X-rays from young clusters reveal binarity of massive stars
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Abstract

We analysed the X-ray emission from massive Wolf-Rayet (WR) stars in vicinity of two young stellar clusters (Danks 1 and Danks 2) in the G305 star-forming region in the Scutum Crux arm of the Galaxy. Ten WR stars fall in the field of view of the corresponding archival Chandra observation. Based on the previous studies of X-ray emission from presumably single and binary WR stars, we estimate that about 60 - 66% of the WR stars in vicinity of Danks 1 and Danks 2 are binary systems.

X-rays from Wolf-Rayet Stars

Wolf-Rayet (WR) stars are downwinders from the most massive stars in the Galaxy and are divided into five subtypes: nitrogen-rich (WN), carbon-rich (WC) and oxygen-rich (WO). Very rare are there four such objects in the Galaxy [see [8] for a review on physical properties of WOs]. They were discovered to be X-ray sources by the Einstein Observatory [1] [3] and the first systematic studies of WRs [10] showed that binaries are the brightest X-ray sources amongst them. Modern X-ray observations (Chandra, XMM-Newton) considerably increased the number of pointed observations, thus, the number of objects with good quality X-ray data which allows estimating some general properties. Table 1 gives the list of WR stars used in the analysis.

Table 1: WR stars of G305 in the ACS-I (SMG2009)

<table>
<thead>
<tr>
<th>Name</th>
<th>log LX</th>
<th>Single or Binary</th>
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<tbody>
<tr>
<td>D0-2</td>
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<td>D0-2</td>
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X-ray Spectra and Binarity of Massive Stars in G305

For analysis of the X-ray spectra of the WR stars in vicinity of Danks 1 and Danks 2, we made use of version 12.9.2 of XSPEC [1]. The spectra were rebinned to have a minimum of 10 X-ray count per bin. We fitted the spectra with absorbed X-ray emission from optically thin plasma in collisional ionization equilibrium. For the objects with better photon statistics (source counts > 480), we used models with two-temperature plasma with individual X-ray absorption. For the other objects, we adopted models with absorbed one-temperature plasma emission. For non-detected objects, we used the latter model with fixed plasma temperature of 1 keV and X-ray absorption that corresponds to the average optical extinction towards Danks 1 and Danks 2 [5]. The continuum emission is adopted [8], to match the 1σ upper limit on the observed count rate. Figure 2 presents the X-ray spectra of detected WR stars and brief comments on individual objects follow (see also Table 2). (1) The X-ray spectrum of this WN3h star was fitted with X-ray emission from a two-component plasma (kT = 0.7 and 2.6 keV) which shared the same absorption of N_H = 2.6 × 10^{22} cm^{-2} (→ A_V = 11.7 mag). The value of its X-ray luminosity is a sign of binary system. Also, we note that this object is a very faint X-ray source (one-temperature spectral fit kT = 1 keV and N_H = 0.9 × 10^{22} cm^{-2} → A_V = 3.2 mag). We note that the X-ray absorption towards this object is relatively low (lower than the average towards Danks 1 and Danks 2 of ~ 9 mag) [5] which might be a caveat due to the low photon statistics. Nevertheless, the X-ray detection means a binary system. (2) For the previous object, the same was valid for this WR star but the thermal component had different X-ray temperatures: kT = 0.34 and 2.7 keV and N_H = 3.4 and 5.8 × 10^{20} cm^{-2}, respectively. The latter correspond to optical extinction A_V = 15 mag. (3) The quality of the spectrum of this WN3h star was lower, thus, we adopted a one-temperature model (kT = 0.6 keV, N_H = 2.6 × 10^{21} cm^{-2} → A_V = 12.6 mag). Similarly to objects (1) and (2), its X-ray properties are typical for binary system.

Conclusions

Adopting the X-ray based criteria for Single or Binary WRs, our analysis of the X-ray emission from massive stars in G305 leads to the following conclusions:

• More than 60% (6 out of 9 objects) of the massive Wolf-Rayet stars in vicinity of the central young stellar clusters Danks 1 and Danks 2 in the star-forming region G305 are binary systems.

• Optical observations are needed to further support or rethink this conclusion.

References


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Danks, A.C., Drennon, M., Wink, M., and Shaver, P.A. 1983, IAUC, 118, 301


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Figure 1: A Chandra ACS-I (Seward 2002) image of the WR stars in G305. The inner circle (2′′ radius) marks the source extraction region while the adjacent annulus denotes the background extraction region for each object. Image labels correspond to the object number in Table 1.

Figure 2: Chandra background-subtracted spectra of the X-ray detected WR stars in G305 sorted with the best fit model of absorbed X-ray emission from 1T or 2T optically thin plasma. Labels correspond to the object number in Table 1 followed by the object’s spectral type.