A First Look at the Disk Population in the Auriga-California Giant Molecular Cloud

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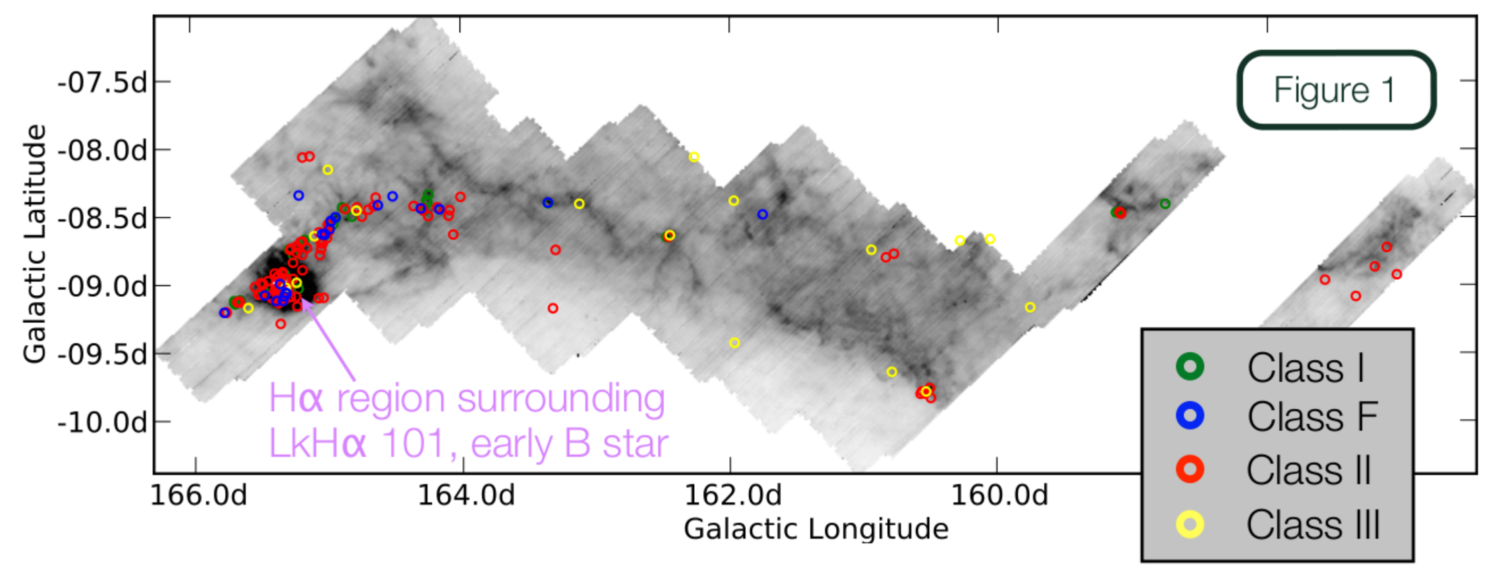
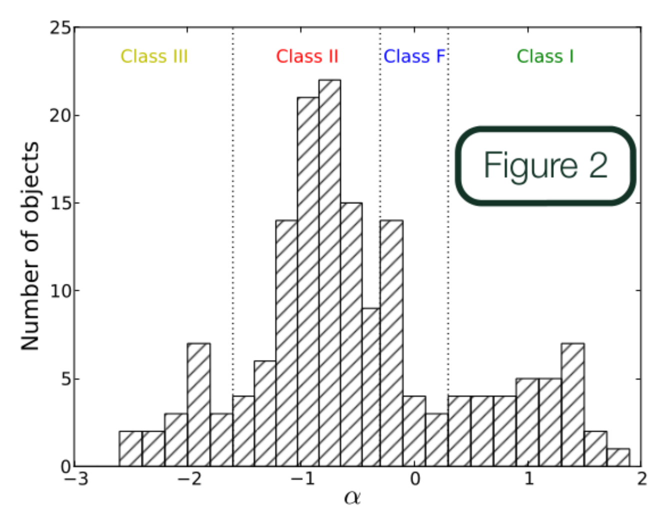
ABSTRACT

- The ACMC is one of two nearby giant molecular clouds, the other being the OMC.
- The ACMC was only recently identified as being one contiguous cloud (*Lada et al. 2009*). Consequently, it is relatively unstudied given its proximity to other nearby star-forming regions such as Perseus and Taurus.
- Although the ACMC is similar in mass, size and distance to the OMC its star formation properties are quite different.
- The ACMC is forming 20x fewer stars than the OMC.
- The ACMC is forming less massive stars. The OMC has 20 OB stars whereas the ACMC has only one B star, LkHα 101.
- This raises the question of how the reservoir of material in the cloud relates to that that is used for the formation of star systems.
- A first look with measurements from *Spitzer* observations suggests that ACMC disk properties are not vastly different from those in other regions.
- However observations in the submm, mm and cm would better compare disk populations by measuring disk masses and the degree of grain growth from spectral slopes.

Defining the target sample



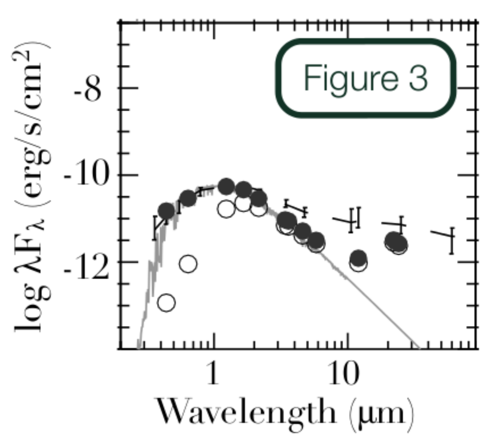
- Using *Spitzer* data (IRAC and MIPS) we have identified 166 young stellar objects (YSOs) in the ACMC. We have also used WISE data to help identify and remove likely background galaxies contaminating the sample.
- 75% of the YSOs are in the region around LkHα 101 and the adjoining filament.



- 91/166 of the YSOs are Class II sources, i.e., likely disk hosts with no remnant circumstellar envelope from the earlier Classes (e.g., Class I s).
- These define our target sample of protoplanetary disks in the ACMC.

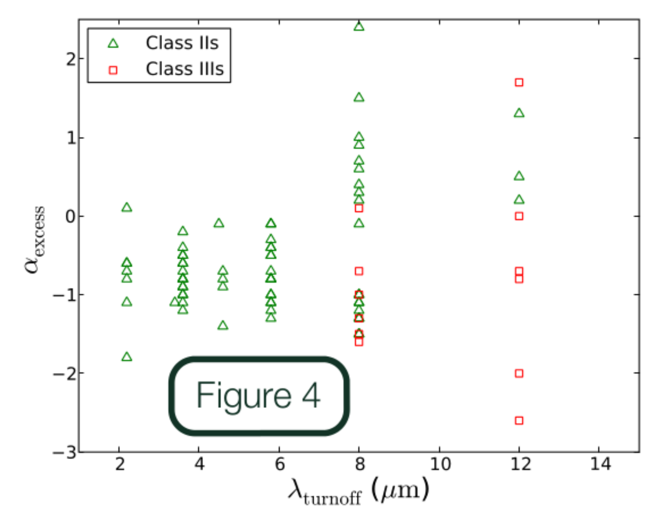
Spitzer data and analysis submitted to the *Astrophysical Journal*

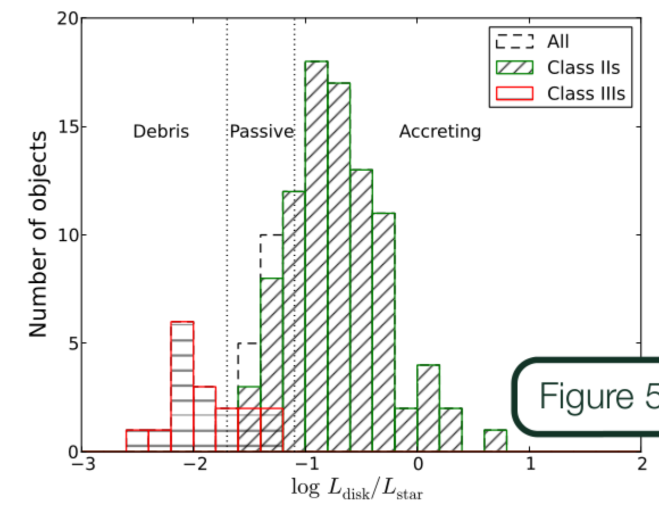
First look at the disk properties



- ○ Observed fluxes
- ● Dereddened fluxes. (A_V value is estimated to match the short wavelength data to the stellar model.)
- – – Median SED of T Tauri stars in Taurus (normalized to the dereddened short wavelength flux).
- —— Model of a K7 stellar spectrum, fit to short wavelength data by normalizing to the shortest available wavelength of 2MASS or IRAC 3.6 μm.

- $\lambda_{turnoff}$ - where the SED departs from the stellar model (the last wavelength before a significant excess is measured).
- α_{excess} - the slope of the excess longward of $\lambda_{turnoff}$.





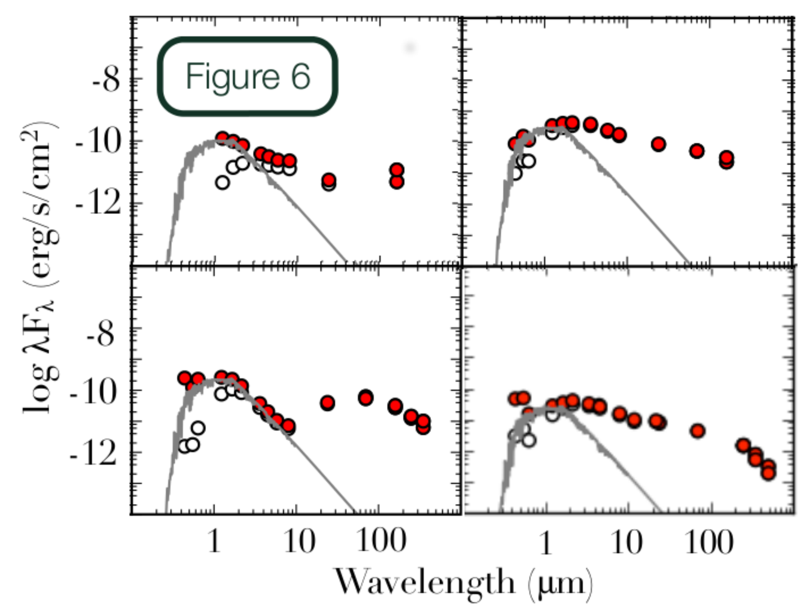
These distributions are similar for disk populations in other clouds observed by the *Spitzer* Gould Belt Survey suggesting, at first glance, the disk populations appear similar regardless of the cloud properties.

Spitzer data and analysis submitted to the *Astrophysical Journal*

New data sets

-- *Herschel* --

- The ACMC was mapped with *Herschel* at 70, 160, 250, 350, and 500 μm. (See P. M. Harvey et al. 2013.)
- SPIRE fluxes provide *preliminary* measurements of the disk masses for a handful of sources.



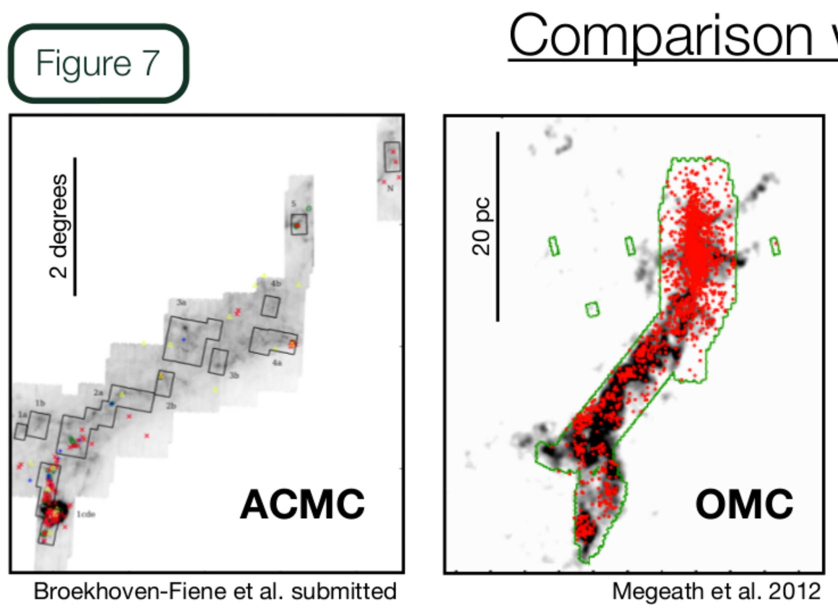
-- *JCMT* --

- Part of the cloud is being mapped with SCUBA-2 by the JLS Gould Belt Survey (PI Jenny Hatchell). Observations at 450 and 850 μm will help constrain disk masses and dust properties.

Current questions/future work

- How does the disk population in the ACMC compare to disk populations in other clouds?
- How do the disks in the environment of LkHα 101 (see Figure 1) compare to those further away along the adjoining filament?
- Measuring the disk mass distribution in the ACMC will be directly comparable to other disk populations, as this has been done for Taurus (*Andrews & Williams 2005*), ρ Ophiucus (*Andrews & Williams 2007*) and Orion (*Mann & Williams 2009*).
- ALMA Cycle 0 observations of protoplanetary disks in the OMC (PI Rita Mann) show how capable ALMA is to observe disks at the distance of the OMC and the ACMC.
- Detections with *Herschel* and SCUBA-2 identify the bright disks that are most likely to be detected with other observatories.
- We want to use ALMA and the VLA to measure disk masses and estimate the degree of grain growth by measuring the spectral slope and constraining the contribution from free-free emission.

Comparison with Orion



The OMC is forming far more stars than the ACMC!

Images shown at the same angular scale (and therefore about the same spatial scale given the similar distances of the two clouds).

Left (x's): YSOs classified as Class IIs by us.

Right: YSOs classified as pre-main sequence stars with disks by Megeath et al.

Object Key

- ACMC - Auriga-California Molecular Cloud - 450 pc
- OMC - Orion A Molecular Cloud - 400 pc
- LkHα 101 - a likely early B star (*Herbig et al. 2004*)
- Class II source - The classification of Class I, F, II and III (*Lada 1987*; *Greene et al. 1994*) is based on the spectral slope of the source in the infrared. Class IIs are likely disk hosts with earlier classes (Is and Fs) likely still having a substantial envelope and the later Class IIIs only having a marginal disk remaining.
- Banner image - The 3-colour Herschel map (70, 160, 250 μm) of the ACMC from Harvey et al. 2013.