

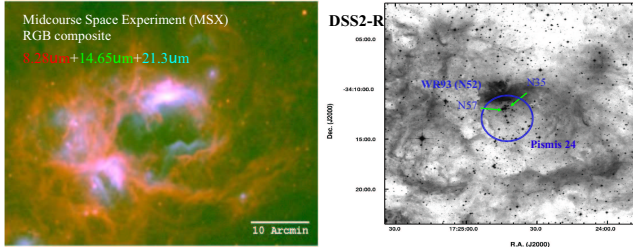
A Chandra Observation of the Massive Star-Forming Complex NGC6357: the HII Region G353.2+0.9 and the Massive Open Cluster Pismis 24

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Three color composite image of HII region G353.2+0.9. Red represents MSX Sum PAH emission; green represents DSS2 red image; blue represents 0.5-8.0 keV X-ray emission. The central cavity is occupied by X-ray emission from OB stars and outlined by ionized gas and warm dust.

I. An Observational Overview



Three color composite MSX image of NGC 6357. Central cavity and bright nebulosities are clearly seen.

Digital Sky Survey 2 Red image of HII region G353.2+0.9. The two bright O3 stars and the WR star are shown.

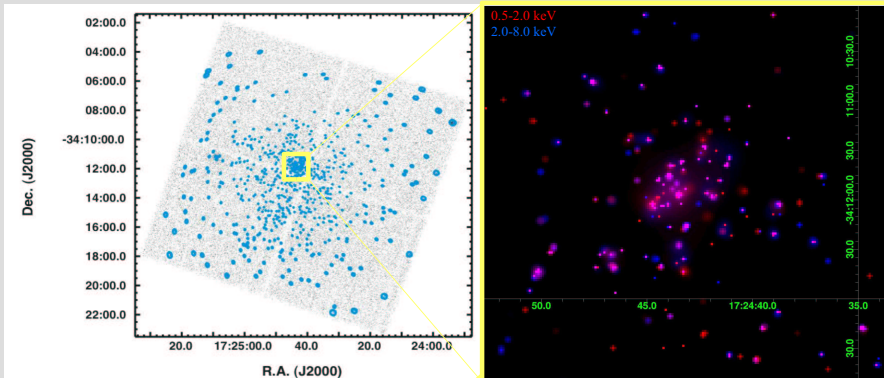
Star-forming complex NGC 6357

- Large HII region complex and Galactic ring nebula $\sim 60' \times 40'$ in southern sky
- Distance = 2.56 kpc
- Three major radio peaks
- Four FIR peaks closely follow the radio emission peaks

Massive open cluster Pismis 24

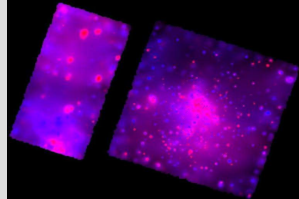
- $\sim 1'$ south of G353.2+0.9 ionization front
- Age ~ 1 Myr
- ~ 20 O and early B stars; 2 (out of 7) Galactic O3 stars and a WC7+O7 binary WR 93
- The ionizing source of the HII region

II. Chandra/ACIS Observation



38 ksec Chandra/ACIS-I observation (FOV= $17' \times 17'$), centered on the O3 star Pismis 24-1 (N35). Blue circles show regions used for photon extraction.

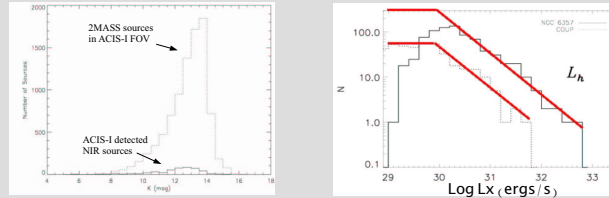
Zoom-in on central $1' \times 1'$ with soft band photons in red and hard band photons in blue. Obscured sources and flaring T Tauri stars show harder X-ray emission.



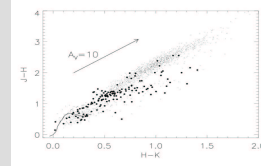
Adaptively smoothed two color (red: 0.5-2.0keV; blue: 2.0-8.0keV) fullfield ACIS image scaled to show possible soft X-ray emission associated with the OB cluster.

- The first high spatial resolution X-ray image
- 779 point sources detected in 38 ks
- 449 with matching 2MASS counterparts within $1''$
- ACIS-I provides 4-D information: coordinates, lightcurve, and spectrum
- X-ray spectra are fit with thermal plasma model with XSPEC

III. Population Study



Ks magnitude distribution of all 2MASS sources (9008) in the ACIS-I FOV compared to those (449) detected in X-ray



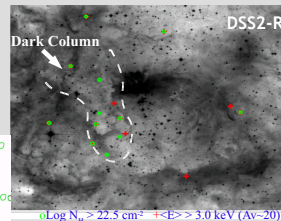
Near-IR color-color diagram of all 2MASS sources in the ACIS-I FOV (small dots) and those emitting X-ray (large dots)

XLFs constructed from hard band luminosities and total luminosities (uncorrected for absorption) compared with Orion XLF from COUP

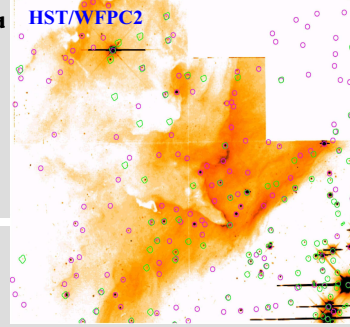
- 2MASS sources are mostly background contamination, not cluster members
- X-ray luminosity function using hard band luminosity seems consistent with Orion XLF from COUP, but ~ 8 times richer
- J-H vs H-K diagram shows cluster members are reddened in a range of $A_V = 5-20$

IV. Embedded Stars

- X-ray discovered deeply embedded population ($A_V > 20$) in the dark column
- Spatial distribution suggests a face-on blister HII region



X-ray selected deeply embedded sources marked on DSS2-R image. Green circles are selected using NH from XSPEC fitting and red plus are selected using high median photon energy $\langle E \rangle$.



X-ray detections (green) and 2MASS sources (red) superimposed on an archival HST/WFPC2 F814W image of the interface between massive stars and the molecular cloud. Chandra detects sources where HST and 2MASS suffer from extinction, nebulosities, and diffraction spikes.

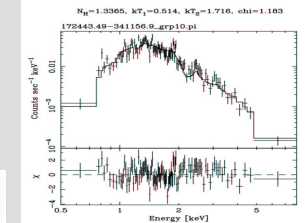
- X-ray emission is detected from an evaporating gaseous globule (EGG) for the first time
- A significant population of X-ray emitting low mass stars (~ 700) detected, increasing the cluster known members by a factor of 40

HIGHLIGHTS

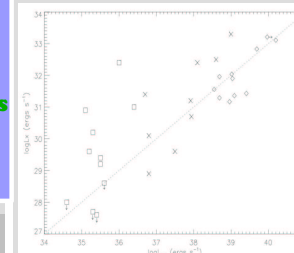
- The first high spatial resolution X-ray image of NGC 6357 obtained in a 38 ksec Chandra/ACIS observation
- The first X-ray detection of an Evaporating Gaseous Globule (EGG)
- The first quantitative measurement of total stellar population assuming Orion XLF
- Increased the number of known cluster members by a factor of 40
- X-ray discovered several candidate O stars
- X-ray discovered ~ 700 low mass Pre-Main Sequence stars that need optical and IR followup

V. X-ray Emission from Massive Stars

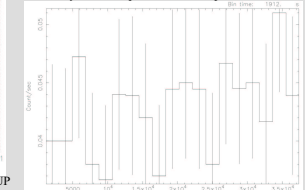
- X-ray emission detected from all OB stars earlier than B1. The brightest source is WR 93
- $L_X/L_{bol} \sim 10^{-7}$ for the O stars
- Candidate O stars were found using X-ray luminosity, constant lightcurves, and near IR colors



X-ray spectrum of massive stars O3 If star Pismis 24-1, which can be best fit by a two temperature thermal plasma.



Lx vs Lbol plot for our O-star sample (diamond), for COUP strong wind early-type stars sample (cross), and for weak wind early-type stars sample (square). Dashed line marks $L_X/L_{bol} = 10^{-7}$



X-ray lightcurve of massive stars O3 If star Pismis 24-1 with a 2 ks binning.

ACKNOWLEDGEMENTS

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