Revealing the young stellar population in the S254–S258 region with X-rays

Paola Mucciarelli

In collaboration with:
Thomas Preibisch
Hans Zinnecker
Outline

- S254/S258 overview
- Analysis of our Chandra X-observation (Mucciarelli et al. 2011)
- Source catalog and basic properties
- Characteristic of the X-ray stellar population in S254/S258
- Preliminary cross-correlation with other wavelength
- Conclusion and perspectives
The star forming region S254/S258

- SE part of the Gem OB1
- Distance = 1.6 Kpc (Rygl et al. 2010)
- Linear scale: 2 arcmin ~ 1pc

Spitzer IRAC (blue=3.6μm, green=4.5μm, red=8.0μm)

Spitzer MIPS1 (24 μm)

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The star forming region S254/S258

S255IR (S255–2: e.g. Chavarria et al 2008, Wang et al 2011)

- evident signature of ongoing SF (IR sources; OH, H2O and methanol masers; jets, molecular outflows; HH-like objects)
- estimated age 1 Myr.

S255N (e.g. Wang et al 2011):

- evident signature of massive SF (far-IR emission; three cores with 6–35 Msun)
- no NIR emission > earlier stage than S255IR;

S255S: in a pre-stellar phase (Minier et al. 2007)

LBT LUCIFER, courtesy of A. Bik
Blue: H-band, Green: H2, Red: K-band
The missing low-mass stars

- Isolated B0 stars (16 Msun) at the center of S255 and S257
- Several hundreds low-mass stars are expected according to standard IMF (Kroupa 2011)

Possible solutions:

- Bimodal star formation: first evidence ever! — No
- Dynamical ejection: not excluded — No
- Multiple generations scenario — Yes

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Chandra observation

PI: Thomas Preibisch
Performed on November 21/23, 2009
Two pointings:
  10983 (40.6 Ks)
  12022 (34.2 Ks)
- Good total observing time of ~ 73 Ks
- Spatial resolution 0.5 arcsec
- Mean background level 0.02 counts/pixel
- Sensitivity limit $L \sim 2.9 \times 10^{29.5}$ erg/s:
- Detection completeness:
  90% for masses greater of 0.5 Msun
  50% for masses smaller of 0.25 Msun

Final catalog of 364 detected sources
(ACIS EXTRACT, Broos et al. 2010)
X-ray spectra

25 sources with more than 80 counts

Absorption * Vapec
* Vapec + Vapec
* Power Law

- no sources with kT < 0.5 keV (6MK)
- 5 sources with kT > 6 keV
- $N_H=20-23.08$ cm$^{-2}$ ($A_V \sim 0.1$ to 65 mag)
  average of 22.04 ($A_V \sim 6$ mag)
X-ray source variability

AE Preliminary indication of variability
- 23 variable sources
- 19 possibly variable sources
Difference between the count rate of the two observations:
- 21 sources

Final sample of possibly variable object: 50 sources
5 flare-like
10 peak
15 irregular
Few in/de-creasing
Cross-correlation & contamination

Preliminary work:
- DSS  26% (94 sources)
- 2MASS  60% (230 sources)
- Spitzer (Chavarria et al 2008) 80% (292 sources)
46 sources (outside the central cluster) with no counterpart in optical/near-IR/IR

Comparison with CCCP (Chandra Carina Complex project, Townsley et al. 2011 + 16 papers)
Scaling the fov and the distance:
  - ~10 foreground stars
  - 48 backgrouns AGNs

Expected level of contamination of S254-S258 sample < 15%
Spatial distribution of X-ray sources

S255IR: 45 sources
S256: 12 sources
S258: 7 sources

250 widely distributed X-ray young stars

With our detection limit logL~29.5 we should detect:
- 70% young stars [0.5–2] Msun
- 30% young stars [0.1–0.5] Msun

About 260 expected sources

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Comparing with COUP (Chandra Orion Ultradeep Project, Getman et al 2005): similar shape at logF > -6
  - Lack of X-ray luminous O stars
  - Higher sensitivity limits
  - Smaller stellar population?

Slope of high luminosity tail (30.5 < logL < 32):
- COUP \( \sim -0.95 \pm 0.09 \)
- S254–S258 \( \sim -0.91 \pm 0.10 \)

Total expected population: \( \sim 2000 \) objects
Summary & Perspectives

- Reasonable X-ray sample of 364 sources, complete down to 0.5 Msun;
- Spatial distribution of the sources support the multiple generation scenario;
- Comparison with the Carina XLF give a total expected population of about 2000 associated young stars.
- Ongoing detailed analysis of optical and IR properties of individual sources (age, mass, presence of circumstellar disk)