Connecting the evolution of young stars with their surrounding disks in Serpens

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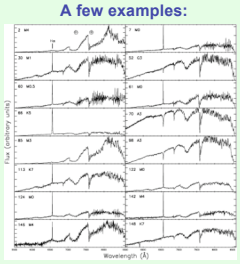
Abstract

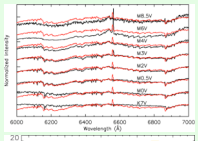
• Based on the "Cores to Disks" (c2d) Spitzer Legacy program, a rich population of young stellar objects (YSOs) was uncovered in a previously unknown region of the Serpens Molecular Cloud (d = 259 pc).
• This sample contains 150 YSOs with associated infrared excess with a broad range of temperatures, luminosities and disk geometries, making Serpens an unique and one of the richest targets for obtaining a complete and well-defined sample of young stars in a possible evolutionary sequence.
• Complementary optical observations in the optical allow us to characterize the central stars.
• Mid-IR observations allow us to characterize the surrounding disks.
• The aim is to connect the evolution of the disks with that of their harboring stars, to establish the mechanisms that determine the evolutionary sequence of protoplanetary disks.

Characterization of Central Sources

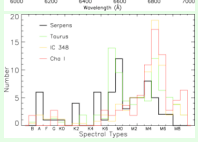
The goal of out optical spectroscopic survey is to derive spectral types, confirm membership to the cloud, study extinction and accretion. The data were taken at the WHT, TNG (both on La Palma) and Calar Alto Telescope.
Almost half of the sample is too extincted to be detected in the optical. Nevertheless, we have obtained optical spectra for 78 objects of our sample (Oliveira et al. ApJ, in press).
A few examples:



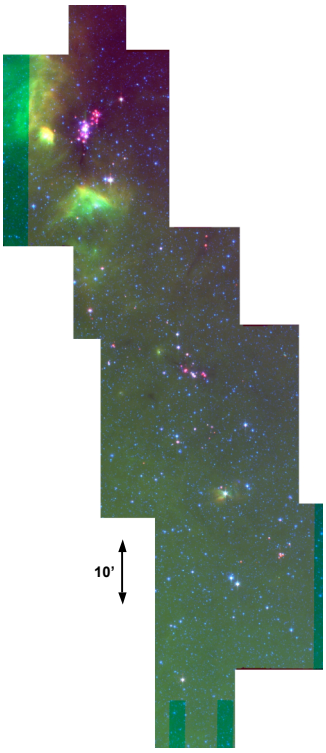
Spectra types were determined by comparing our normalized spectra to a library of spectroscopic standards, as shown in this figure:
(red: our data, black: standards)



The distribution of spectral types in our sample is:



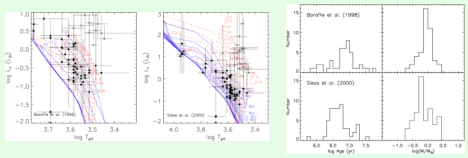
From Hα in emission, we derive that 55% of the stars are actively accreting



The Serpens Molecular Cloud, imaged by the c2d Spitzer Legacy Program. 24.0, 8.0 and 4.5 μm color composite. The red objects are YSOs in our program.

Relative Ages and Masses

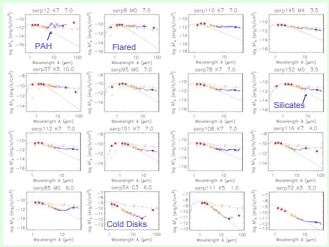
With spectral types and photometry, we are able to plot SEDs for our sources and derive their luminosities.
This information allows us to place them in a Hertzsprung-Russel Diagram, overlaid with pre-main sequence tracks, and estimate ages and masses for the individual sources.



From the HRD we conclude that 20 sources are too luminous and therefore do not belong to the cloud.

Spitzer IRS mid-IR spectra

IRS spectra show a population of circumstellar disks in all stages of evolution: from flared disks (still surrounded by lots of material), to settling disks (where grains have started to grow and settle to the midplane), to cold disks (with gaps or holes in the inner disk), to diskless sources



So far we know:

• Majority of stars are late type (88% of sources are K or M)
• 20% of background contamination (Serpens is very close to the Galactic plane)
• 55% of YSOs actively accreting
• Theoretical models imply a population with ages ranging from 1 to 15 Myr, strongly peaked at 2-6 Myr. The median age is found to be 7.5 and 4.7 Myr (Baraffe and Siess tracks)

Science In Progress

• NIR (K-band) spectroscopy survey with VLT/ISAAC: reaching the most extincted sources in the sample
⇒ Complete the characterization of the central sources
• SED modeling of the entire sample of 150 sources
⇒ Characterization of surrounding disks

And Then

Connect the evolution of the central sources
with the evolution of their disks

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