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

Young Stars & Star Formation



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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



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)

S254

estimated age 1 Myr.

S258

Mucciarelli

X-ray Universe 2011

S255N 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;

S255-2

S255S

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 standard IMF (Kroupa 2011)

| Possible solutions: | Low mass | stars |
|--|----------|-------|
| Bimodal star formation: first evidence | ever! | No |
| Dynamical ejection: not excluded | | No |
| Multiple generations scenario | | yes |

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~2.9x10^{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

| Absorption | * | Vapec |
|------------|---|-----------------------|
| | * | <u> Vapec + Vapec</u> |
| | * | Power Law |

25 sources with more than 80 counts

| no sources with kT < 0.5 keV (6MK) |
|---|
| 5 sources with kT > 6 keV |
| $N_{\rm H} = 20 - 23.08 \ {\rm cm}^{-2}$ (A _V ~ 0.1 to 65 mag) |
| average of 22.04 ($A_V \sim 6 \text{ mag}$) |

| $(10^{22} \text{cm}^{-2}) $ (4) | $ \begin{array}{c} kT_1 \\ (keV) \\ (5) \end{array} $ | $ \begin{array}{c} kT_2 \\ (\text{keV}) \\ (6) \end{array} $ |
|---------------------------------|---|--|
| 0.65 | 0.7 | 1000 |
| 1.10 | 15.0 | 223 |
| 2.42 | 2.6 | - |
| 0.26 | 0.5 | - |
| 0.03 | 9.4 | - |
| 1.17 | [15.] | 0000 |
| 0.91 | 3.8 | |
| 0.36 | 0.6 | 3.43 |
| 0.41 | 3.1 | - |
| 0.01 | 1.5 | - |
| 0.34 | 0.7 | 0000 |
| 0.01 | 1.0 | |
| 11.90 | 54.2 | 3440 |
| | | - |
| 9.69 | 5.4 | |
| 7.20 | 8.6 | |
| 2.00 | 0.9 | 8.73 |
| 2.21 | 2.6 | - |
| 3.65 | 7.9 | - |
| 1.65 | 3.9 | - |
| 0.55 | 5.0 | |
| 1.53 | 1.6 | <u></u> |
| 0.01 | 1.0 | 223 |
| 0.81 | 5.6 | - |
| 1.30 | 3.8 | - |
| 1.41 | 4.3 | 5775 |

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



5 flare-like 10 peak 15 irregular Few in/de-creasing

Mucciarelli X-ray Universe 2011



061231.17+180853.8

20 Time [ks]

15

10

Obs. 10983

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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X-ray luminosity function



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 ~ -0.95 ± 0.09</pre>

■ S254-S258 ~ -0.91 ± 0.10

Total expected population: ~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.
- See Mucciarelli et al 2011
 [http://arxiv.org/abs/1106.2003]
- Ongoing detailed analysis of optical and IR properties of individual sources (age, mass, presence of circumstellar disk)