Massive Stars Near and Far
Proceedings IAU Symposium No. 361, 2024
J. Mackey, J. S. Vink, & N. St-Louis, eds.
doi:10.1017/S1743921322002721

X-ray emission characteristics of an O+O binary HD 93205

Bharti Arora[1,2] and **Jeewan C. Pandey**[1]

[1]Aryabhatta Research Institute of Observational Sciences, Nainital-263 002, Uttarakhand, India

[2]School of Studies in Physics & Astrophysics, Pt. Ravishankar Shukla University, Raipur−492 010, India
email: bhartiarora612@gmail.com, jeewan@aries.res.in

Abstract. A detailed X-ray study of a massive binary called HD 93205 has been made using long-term XMM-Newton observations. The X-ray spectrum of HD 93205 displays negligible counts above 5 keV. The two thermal plasma emission models with average temperature values as ∼0.20 and ∼0.60 keV are required to explain the X-ray spectra. The X-ray flux variations in the binary are noticed to be in qualitative agreement with the wind-wind collision model but with a few deviations from the expected 1/D trend (D is the binary separation).

Keywords. Stars:early-type; binaries:colliding-winds; X-rays:stars; stars:individual: HD 93205

1. Introduction

The Carina nebula region is an interesting star-forming region of the Galaxy. The open clusters Trumpler 14, Trumpler 16, and Collinder 228 present in this region harbor significant fraction of the known O-type stars in the nearby Milky Way. HD 93205 is a massive binary in Trumpler 16 with binary components as O3.5 V((f))+O8 V (Sota et al. 2014). Conti & Walborn (1976) estimated the first radial velocity solution for the binary orbit of this system and derived an orbital period of 6.0810 ± 0.0007 d, along with minimum masses of primary and secondary stars as 39 and 15 $M_\odot$, respectively. The elliptical orbit of HD 93205 with an eccentricity of ∼0.5 points toward very young evolutionary status of both the components lying near the zero-age main sequence.

HD 93205 is moderately luminous in X-rays with luminosity of $\sim 10^{32}$ erg/s. Using five X-ray observations from XMM-Newton, Antokhin et al. (2003) has suggested that X-ray flux in HD 93205 changes in accordance to the distance between two binary components. In order to deeply investigate colliding winds of HD 93205, we have performed its detailed X-ray analysis using data observed with European Photon Imaging Camera (EPIC) onboard XMM-Newton obtained over a considerably longer time baseline (July 2000 to July 2015). The X-ray data has been reduced following the standard procedure with Science Analysis Software (SAS v.17.0.0).

2. Results: X-ray spectral modeling of HD 93205

The X-ray spectrum of HD 93205 is similar to the hot stars' spectra displaying optically thin thermal plasma emission at high temperature where the soft band is populated by several emission lines. The spectrum of HD 93205 appears much softer with negligible counts above 5 keV (Fig. 1 *left*). Therefore, the spectral fitting was performed

https://doi.org/10.1017/S1743921322002721 Published online by Cambridge University Press

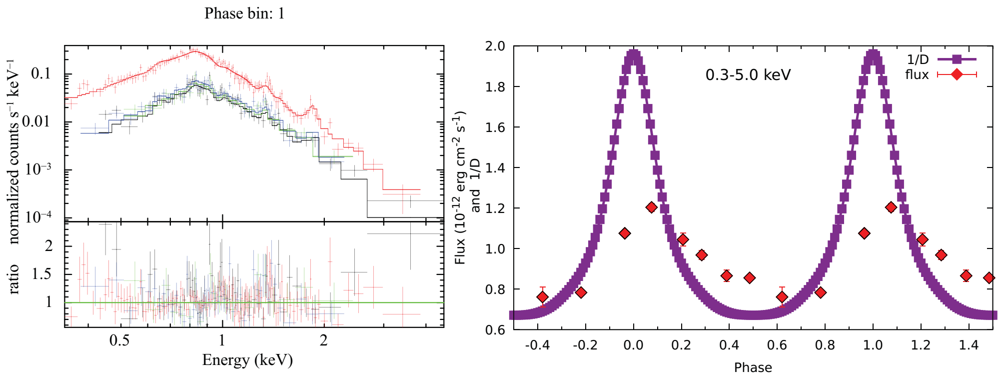

Figure 1. Left: X-ray spectra of HD 93205 fitted with two absorbed components of thermal plasma emission model. Right: Variation of X-ray flux from HD 93205 with orbital phase. The solid line shows the 1/D function, where D is the binary separation in terms of semi-major axis.

in 0.3-5.0 keV energy band using two components of thermal plasma emission model, further corrected for ISM absorption by fixing N_H^{ISM} to 0.24×10^{22} cm^{-2} (Jenkins 2019).

The quality of the EPIC spectrum of HD 93205 was not good enough to properly constrain the spectral parameters from a single observation ID upon modeling. Therefore, all the spectra available within similar orbital phases were fitted jointly (total eight phase bins). Fig. 1 (*left*) presents the joint X-ray fitting of spectra observed near the phase 0.07. The estimated ISM corrected X-ray flux in 0.3-5.0 keV energy band as a function of orbital phase has been shown in Fig. 1 (*right*). Here, the orbital phase is estimated using the ephemeris JD= 2442532.784+6.081E and zero phase represents the time of periastron passage (Conti & Walborn 1976). The average values of two temperatures (kT_1 and kT_2) were estimated to be 0.20±0.07 and 0.60±0.08 keV, respectively.

The phase locked variations in X-ray emission from HD 93205 are clearly displayed being maximum around periastron and minimum near the apastron as expected from the colliding winds of an eccentric massive binary. The X-ray flux is maximum around the orbital phase ∼0.07 and minimum at ∼0.62 and the maximum to minimum flux ratio is 1.58±0.11. In the case of adiabatic wind collision, the variation of X-ray luminosity is expected to be 1/D, where D is the separation between the two stars. However, theoretical studies suggests that mutual radiative influence of the two components of the binary may significantly alter wind dynamics in the wind collision region leading to deviations from 1/D trend (as observed for WR 25 also by Arora et al. 2019). Such phenomena may also reduce the wind speeds before interacting which further reduces hard X-ray generation from the wind collision. This may be another reason that HD 93205 displays mostly soft X-ray emission additional to fact that O-type stars intrinsically possess relatively lesser wind speeds than their evolved counter parts, Wolf-Rayet stars. To verify these effects, we are working on applying recent wind collision models to our observations and their implications on the X-ray emission will be considered in our upcoming paper.

Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S1743921322002721.

References

Antokhin, I. I., Rauw, G., Vreux, J.-M., et al. 2003, *Magnetic Fields in O, B and A Stars: Origin and Connection to Pulsation, Rotation and Mass Loss*, 305, 383

Arora, B., Pandey, J. C., & De Becker, M. 2019, *MNRAS* 487, 2624
Conti, P. S. & Walborn, N. R. 1976, *ApJ*, 207, 502
Jenkins, E. B. 2019, *ApJ*, 872, 55
Sota, A., Maíz Apellániz, J., Morrell, N. I., et al. 2014, *ApJS*, 211, 10