STARS WITH CIRCUMSTELLAR DISKS IN NGC 6611.

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We present a multi wavelength study of the stars with circumstellar disk of the young open cluster NGC 6611, aiming to investigate how the UV radiation from massive stars affects the evolution timescales of disks of nearby stars. Several studies on stars with circumstellar disk in the Orion Nebula showed that the ionizing radiation from OB stars heats the nearby disks up to thousand degrees, inducing their photoevaporation (see, e.g., Hollenbach, 1994, and Störzer & Hollenbach, 1999). This process alters the evolution of the disks, that are disrupted in shorter time scale than the disks formed in different environments. NGC 6611 is a suitable target for this kind of study thanks to its large population of massive stars (more than 50 stars with spectral class earlier than B5), distributed irregularly in the central region of the cluster. We compiled a multi wavelength catalog using optical WFI observations in BVI bands, 2MASS catalog and SPITZER/IRAC data from the GLIMPSE survey, in a region of $33' \times 34'$ centered on the cluster, and a CHANDRA X-ray observation in a smaller central region of $17' \times 17'$. We compared the spatial distribution of disk-less members, identified by their X-ray emission, and that of stars with circumstellar disks, identified by the excesses in their infrared emission, with the spatial distribution of the massive stars with a spectral class earlier than B5. We found that the stars with circumstellar disk are more frequent at larger distances from the massive stars, where the incident UV radiation is weaker, than the disk-less members.

Cluster parameters

Young pre-main sequence stars are characterized by strong coronal activity, so we have used the X-ray emission as a membership criterion, especially useful for Class III T-Tauri stars, that have dissipated their disks. The diagram in the upper panel of Fig. 1 shows that most of the X-ray sources are pre-main sequence members of the cluster.

In Guarcello et al. (2007) we have determined the following cluster parameters:

- a distance of 1750 parsec, in agreement with previous recent studies, was obtained taking advantage of the presence of the nebula at the cluster distance that absorbs the radiation of background stars;
- an age interval of 0.1-3 Myrs, obtained by fitting the isochrones to the locus of massive members;
- we confirmed the anomalous reddening in the direction of NGC 6611, evaluating $R_V = 3.27$;
- using all the cluster members (see below) we found that the core radius is 1.5 ± 0.1 parsec, obtaining a relaxation time for the core of 4.2 Myr, greater than the age of the pre-main sequence population.

We have matched the compiled optical-2MASS catalog with the SPITZER one. The lower panel of Fig. 1 shows that the optical sources with emission at 8.0 μm are mainly massive stars or pre-main sequence members of the cluster. For the latter the emission in this band is unlikely to be photospheric and it is dominated by disk emission.

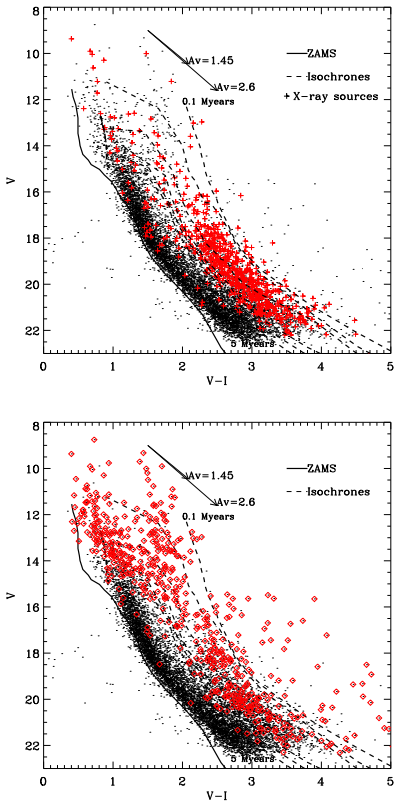

Figure 1: V versus $V-I$ diagram for the stars in the WFI FOV (dots). Plus symbols indicate X-ray sources (upper panel) while diamonds indicate stars with emission at 8.0 μm (lower panel). The ZAMS and the isochrones are from Siess et al. (2000), the extinction vectors was obtained from the reddening laws of Munari & Carraro (1996).

Stars with circumstellar disk

We identified the stars with circumstellar disk by the excess in their infrared emission. The excess in infrared bands was detected by suitable free-reddening optical-2MASS and optical-IRAC color indices, that are more negative for star with excess (see an example in Fig. 2). The indices are defined as:

$$Q_{ABCD} = (A-B) - (C-D) \times E_{A-B}/E_{C-D} \quad (1)$$

where A, B, C and D are magnitudes in four different bands and E_{A-B} and E_{C-D} are the corresponding color excesses.

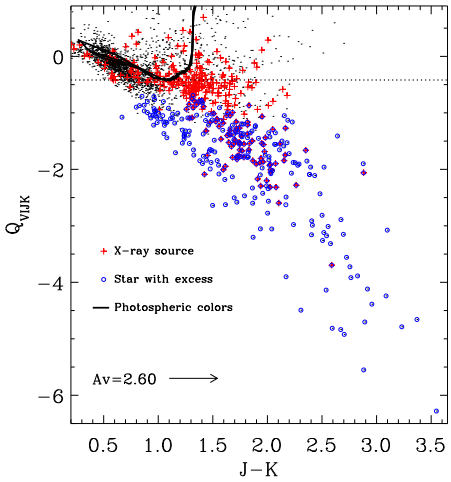

Figure 2: Diagram of the color index used to identify the members with excess in K band. Members with the index significantly smaller than the limit for photospheric emission, marked by the dotted line, are selected.

With this method, we identified 360 stars with disk in the $33' \times 34'$ FOV. 99 of the 207 stars with disk in the $17' \times 17'$ central region are also X-ray sources.

The nature of the stars with infrared excess as Young Stellar Objects (YSO) was also confirmed by the IRAC Color-Color diagram (see Fig. 3). Using this diagram, it was also possible to identify 110 other stars with circumstellar disk. Most of them are Class II YSO, while 12 are classifiable as Class I and 29 are Class I or reddened Class II. Classification is based on the colors predicted for CTTS by the models of D'Alessio (1998, 1999, 2001).

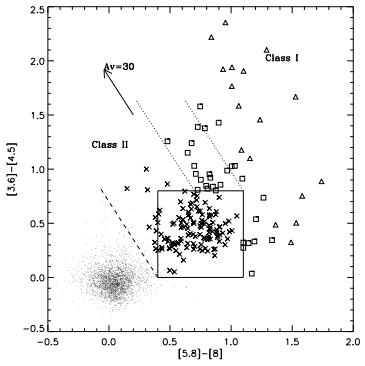

Figure 3: Spitzer Color-Color diagram for the sources in the WFI $33' \times 34'$ FOV, with the stars identified as Class II YSO (crosses), Class I (triangles) and stars that might be either Class I or reddened Class II (squares). The reddening vector was obtained as in Hartmann et al. (2005).

Spatial distributions

In the central $17' \times 17'$ region, we calculated the UV flux, emitted by the massive members with spectral class earlier than B5, incident on the members with and without disk. In particular, we have considered the histogram of the number ratio between members with and without disk, versus the incident UV flux (see Fig. 4). Using this ratio, that is more significative of only the number of stars with disk, we took into account the inhomogeneous spatial distribution of the cluster. The histogram shows that the members with disk are more frequent at low values of incident UV flux, i.e. at larger distances from massive stars. Considering that the central region is not relaxed yet and that we have no evidence of sequential star formation, we conclude that this result is in agreement with the hypothesis that the evolution timescales of the circumstellar disk have been modified by the photoevaporation process.

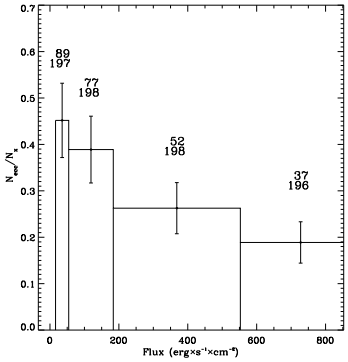

Figure 4: Histogram of the number ratio of the members with and without disk as function of the incident UV fluxes. The numbers used to compute the ratio are indicated.

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