Chandra Observations of the Massive Stellar Cluster Trumpler 14 in Carina

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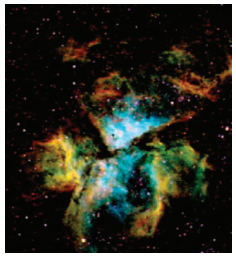
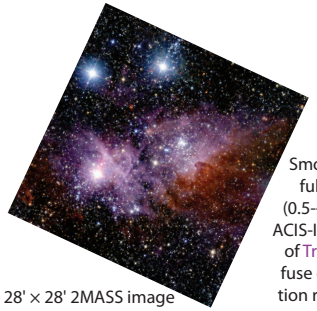
THE GREAT NEBULA IN CARINA

* D = 2.8 kpc (Tapia et al. 2003, MNRAS 339, 44); 10′ ~8.1pc. Age ~1 Myr.
* Trumpler 14 (Tr14): a very rich cluster on the edge of the giant molecular cloud Carina I, which contains several embedded IR sources.
* Tr14 contains at least 30 O and early-B stars, including an O2 star; evolved Wolf-Rayet stars are nearby (so maybe supernovae).
* The massive young cluster Tr16, containing Eta Carinae, lies ~15′ SE of Tr14. The Carina complex contains at least 10 more young clusters.
* Images below are shown in Galactic coordinates to emphasize the Carina superbubble.

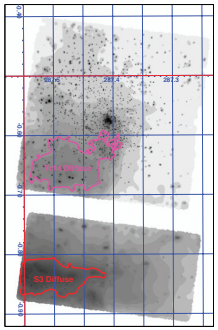


2° × 1.8° visual image from N. Smith et al. 2000 (ApJ 532, L145): OIII, Hα, SII.

2° × 1.8° mid-IR image from MSX (MSX/IPAC/NASA): 8.28μm, 12.13μm, 14.65μm.



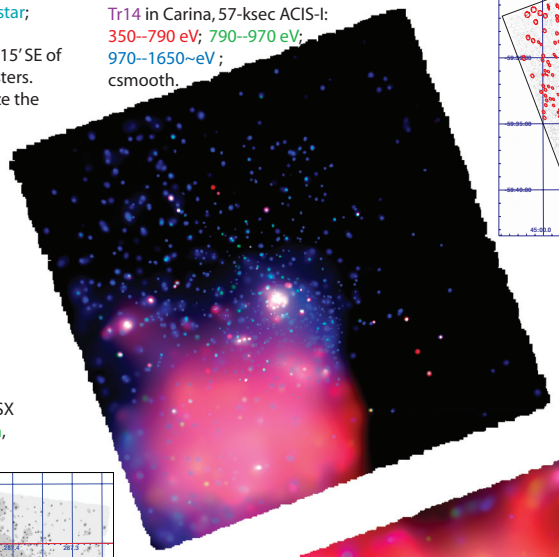
28′ × 28′ 2MASS image of Tr16 and Tr14.

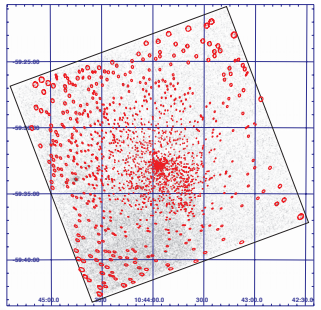


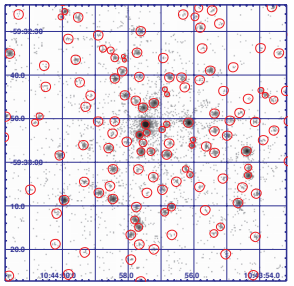
Smoothed full-band (0.5--7 keV) ACIS-I image of Tr14; diffuse extraction regions marked.

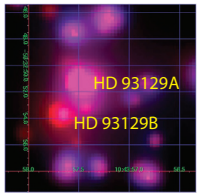
OUR CHANDRA OBSERVATION

Tr14 in Carina, 57-ksec ACIS-I: 350--790 eV; 790--970 eV; 970--1650~eV ; csmooth.









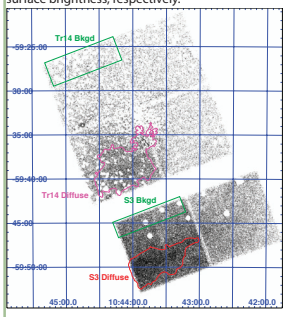
ACIS-I aimpoint: 0.5--2 keV; 2--7 keV

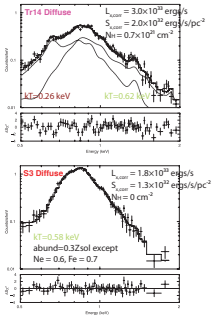
X-RAYS FROM YOUNG STARS

* Aimpoint on HD 93129AB, Tr14's central O2I -- O3V binary. Chandra detects 31 of the 37 O and early-B stars in the ACIS FoV.
* We find ~1600 point sources suffused by soft, bright diffuse emission.
* Based on other studies (e.g. Getman et al. 2005, APJS 160, 353) we expect only ~10% contamination from foreground stars and background AGN.
* This increases the number of known members of Tr14 and Tr16 by a factor of several and provides many identifications of pre-main sequence members.

DIFFUSE X-RAY EMISSION

* Point sources were extracted and masked using ACIS Extract (www.astro.psu.edu/xray/docs/TARA/ae_users_guide.html); see poster by Patrick Broos.
* Diffuse regions and backgrounds were defined with SAOImage DS9.
* Diffuse spectra were extracted using ACIS Extract, fit with XSPEC: wabs(apec+apec) for Tr14 diffuse, vapec (no absorption) for S3 diffuse.
* $L_{x,corr}$ and $S_{x,corr}$ are the soft-band (0.5--2 keV) absorption-corrected X-ray luminosity and X-ray surface brightness, respectively.





* Diffuse emission in Tr14 not cospatial with the cluster's stars!?
* S3 emission appears brighter but has smaller intrinsic L_x, S_x.

INTERPRETATION

* A modest Chandra/ACIS-I exposure of Tr14 in Carina reveals 1600 point sources, mostly members of the Tr14 and Tr16 massive stellar clusters.

* HD 93129AB, a very early-type binary at the heart of Tr14, is resolved and the components are shown to possess very different X-ray spectra. Other O stars in the field show a similar mix of soft and hard spectra. Hard emission may be due to colliding winds in yet-to-be-discovered close binary systems or to complex magnetic field interactions.

* Soft diffuse X-ray emission pervades the Tr14 H II region and is resolved from the point source population; it is most likely from the fast O-star winds that thermalize and shock the surrounding media, although its spatial distribution is mysterious.

* We also see soft, bright diffuse emission requiring enhanced Ne and Fe on the S2 and S3 off-axis CCDs, far from any of Carina's massive stellar clusters. This emission may be from a ``cavity" supernova remnant that exploded inside the Carina superbubble (e.g. Chu et al. 1993, ApJ 414, 213).

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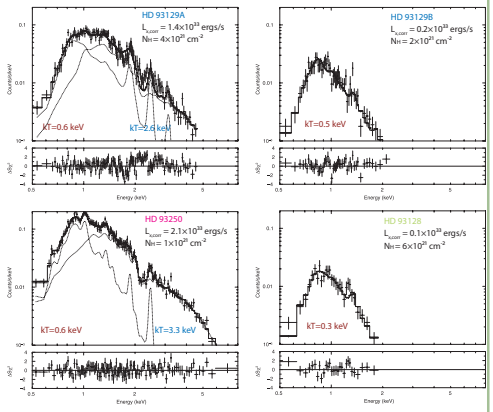
EARLY O STAR SPECTRA

The earliest O stars in Tr14 were fit in XSPEC with thermal plasmas, wabs(vapec + vapec) or wabs(apec). $L_{x,corr}$ is the full-band (0.5--8 keV) X-ray luminosity corrected for absorption.



* HD 93129A, the prototype O2 If* star (Walborn et al. 2002, AJ 123, 2754) was recently resolved into a 55-mas double (Nelan et al. 2004, AJ 128, 323).
* The hard X-ray component seen in its ACIS spectrum, along with its high L_x and high abundances, suggests that HD 93129A may be a colliding-wind binary (Portegies Zwart, Pooley, & Lewin 2002, ApJ 574, 762).
* Comparing its spectrum and L_x to HD 93250 above suggests that HD 93250 may also be a colliding-wind binary.
* An alternative explanation for the hard X-ray emission might be magnetically-confined wind shocks (e.g. Stelzer et al. 2005, ApJS 160, 557), but HD 93129A at least is known to be more than one star.
* In contrast, HD 93129B and HD 93128 show soft X-ray spectra more typical of single O stars and are much fainter.