SPITZER AND CHANDRA OBSERVATIONS OF THE SERPENS YOUNG STELLAR CLUSTER

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At a distance of 310 pc, the Serpens Cluster is one of the nearest regions of clustered star formation to the Sun. Here, we present the first stage of a multi-wavelength study of the young, pre-main sequence stars composing the cluster, and of the development of the cluster. These observations are a part of the *Spitzer* Young Cluster Survey. The poster presents observations from the *Spitzer* Space Telescope, utilising the IRAC and MIPS instruments to view the region at infrared wavelengths from 3 to 24 microns. These data allow us to detect thermal emission from circumstellar disks and protostellar envelopes, and to classify stars with disks and protostars using both colour-colour diagrams and spectral energy distributions (SEDs). These data are further combined with optical (far-red) spectra and Chandra X-ray data to understand the evolution of the disks and envelopes and the X-ray properties of the young stars.

The Serpens region is an example of a very young, deeply embedded cluster, containing a number of protostars (Kaas et al 2003). Submillimetre observations of the region, at 450 μm and 850 μm, identify at least 10 sources in the Serpens Cloud Core (Davis, 1999). Previous mid-IR and sub-mm studies of the Serpens region by Kaas et al, using the ISOCAM instrument aboard ISO, detected a total of 407 sources in their two bands, 6.7 μm and 14.3 μm, (124 detected in both bands) over a field of view of 0.13 square degrees, of which 61 sources were identified as young stellar objects. The molecular cloud is heavily extincted, exceeding 50 mags in the visual. Classification of the sources yielded 20 Class I sources, 13 flat-spectrum sources, and 43 Class II sources.

The current study utilises observations taken with the *Spitzer* instruments IRAC (Infra-Red Array Camera) and MIPS (Multiband Imaging Photometer), at wavelengths of 3.6, 4.5, 5.8, 8.0 μm (IRAC) and 24 μm (MIPS). The IRAC mosaics cover a 29' by 33' field of view (Figure 2). The effective exposure time is 41.6 sec. The MIPS 24 micron mosaic of the region covers a 30' by 54' field. The total effective exposure time at 24 μm was 80 sec. Chandra data for the region, with an exposure time of 88.45 ks, will also be used to correlate disk candidate sources with observed x-ray activity, and to identify Class III member candidates. The Chandra data comes from the ANCHORS (AN archive of Chandra Observations of Regions of Star formation) archive. Near-IR photometry was provided by the 2MASS in J, H, and K bands.

The IRAC detections yielded a total of 1083 sources measured in $[3.6]$, $[4.5]$, $[5.8]$, $[8.0]$. We used combined near- and mid-IR colour-colour diagrams to determine those sources that have an excess (Allen et al. 2004, Megeath et al. 2004 and Muzerolle et al. 2004) (Figure 1). This excess at IR wavelengths arises from the presence of dusty disks or envelopes around the star. Of these, 92 were identified as having infrared excesses. Seventy-five sources were detected at 24 μm and IRAC, 66 of which exhibit an excess, 11 not identified with IRAC alone, giving a total of 103 excess sources in the cluster. Chandra data of the region provides 88 detections of suspected cluster members, of which, 67 are identified with IRAC and MIPS sources. Of this 67, 42 show IR excess and 25 have no excess.

Spectral Energy Distributions (SEDs) have been analysed for 75 objects detected in the 2MASS H and K, IRAC and MIPS bands with uncertanties less than 0.1 mag. The Spitzer photometry is dereddened using extinctions determined with H, K, and [3.6] - [4.5] (Gutermuth et al., in prep). Dereddening can distinguish between those sources that are truly Class I (retaining their natal envelopes) and highly reddened Class II objects seen through the dust in the cloud. The sources were classified by their 2-24 micron power-law slopes, α, where $\lambda F_\lambda \propto \lambda^\alpha$. Objects with slopes greater than 0 were classified as protostars (class I), objects with slopes ~ 0 were classified as flat spectrum sources (thought to be in a transitional phase between Class I and Class II), and objects with slopes between 0 and -2 are classified as stars with disks (class II). Classification of the 75 sources yielded 10 class I objects, 8 flat spectrum sources and 25 class II objects. An additional three objects appear to be transition objects which have little to no excess in the IRAC -bands and a marked excess at 24 μm; suggesting that the inner disks of these objects have been cleared of small grains. The remaining 29 sources appear to be pure photospheres and may be member stars without disks (or perhaps weakly emitting, optically thin disks) and/or field stars in the line of sight. Membership of these sources cannot be ascertained from their IR colors, we are currently assessing their membership using the X-ray data.

Previous studies of the region have not given any satisfactory age for the cluster. Spectra of selected excess sources in the Serpens Cluster were taken using the Hectospec instrument on the MMT on Mt. Hopkins, in the I-band. Of the 22 spectra with good signal-to-noise typed, 15 were M type, 4 K type and 2 G type stars. With these spectral types, an Hertzprung-Russell diagram was obtained, using isochrones from Baraffe et al.,1998. The typed objects lie about the 1 Myr isochrone: implying an age for the Serpens Cluster of approximately 1 Myr.

Finally, we will compare the X-ray and IR properties of the young stellar objects to correlate X-ray activity with evolutionary class, including analysis of stars from other regions in the *Spitzer* Young Cluster Survey and ANCHORS, and probe the connection between disks and envelopes and the X-ray emission observed toward these stars.

References:

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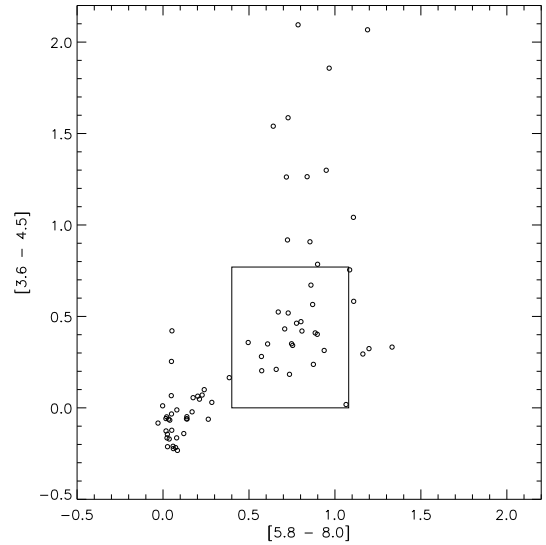

Figure 1: *: Serpens IRAC:* Colour-colour diagram of [3.6 - 4.5] against [5.8- 8.0] showing the field stars and young diskless cluster members centred on the origin. The polygon outlines the area of the Class II sources. The sources with very red [3.6]-[4.5] colours are protostars.

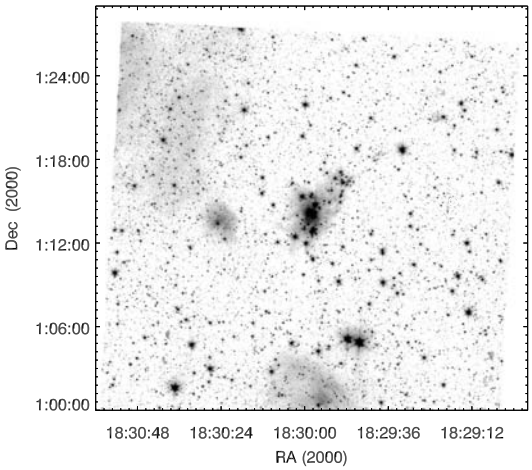

Figure 2: *: Serpens IRAC:* Grey scale image of the 4.5 μm IRAC mosaic. The cluster is evident in the centre of the mosaic.