Brief Overview of Projects on Circumstellar Disks

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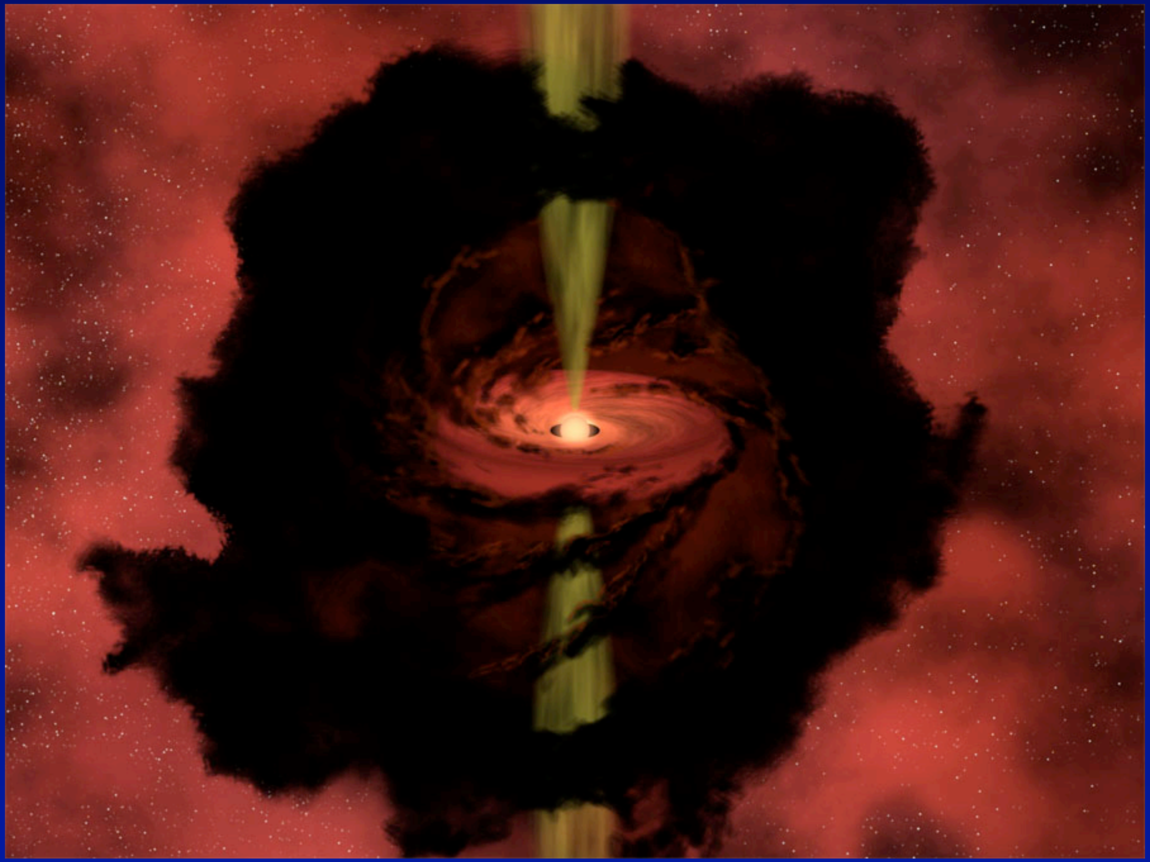
Circumstellar Disks

- The disks form as part of the collapse of a dense molecular core to form a star
- Angular momentum implies most matter falls onto disk, not star
- Disk feeds star, provides raw materials for planet building
- Star-disk system sheds angular momentum in bipolar jets

The Artist's Conception

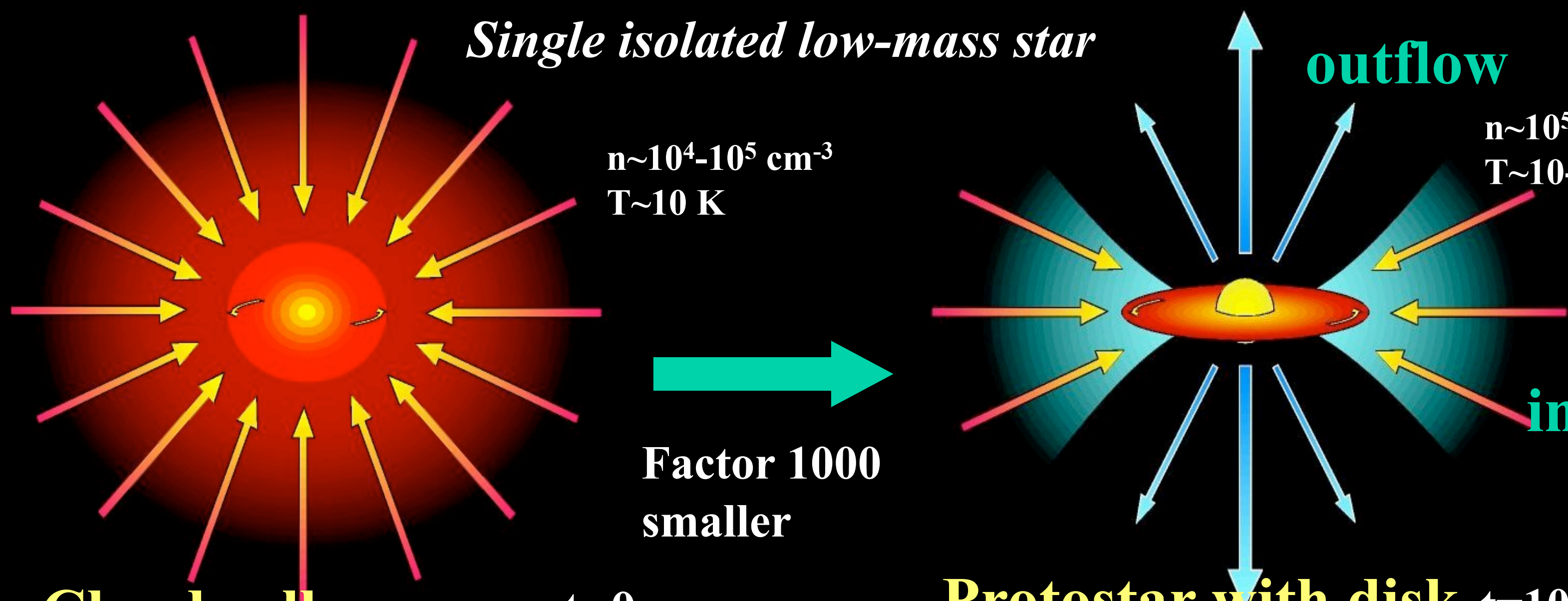


R . Hurt

Standard Evolutionary Scenario

Single isolated low-mass star

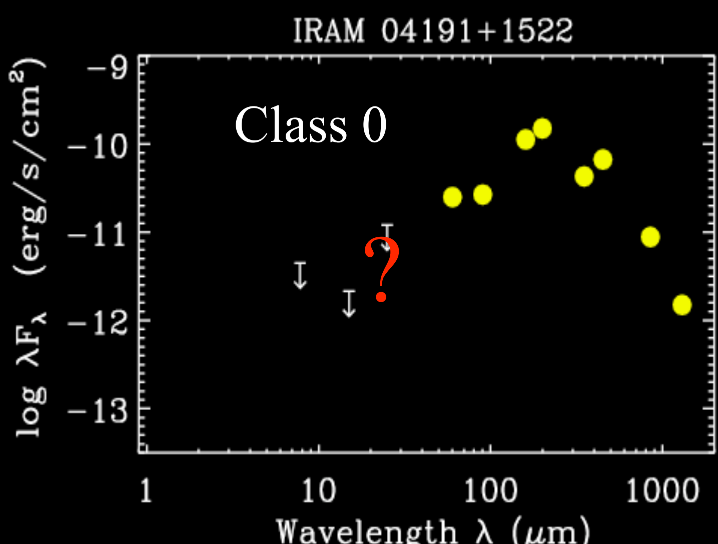
Stages

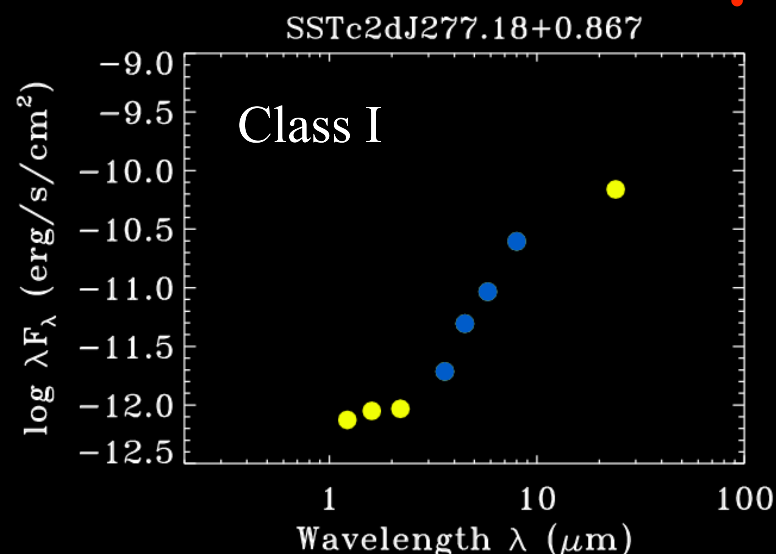


Cloud collapse t=0

Protostar with disk t=10^5 yr ?

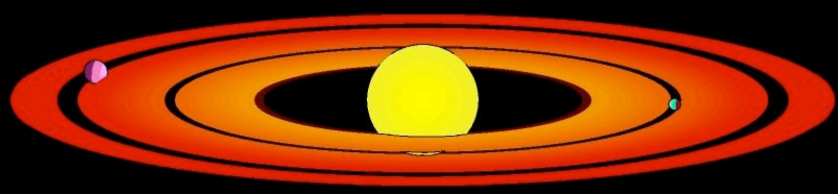
Classes

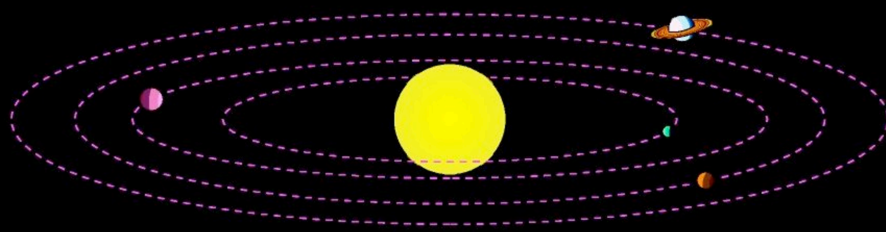




Between stages! Note axis change!

Scenario for star- and planet formation





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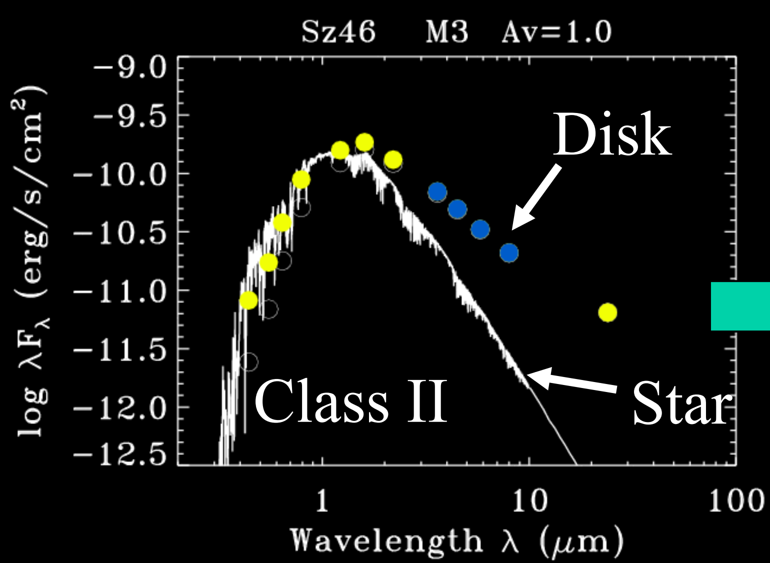
Formation planets $t=10^6$-10^7 yr

Solar system $t>10^8$ yr (?)



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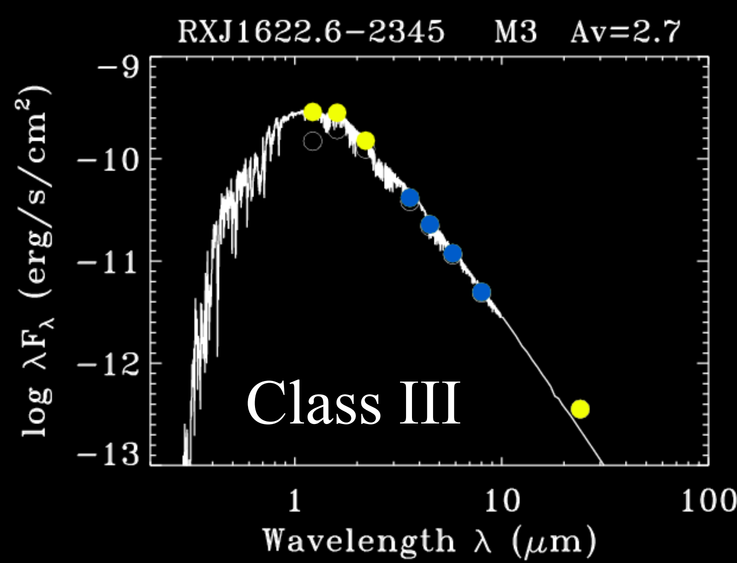
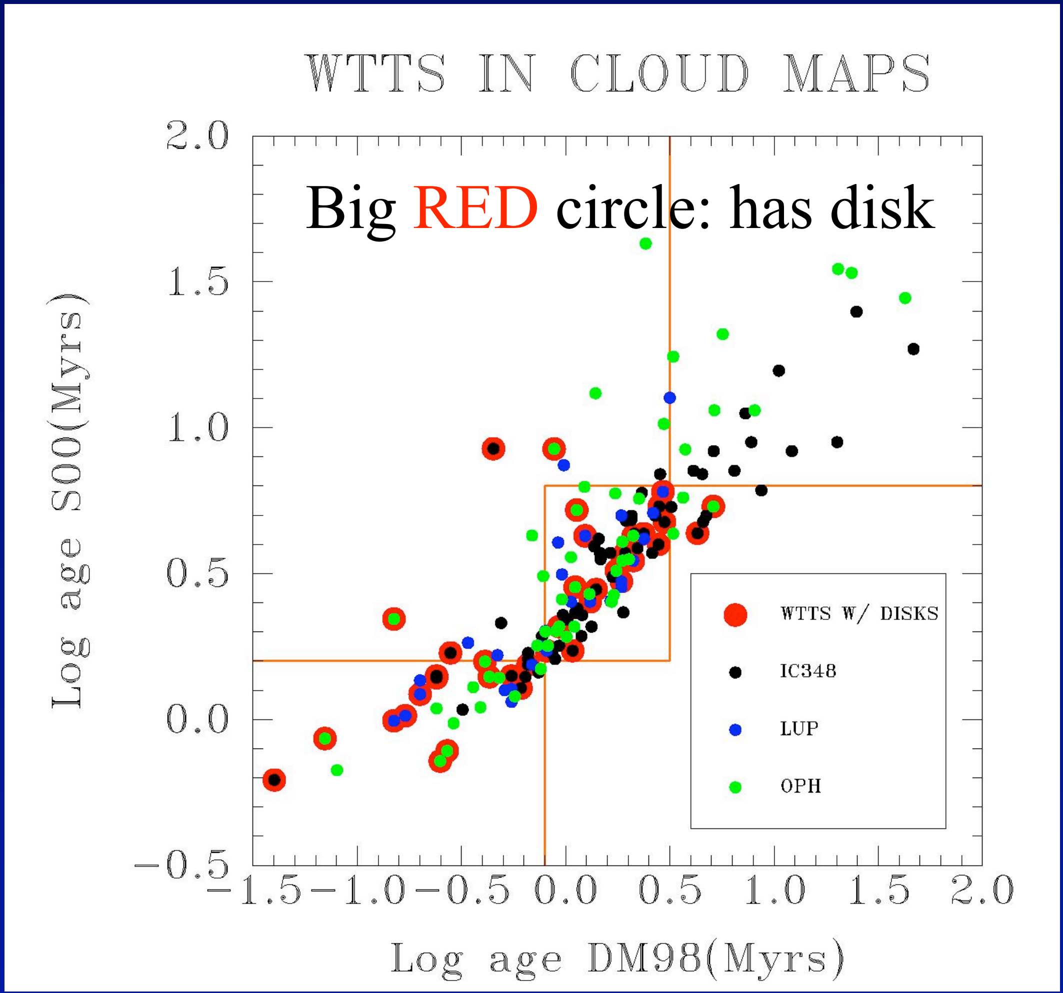


Studies of disks

- Survey of star forming regions, known disks with Spitzer Space Telescope
  - c2d (Evans et al.) and IRS team (Joel Green)
  - Constrain timescales
  - Study structure and composition
- Studies of gas phase species in disks
  - IR spectroscopy from ground (Lacy, Jaffe, Salyk)
- Far-infrared spectroscopy of disks with Herschel Space Telescope
  - Dust, Ice, Gas In Time (DIGIT) Key project

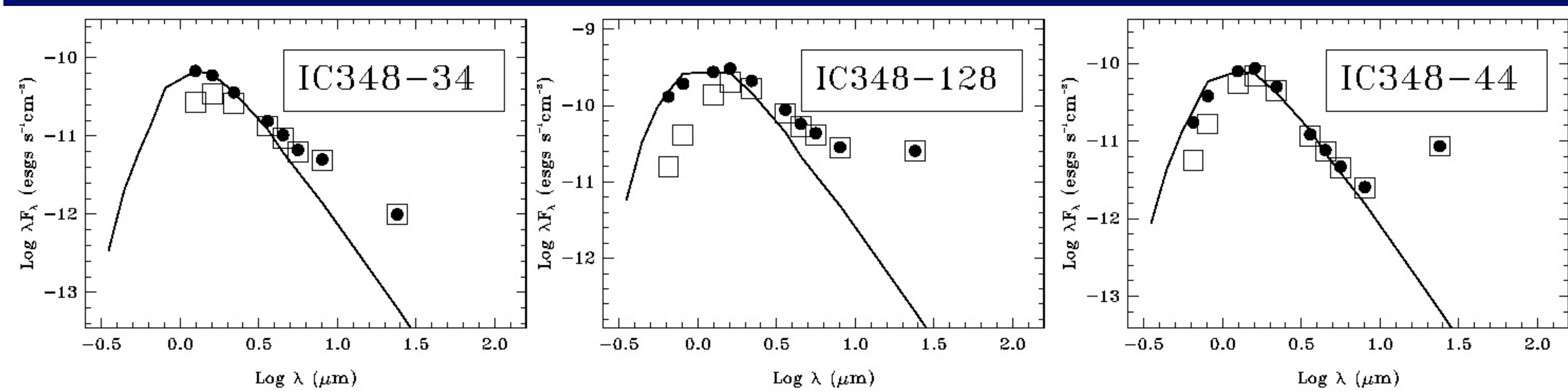
Disk Timescales



Some wTTs do have disks
Not seen before
But only the young ones
(age < 3 to 6 Myr)
Ages are uncertain due to models
Half the young ones lack disks (even at 0.8 to 1.5 Myr)
Time is NOT the only variable. Think of half-life.

Padgett et al., 2006; Cieza et al., 2006

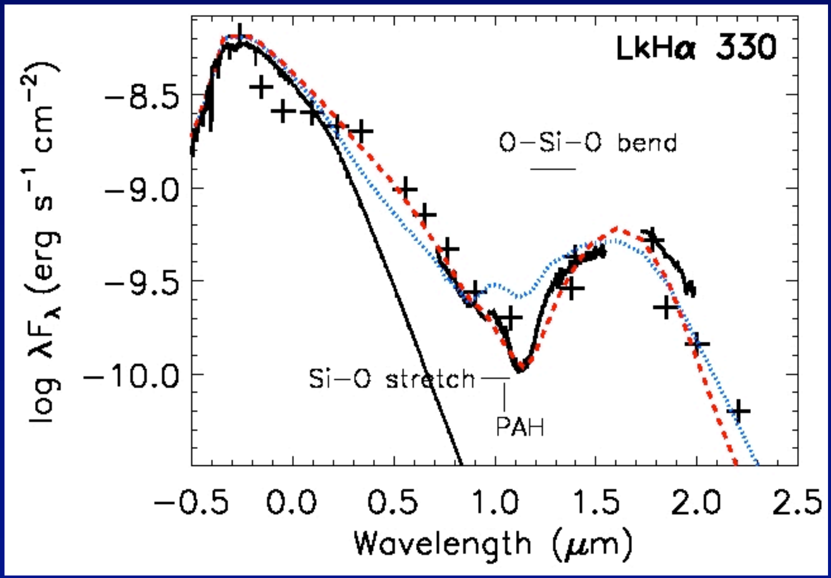
Diversity in disk SEDs



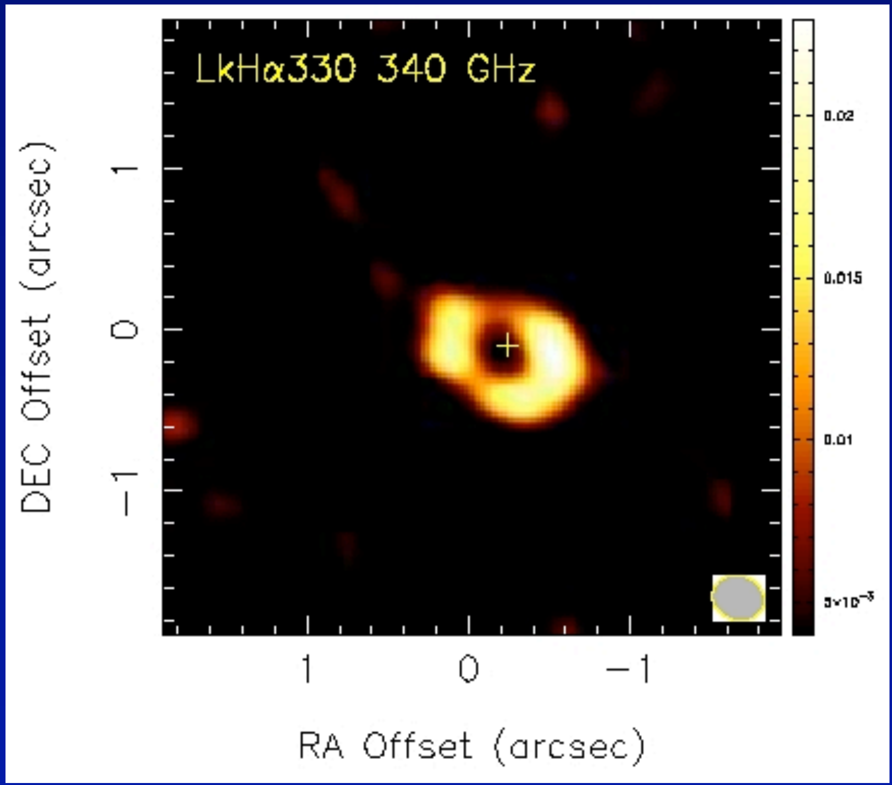
Traditional III | III, then flat | III, then rising

Some excesses start only at long wavelengths but are substantial: We call these cold disks. The dust is mostly colder, which means that it is farther from the heating source (the star).

A Case Study LkHα330



Brown et al. 2007b



Some excess at short λ, but much more beyond 20 μm. Blue line has no gap, red has gap.
Implies large gap; models predict about 40 AU radius. Submm interferometer should show ring.
J. Brown et al. 2007

Speculation

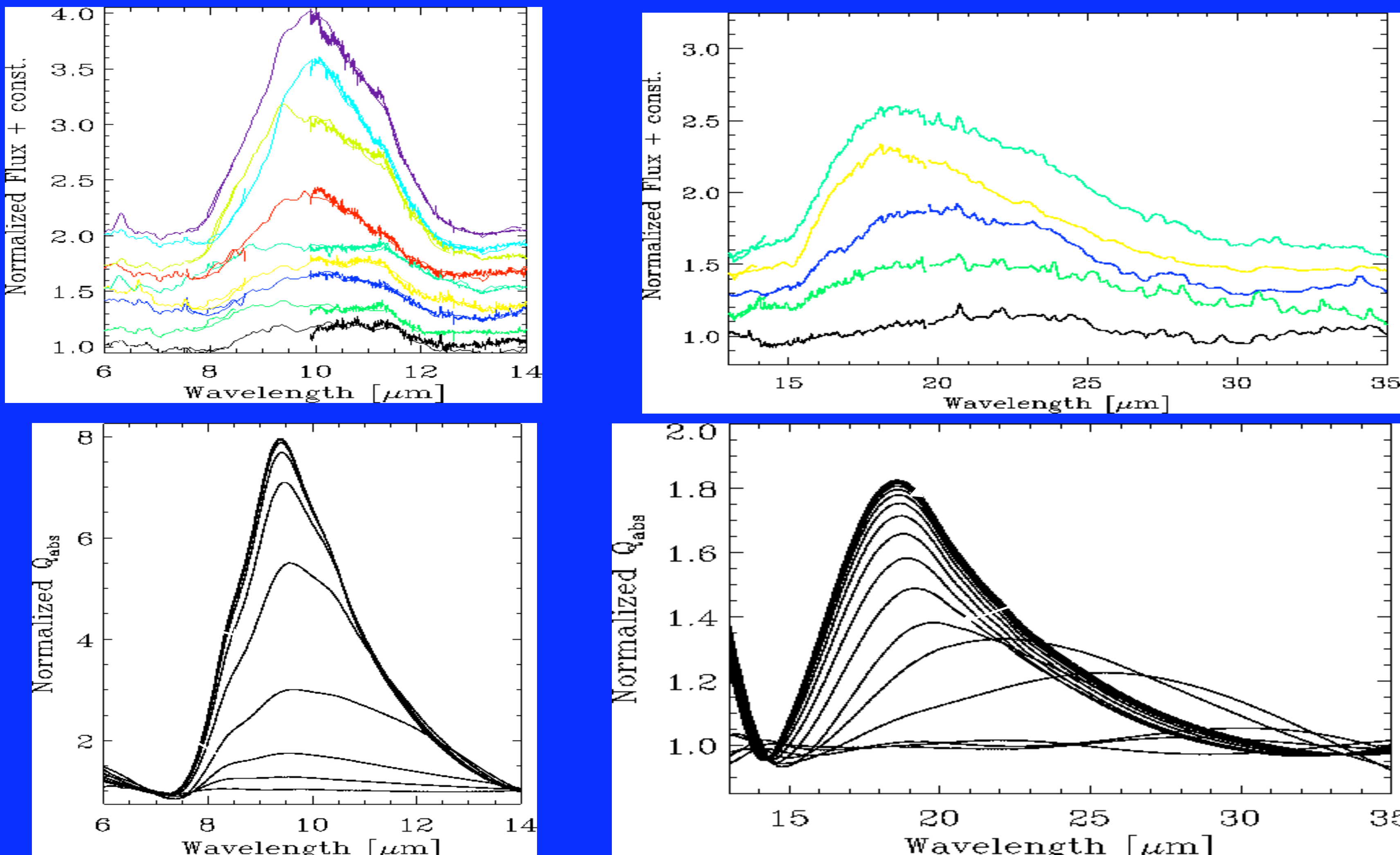
- Diversity in disk timescales, evolutionary paths may translate into diversity of planetary systems
- This diversity may in turn be related to the fact that accretion onto the star seems to be episodic, rather than steady
  - Studies by Mike Dunham indicate that this seems to be necessary to explain the data

Dust Growth and Composition

- Infrared Spectroscopy of hundreds of disks
  - IRS on Spitzer
  - Shape of 10, 20 micron silicate feature reveals growth of dust grains
  - Features indicate transition from amorphous to crystalline grains

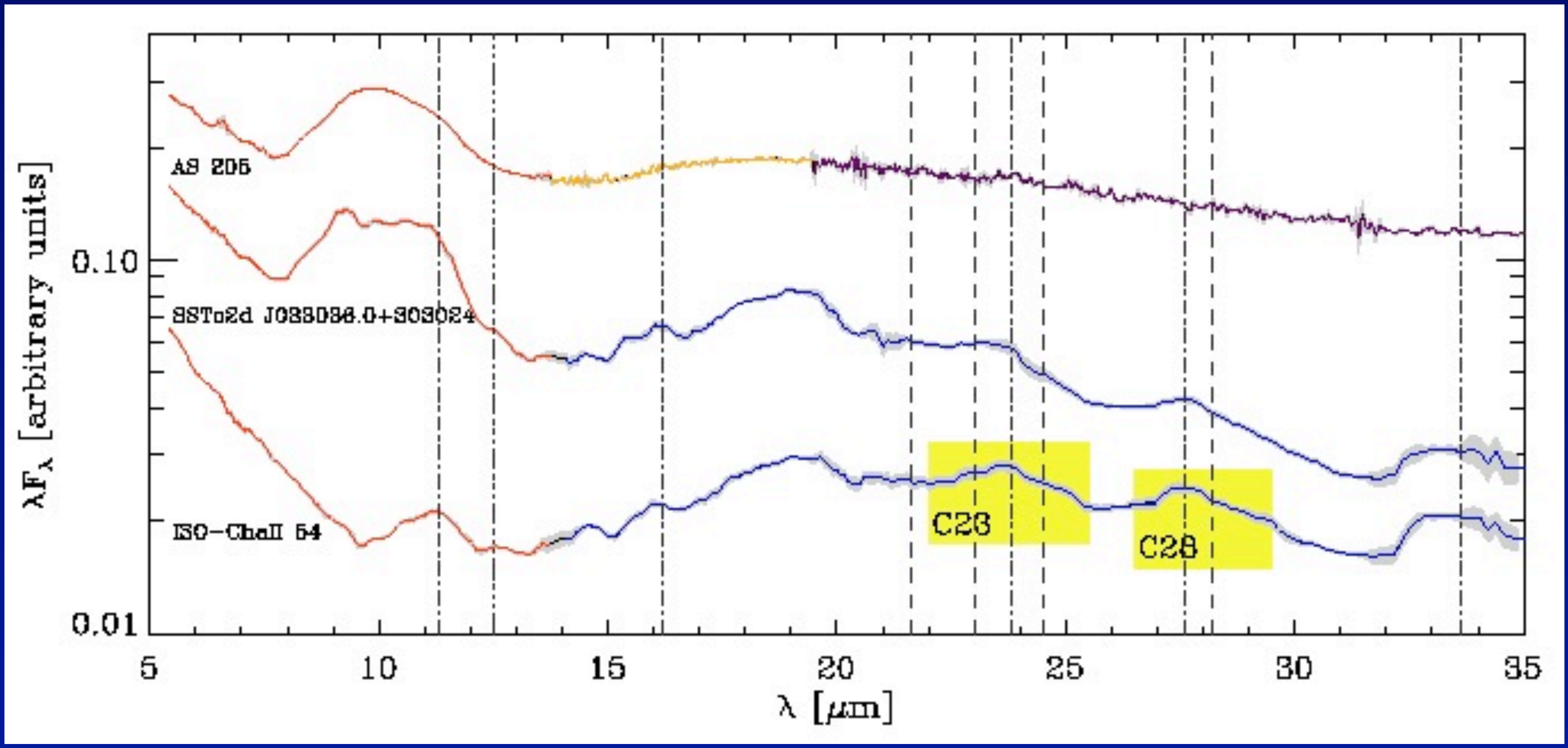
Grain Growth in Disks

10 μm band **20 μm band**



Kessler-Silacci et al., 2006

Composition of dust in disks



J.Oloffson et al. in press
over 100 stars in sample

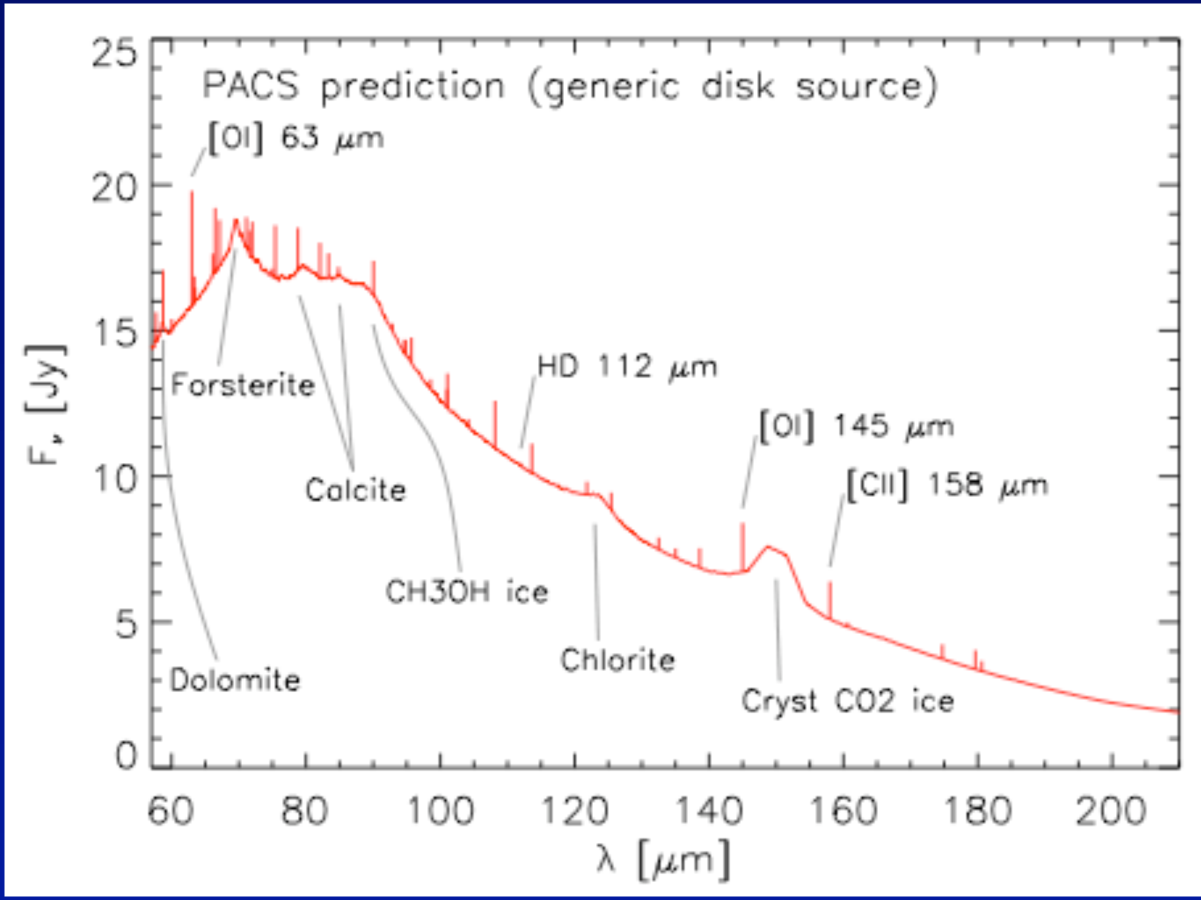
A Key Project with Herschel

A 3.5-m Telescope
Passively cooled
Launched May 14, 2009
Ariane 5 from French Guiana
At L2 point
Focus on far-infrared and submillimeter
PACS: 57- 210 microns photometry and spectroscopy
R ~ 1500
Two other instruments

Evolution of Dust, Ice, Gas

- Follow the three components from embedded through disk phases
  - Range of masses, luminosities
- Sample from Spitzer programs and others
  - Embedded objects with disks
  - Revealed disks: cTTS, wTTS, cold disks
  - PACS spectroscopy and photometry
  - Atomic, molecular lines, ice/dust features

Expected Features



Model disk around He Ae star, 30 L_{sun}, at 120 pc.
Ice and dust features are illustrative

Summary

- Observations of circumstellar disks
  - Can constrain time for building planets
  - Can provide information on nature of dust, ice, and gas in planet-forming disks
  - Interested in connections to related work in solar system