Disks around Brown Dwarfs

ALMA study of the size, mass and gas content of disks around 32 Brown dwarfs and very low mass stars in two nearby star formation regions

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Why are disks around Brown Dwarfs so interesting?

Brown Dwarfs (BD) and M stars are the most numerous stellar objects in our universe. At young ages (and based on IR observations) these objects have disk fractions similar or higher to those around the more massive solar-like stars, which suggests the possibility that they could host a vast reservoir of planets. However, although differences may exists in the internal properties of the disks around solar-mass stars compared to low-mass stars (i.e. timescales for grain growth and disk dissipation), **several of the key structural parameters (size, mass and gas content) of the disks around low-mass stars and BDs remain poorly constrained**. These properties are critical to assess and understand their capacity to form planets.

What is this poster about? (← take home message)

In this poster, we describe our effort to use ALMA (cycle 1) to obtain the 345 GHz fluxes of a sample of 32 disks around stars across the stellar / sub-stellar boundary with spectral types M3-M7, located in two nearby star formation regions of ~2 Myr and ~10 Myr old. This represents the first statistically significant sample of BD disks studied at such long wavelength. With these fluxes it becomes possible to (through modeling the SED (Spectral Energy Distribution)) extract the dust mass present in the disks. Our observations also will allow us to detect or put upper limits on the disk sizes and the CO gas content of the disks.

Immediate objective

Our research is designed to understand **(1)** whether there is enough dust and gas to form planets around the objects located at the lower end of the IMF, **(2)** how the disk mass scales with central object mass, and **(3)** how the properties of the disks evolve over the two age groups spanning the range of 2-10 Myr. **(4)** Our observational set-up is such that we also try to serendipitously detect CO emission and spatially resolve the larger disks.

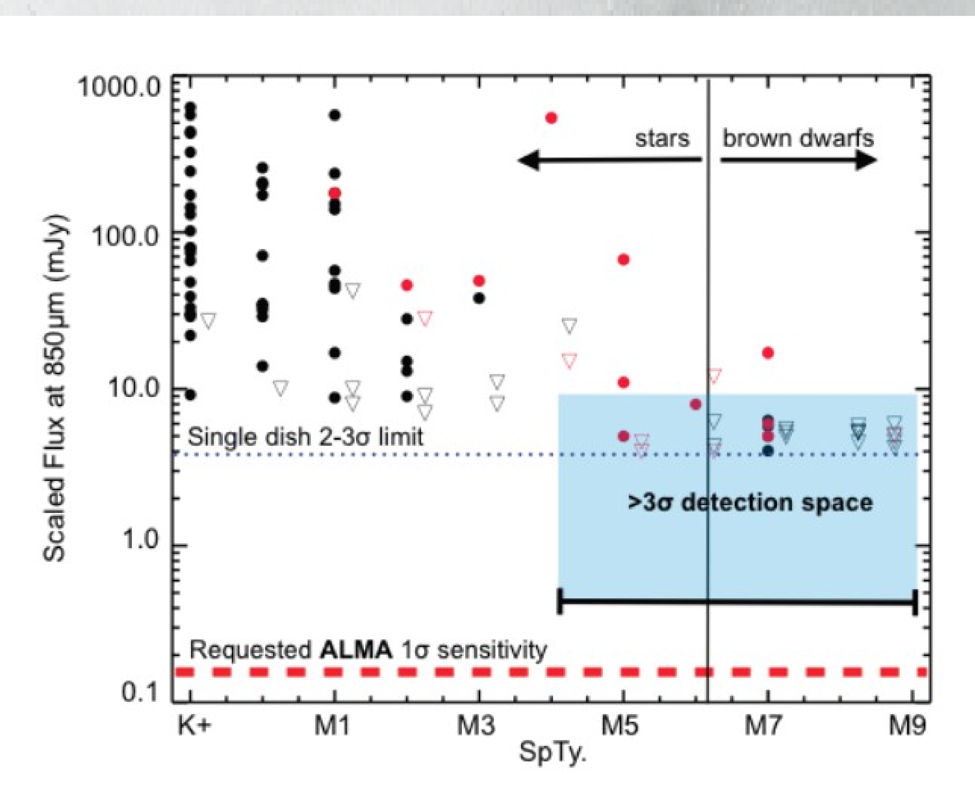

Figure 1: Fluxes (circles) and upper limits (triangles) of previous sub-mm/mm surveys (350 micron-1.2mm) of Taurus are plotted as 850 micron fluxes scaled assuming a v^2 relation. Black symbols are from the literature (Andrews & Williams 2005, Scholz et al. 2006), red symbols are from Patience, Bulger et al. (2013, in prep.). K and early-M stars show a large range of disk fluxes, detectable with single dish measurements. For targets later than M4, the current sensitivity limits are not good enough to measure the range in expected disk masses - only the brightest objects are detected. The detection limit of our ALMA observations is indicated and will enable the detection of a large sample of low mass stars and BDs, revealing the currently unknown properties of disks around low mass objects.

Target Selection

Table 1: Spectral types and PACS flux ranges of the ALMA sample

	M3	M4	M5	M6	M7
Number of Targets	1	7	8	9	7
70μm fluxes (mJy)	34	38 – 274	11 – 379	7 – 274	3 – 81
160μm fluxes (mJy)	41	49 – 835	6 – 235	11 – 110	4 – 65

Currently, a very limited number of BD disks have been detected at Far IR / sub-mm wavelengths, (<10, e.g. Klein et al. 2003; Scholz et al. 2006; Harvey et al. 2012, Ricci et al. 2012) and surprisingly even fewer late-M stars (Figure 1). ALMA allows us for the first time to efficiently probe the disk population around low mass objects.

Our targets are chosen from the results of two successful Herschel surveys (PI: P. Harvey and PI: J. Patience; see Harvey et al. (2012) and Bulger, Patience et al. (2013, in prep.)) targeting low mass stars and BDs. It is selected to (1) maximize the number of detections and (2) to enhance the interpretation of the ALMA results with complementary 70 micron and 160 micron fluxes, hence providing a full coverage of the Spectral Energy Distribution (SED, see method). The sample covers the M3-M7 spectral type range distributed as indicated in Table 1.

Method

Quantitative information will be extracted from the SED and CO (non) detections with a state-of-the-art and automatized suite of codes: the radiative transfer code MCFOST (Pinte et al. 2009) and the thermo-chemical code ProDiMo (Woitke et al. 2009).

The larger, brighter disks in our sample might be spatially resolved, for the other disks we derive upper limits from the beam size.

Because all objects in our sample have been detected by Herschel at 70 and 160 micron. Building the SED all the way to the largely optically thin sub-mm regime will allow a statistical analysis of BD disk properties far more reliable than before (Figure 2).

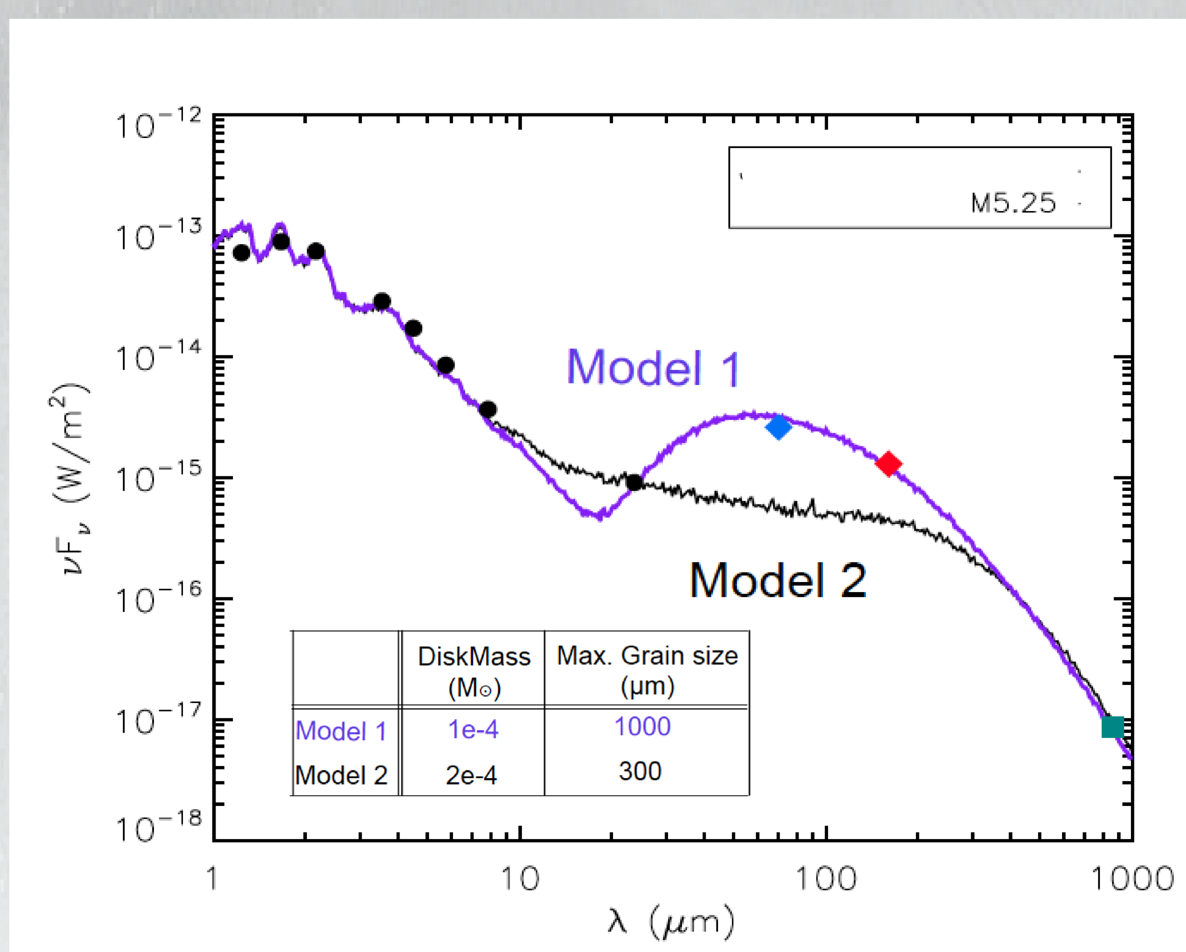

Figure 2: The SED from 1-170 micron is plotted for a low mass star detected in our Herschel survey (Patience et al. (2013, in prep)). Most low mass stars and BDs only have detections up to 24 micron from Spitzer. The figure shows how the Herschel detections (70, 160 micron) are important to connect an ALMA detection (simulated 850 micron data point) with the 24 micron detection to properly interpret the SED. Here, two possible models are plotted that fit the ALMA and Spitzer points, but the inferred physical properties of the disk are substantially different. The different disk masses and maximum grain sizes of the two model fits are listed in the figure.

Affiliations

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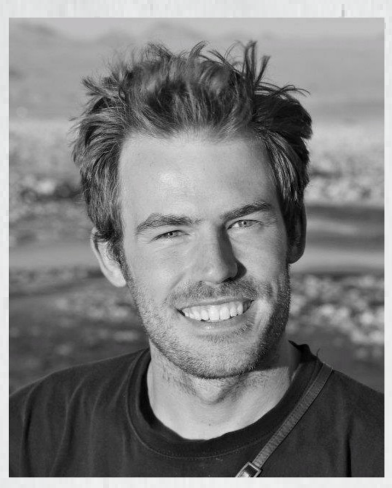
What is MAD?

The Milenium Scientific Iniciative (ICM) Nucleus on "Protoplanetary Disks in ALMA Early Science" (MAD Nucleus) is a center for research on planet formation and protoplanetary disks. MAD is a 14 member collaboration hosted by the Universidad de Chile and the Universidad de Valparaiso. Our members are: Simon Casassus (U. de Chile), Matthias Schreiber (Valparaiso), Francois Menard (CNRS, U. de Chile), Antonio Hales (ALMA), William Dent (ALMA), Andrés Jordán (U. Católica), Gerrit van der Plas (U. De Chile), Héctor Cánovas (Valparaiso), Claudio Caceres (Valparaiso), Pablo Roman (CMM), Sebastian Pérez (U. De Chile), Valentin Christiaansen (U. De Chile), Adam Hardy (Valparaiso) and Vachail Salinas (U. De Chile). You can find more about us on our website: http://mad.das.uchile.cl/

Questions?

If this poster has left you curious and you want to have a more in depth talk about disks, brown dwarfs or just want to buy me a mai tai and try to extract more information on this ongoing project or talk about yours, come find me.



I am easy to find (upper end of the height distribution). Alternatively, you can send me an email at info@gerritvanderplas.com