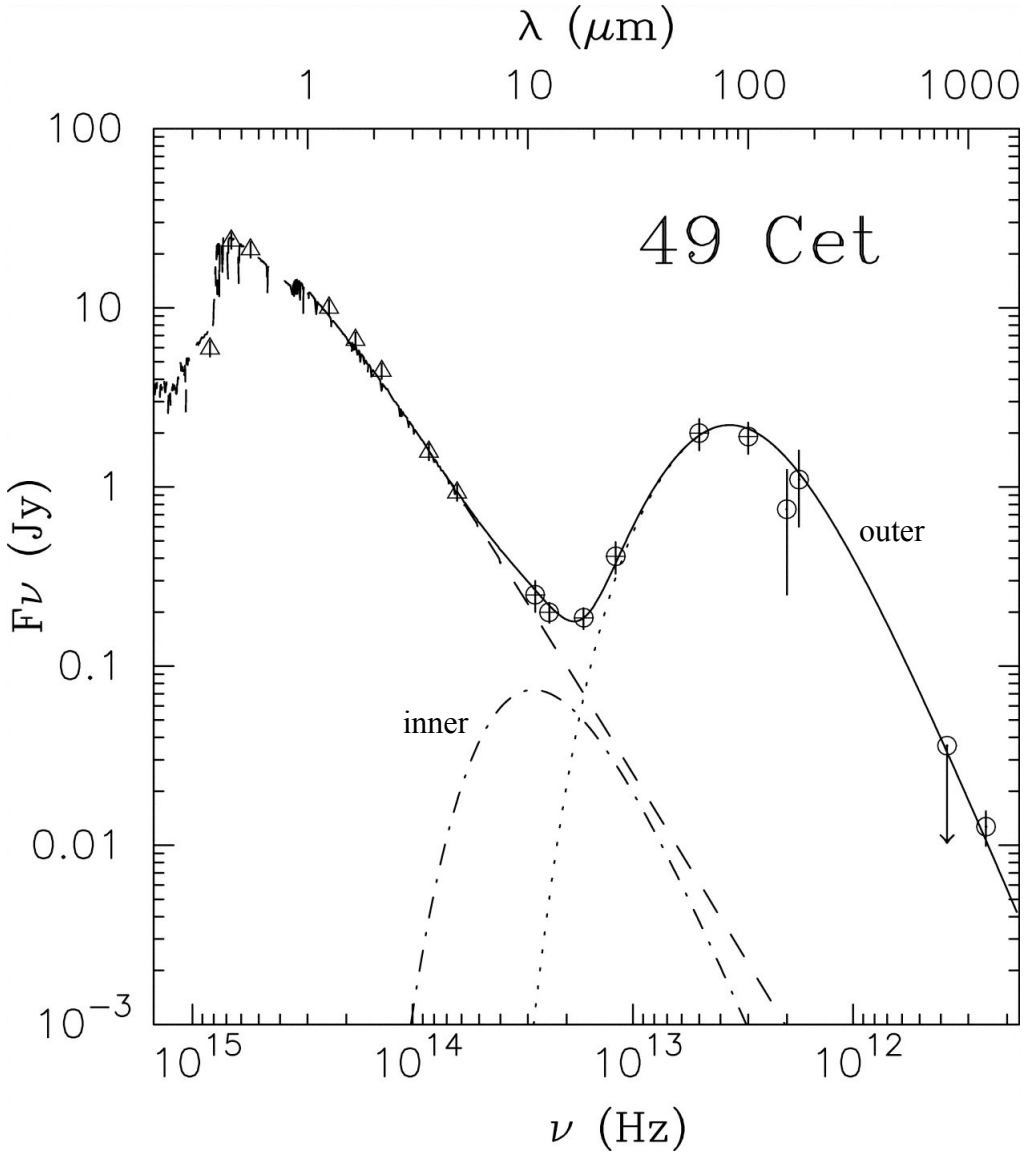
Dust Emission





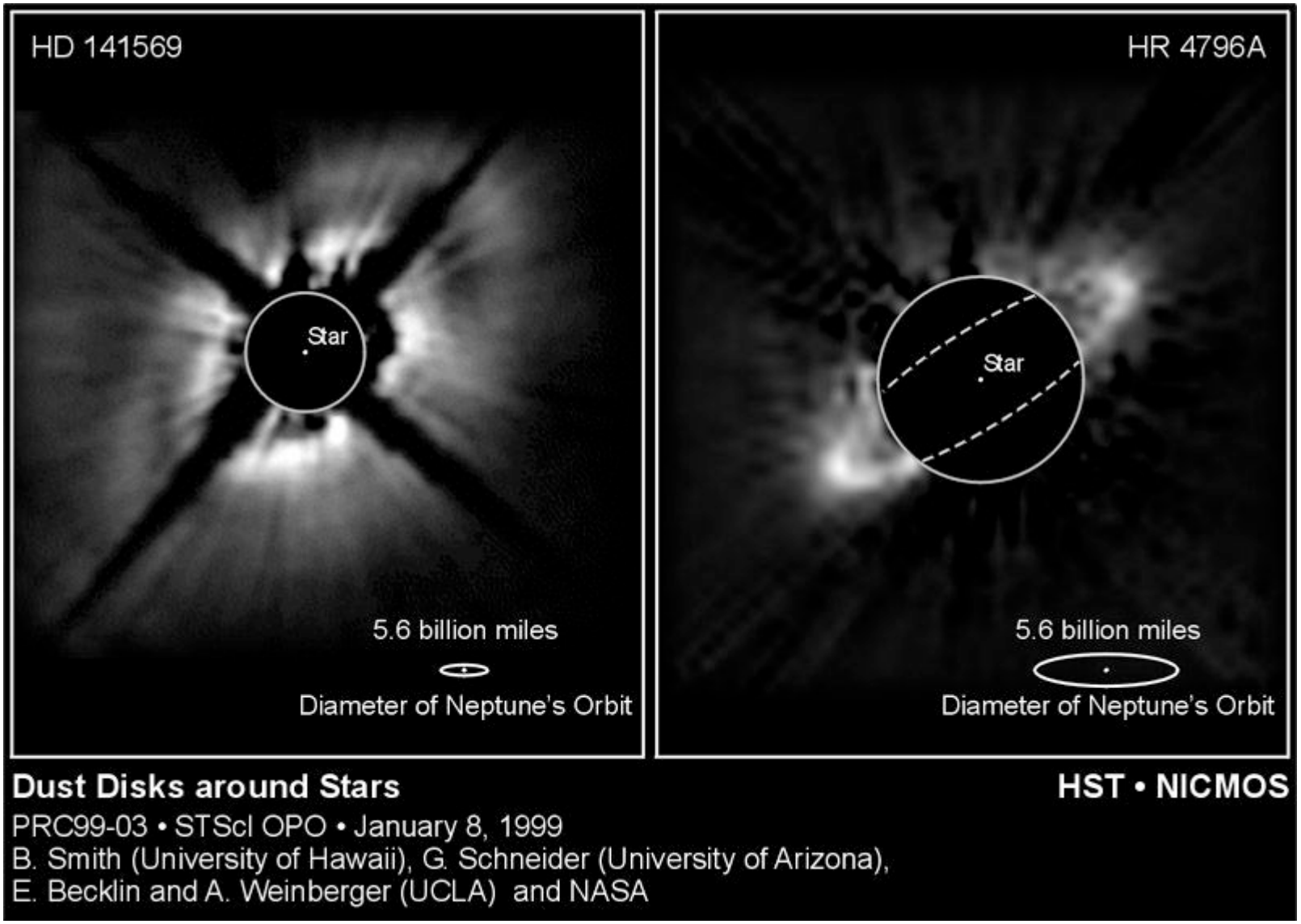
- Wahhaj et al. 2007 Bayesian analysis of resolved mid-ir & SED
  - i ~ 60, P.A. ~ 125
  - two disk components
  - inner R_{in}~35, ΔR~10 AU
  - outer R_{in}~60, ΔR~300 AU

Dust Emission

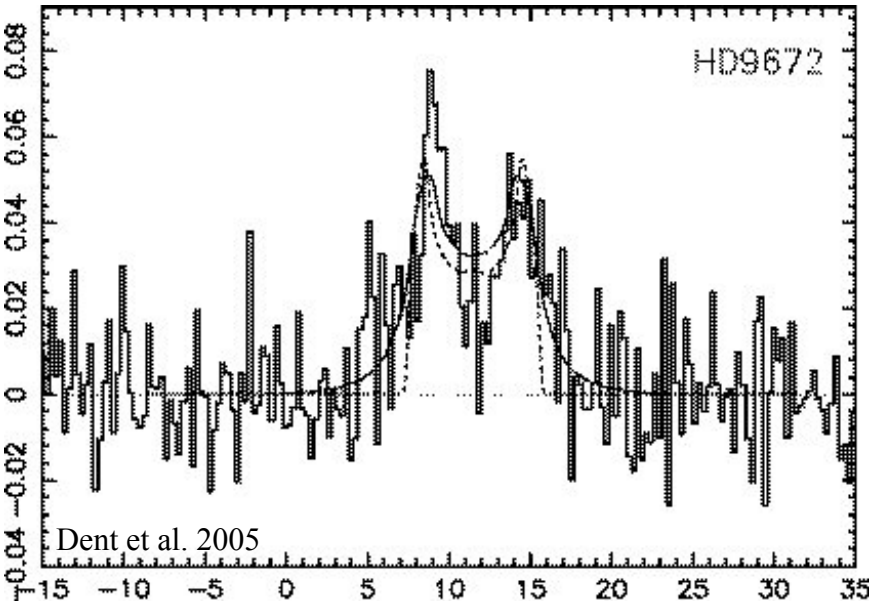


- millimeter flux ?
  - $F_{1.3mm}$ = 12.7±2.3 mJy
    Bockelee-Morvan et al. 1995
  - $F_{850\ \mu m}$ = 8.2±1.9 mJy
    Song et al. 2004
- $F_{850\ \mu m} * d^2$
  - <1% HD169142
  - 80% β Pic
  - if standard κ, then
    $M_{dust} \sim 0.1\ M_{Earth}$

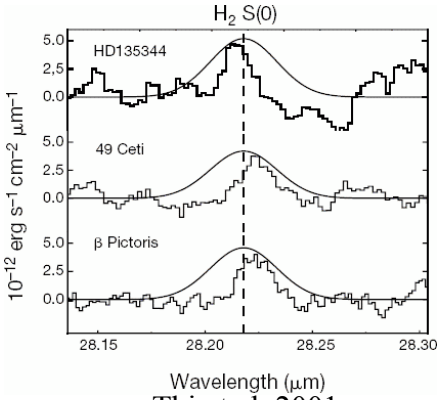
Scattered Light



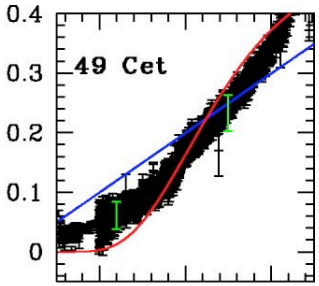
Molecular Line Emission



Dent et al. 2005



Thi et al. 2001

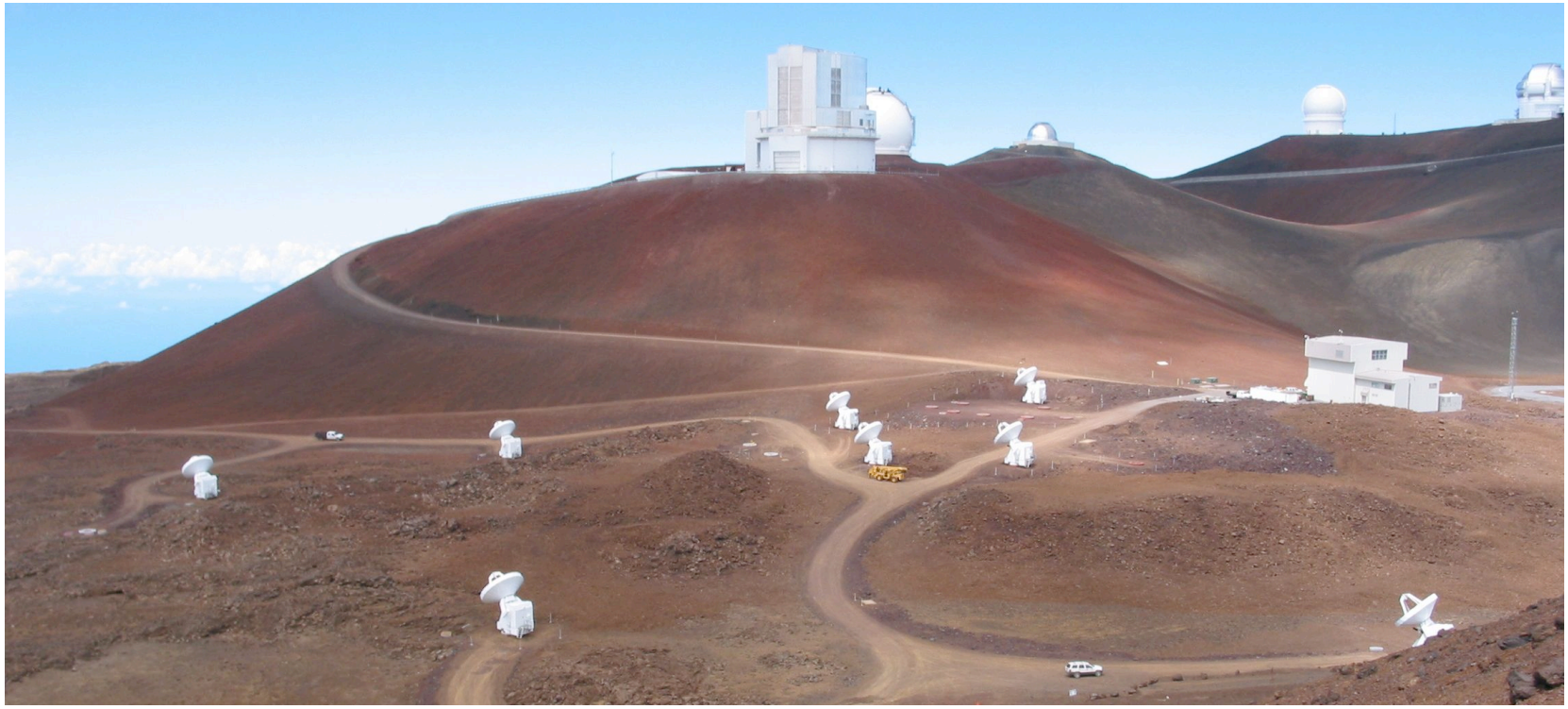


Chen et al. 2006

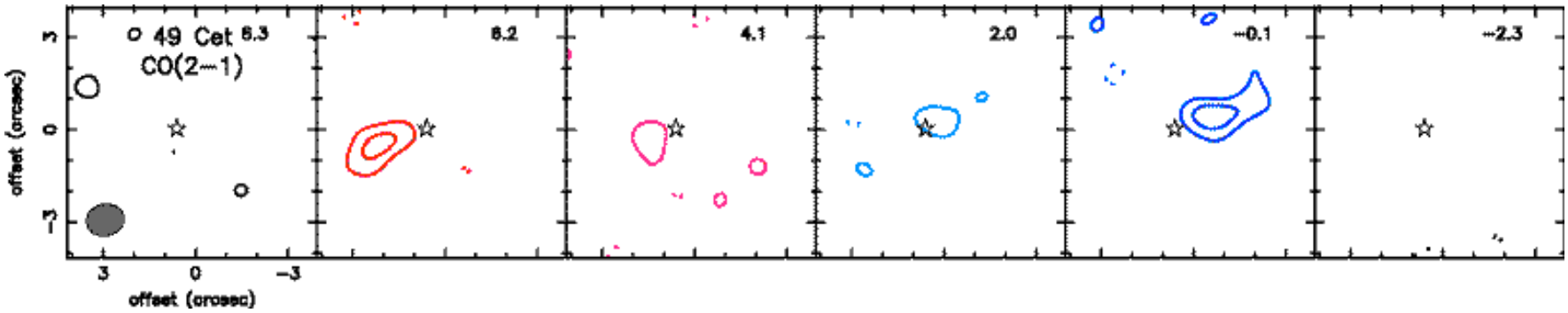
- CO J=2-1, IRAM 30m
  Zuckerman et al. 1995
  - weak
  - $M_{gas} \sim 2\ M_{earth}$
- CO J=3-2, JCMT
  Dent et al. 2005
  - models: compact
    $R_{out} \sim 17$ AU, i=16
    $R_{ring} \sim 50$ AU, i=35
- H_2 S(0) 28 μm, ISO ?
  Thi et al. 2001
  - $M_{gas} \sim 60\ M_{earth}$
  - not seen by Spitzer

SMA Observations

- CO J=2-1 (and isotopes), 1.3 mm continuum
- beam size 1.2 x 1.0 arcsec (70 x 60 AU)

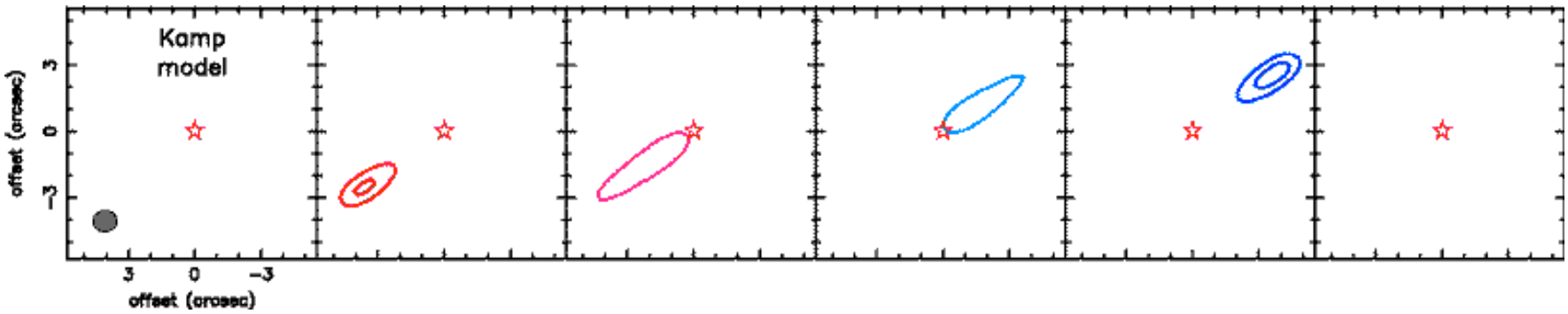


SMA Results



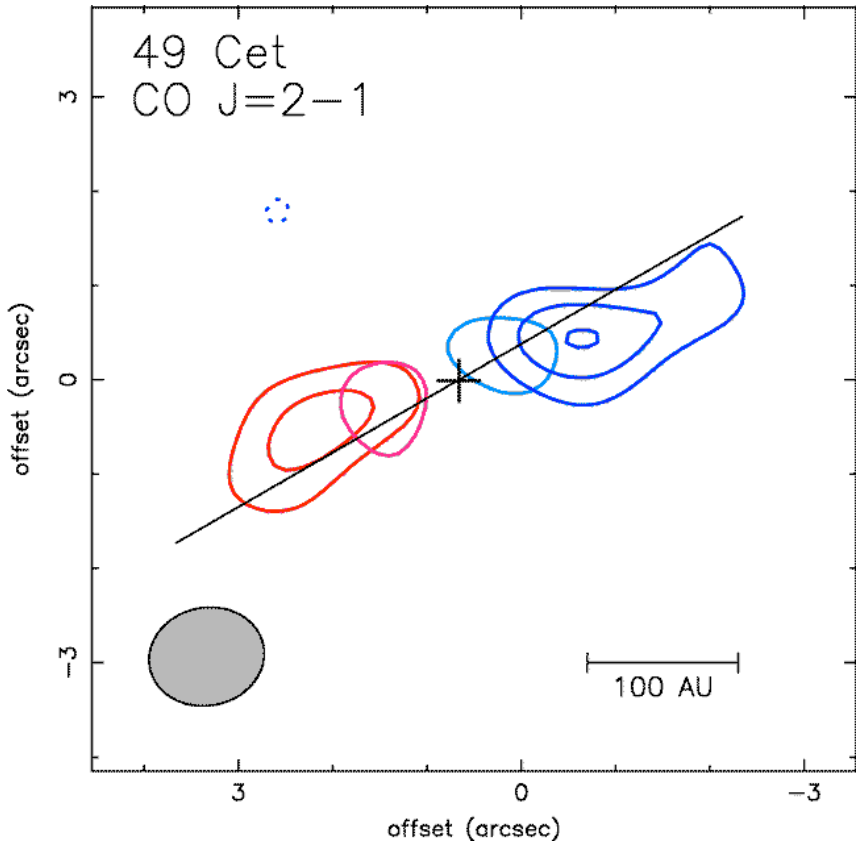
- extended CO emission, R_{out} > 120 AU
- closely aligned with mid-ir emission, high inclination
- velocity gradient consistent with rotation, M_*=2.5 $M_\odot$
- no detectable CO emission within ~ 95 AU
- 1.3mm continuum < 2.4 mJy beam^{-1} (3σ)

CO Modeling (preliminary)



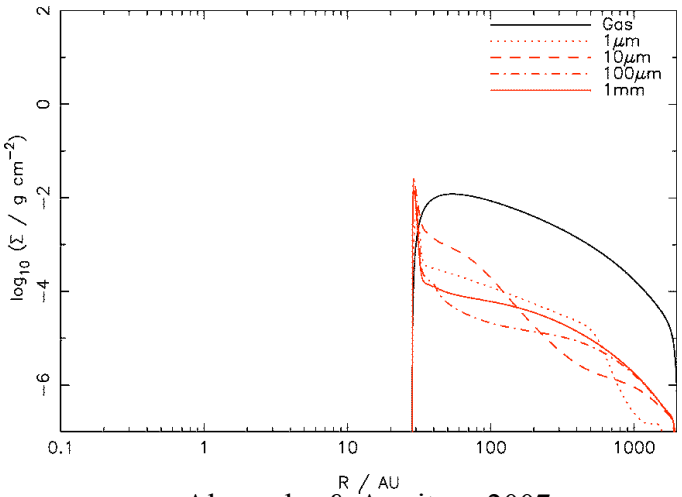
- COSTAR (Kamp & Bertoldi 2000) computes 2D chemical structure and gas temperature, RATRAN (Hogerheijde & van der Tak 2000) computes CO excitation and emission
- adopt Wahhaj et al. 2007 disk model, Keplerian rotation, vertical pressure equilibrium, normal gas:dust
  - close match to CO morphology but intensity ~ 25x too low
  - stellar uv dissociates CO in inner disk and inner edge of outer disk

A Transitional Gas Disk



Hughes, Wilner et al., in prep

- low L_{IR}/L_*, low M_{dust}, dust cleared < 20 AU (small and large grains)
- no evidence for accretion, but gaseous outer disk
- late stage photoevaporation?



Alexander & Armitage 2007

Concluding Remarks

- 49 Cet infrared properties similar to a β Pic, HR4796: optically thin, low mass, inner hole ("debris" like)
- SMA resolves CO J=2-1 emission, significant molecular gas, R > 95 AU, in outer disk
- Next: CO J=3-2 (excitation), 870 μm cont. (dust morphology)

- ALMA
  - angular resolution/sensitivity are important
  - much more detailed look at gas and dust in transitional disks
  - more systems, all spectral types, more distant
  - can we construct physical models that explain this evolutionary phase?