Young stars around the Horsehead Nebula

AUTHORS

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ABSTRACT

The Horsehead nebula is the nearest bright-rimmed cloud to the Sun, where star formation is taking place at different scales. Deep mid-infrared observations reveal a large variety of objects, from class I to class III stars, including transitional disk objects. Of the 45 reddened sources inside the Horsehead nebula, 14 are bonafide young stellar objects (YSOs), being 12 of them in the surroundings of the pillar. Due to its proximity (~400 pc), the Horsehead nebula is an excellent laboratory to study the physics of the X-ray emission in young stellar objects at similar evolutive stages in different environments. We present a partial X-ray view of this region and discuss the impact of a new X-ray observation centered at the Horsehead region.

MAIN OBJECTIVES FOR THE CHANDRA AO13:

- provide an unprecedented X-ray snapshot of this nearby young stellar association.
- study the unknown X-ray properties of the young stars placed in the famous emergent dark cloud of dense dust and gas globule, the Horsehead Nebula.
- understand X-ray emission of very young stars with different near-IR characteristics, which are also immersed in different circumstellar gas and dusts structures, i.e. by comparision of the near-IR and X-ray properties of stars placed in the pre-filament, on-filament and post-filament regions.
- probe the X-ray luminosity function and flare rate for young FGK stars, but at lower masses, which is important for understanding their magnetic activity
- test the consequences of the X-ray ionization in the evolution of proto-planetary disks
- confront near-IR and X-ray properties of young stars of the Horsehead nebula with those already known of the nearby cluster NGC 2023 and NGC 2024.

ASTROPHYSICAL CONTEXT

The ionizing HII region IC434 is seen as a bright north-south ridge of glowing gas with the Horsehead nebula (B33). Since the Horsehead is seen in absorption against the nebula, it must be at the same distance or closer to us than σ Ori, which has a distance of 330-385 pc. Because protostars are surrounded by a large amount of neutral material that absorbs the soft X-rays, we confront X-ray properties of sources over the entire region to show how different star environments affects X-ray emission.

NCC2024 (Skinner et al 2004): They made use of 75 ksec Chandra observation on this young (0.3 Myr) stellar cluster. More than 200 X-ray sources, with IR counterparts, are known. Most of the known class II IR sources (classical T-Tauri stars) in the region were detected, but the only known class I protostar was not.

Zeta Ori

The HD37903 is a B2 Ve with clear IR excess. However, it may be probably a young Herbig Be star.

ACIS-I requiered FOV

B33 points directly towards the binary system σ Ori, i.e. Shaped by the radiation preasure onto the gas-dust structure

NGC2023 (see poster M. A. Lopez-Garcia): We have re-analyzed the XMM-Newton observation. 41 X-ray source were detected. Four of them are close to the molecular cloud rim, to the north of the Horsehead nebula, HD37903 and three very likely M dwarfs by their IR colors.

New star formation is taking place mainly in the bright rim or inside the pillar. We find notable differences in the X-ray emission properties of class I and class II objects). No X-rays from Class 0 (NGC2023 MM1 star) objects has been reported.

Caballero (2008, A&A, 478, 667), using a Chandra/HRC observation have compiled a catalogue of 84 young stars at less that 30 ' around σ Ori. Two of them are bona fide brown dwarfs with signposts of youth.

Most of the σ Orionis T-Tauri stars with the largest infrared excesses have not been detected in X-ray surveys in the area, which supports the scenario of a lower frequency and intensity of X-ray emission of classical (accreting) T Tauri stars than weak-line (non-accreting) T Tauri stars.

A stream of emission-line stars in the direction of the nebula and its surroundings was confirmed. More than 10 young stars are at less than 15 arcsec from Barnard 33.

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SPITZER mosaic

HH247
RA = 05:41:34.67
DEC= -02:17:24.3

NGC2023 HH 1B
HH 247
NGC2023 HH 1C

V615 Ori, is a heavily reddened T Tauri star lying to the north of the Horsehead nebula, though most likely surrounded by an accretion disk. It is not detected in the sub-millimeter.

V615 Ori
RA = 05:41:24.51
DEC= -02:22:36.

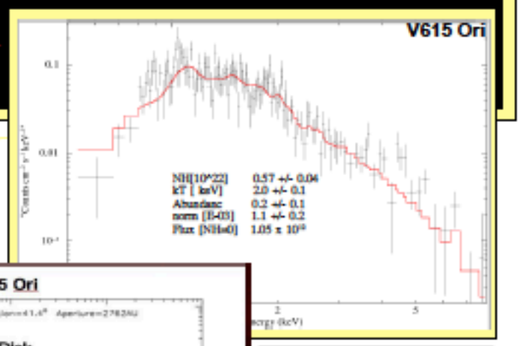
X-ray image [0.5-8.0 keV]

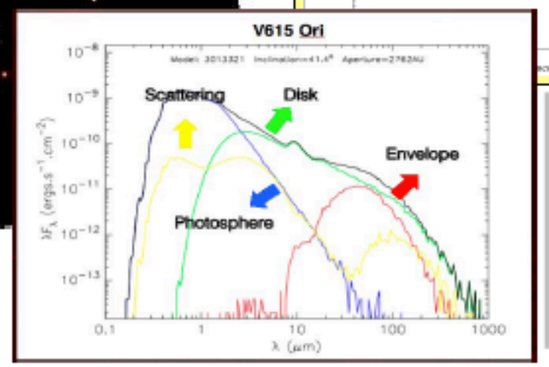
Herbig-Haro Objects on V615 Ori

HH 2B
HH 248

HH (A,B,C) are probably excited by V615 Ori, although deeper observations with better spatial resolution are needed. HH2 may be part of the V615 Ori outflow.

HH 3C
HH 3B
HH 3A





The used model* fit the Spectral Energy Distribution of the star.

Most important contributions to the emission in the mid-IR are disk and the star envelope.

* Robitaille, T. P., Whitney, B. A., Indebetouw, R., Wood, K., and Denzmore, P. 2006, ApJS, 167, 256

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