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

Bharti Arora and Jeewan C. Pandey
Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital, India
contact: bhartiarora612@gmail.com

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ABSTRACT: A detailed X-ray study of a massive binary called HD 93205 lying in the Carina nebula region has been made using XMM-Newton observations. The X-ray spectra of HD 93205 display 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 spectra indicating X-ray emission from HD 93205 is rather soft. The X-ray flux variations with binary separation are noticed to be in qualitative agreement with the wind-wind collision model but with few deviations from the expected 1/D trend (D is the binary separation).

Introduction

- The Carina nebula region is an interesting star-forming region of the galaxy containing some of the youngest and most massive O-type stars.
- HD 93205 lies in the vicinity of WR 25 and is a O3.5 V((f))+O8 V binary system.
- The orbital parameters in Table 1 indicate that HD 93205 has an elliptical orbit consisting of an earliest type star (Sota et al. 2014, ApJS, 211, 10).
- Many previous studies have discussed about variable X-ray emission from the source.
- The aim of the present analysis is to systematically probe the wind collision in HD 93205 in X-rays.

Parameter	Value
Period (d)	6.08102 ± 0.00066
Primary:	
V_o (km s^{-1})	3.6 ± 2.5
K_1 (km s^{-1})	139.1 ± 6.0
$a \sin i$ (km)	$(1.015 \pm 0.047) \times 10^7$
eccentricity	0.49 ± 0.03
ω (degrees)	12 ± 3
$T_{periastron}$ (JD)	2442532.784 ± 0.060
$M_{pri} \sin^3 i\ (M_\odot)$	39
Secondary:	
K_2 (km s^{-1})	360 ± 53
$M_{sec} \sin^3 i\ (M_\odot)$	15

Table 1: Orbital parameters of HD 93205 from Conti & Walborn 1976, ApJ, 207, 502.

Observations and Data Reduction

- The X-ray data observed by XMM-Newton for a total of 24 epochs has been used for HD 93205.
- The data span over a period of ~15 years from 2000 to 2015.
- Data has been analyzed using standard SAS and HEASoft tasks.

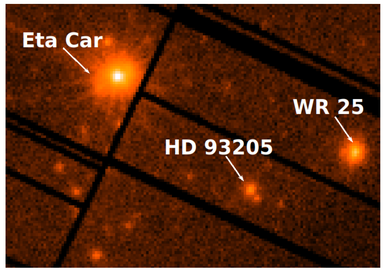

Figure 1: XMM-Newton image of the Carina region in 0.3-10.0 keV energy band.

X-ray light curve and spectral analysis

- The phase folded X-ray light curves of the binary (using the ephemeris provided in Table 1) are shown in Figure 2 in three energy bands defined as

  Broad (B) = 0.3-5.0 keV
  Soft (S) = 0.3-2.0 keV
  Hard (H) = 2.0-5.0 keV

- The X-ray spectra appear much softer with negligible counts above 5 keV in Figure 3.
- Total eight orbital phase bins were analyzed by jointly fitting the spectra obtained within very close by orbital phases using two temperature thermal plasma model "apec" in XSPEC modified by the local and galactic N_H.
- Fixed $N_H^{ISM} = 0.24 \times 10^{22}$ cm^2 (Jenkins, 2019, ApJ, 872, 55) and varied all other model parameters.
- Average $kT_1 = 0.20 \pm 0.07$ keV and $kT_2 = 0.60 \pm 0.05$ keV.
- The ISM corrected X-ray flux as a function of orbital phase is shown in Figure 4(left) which is maximum around periastron and becomes minimum close to the apastron.

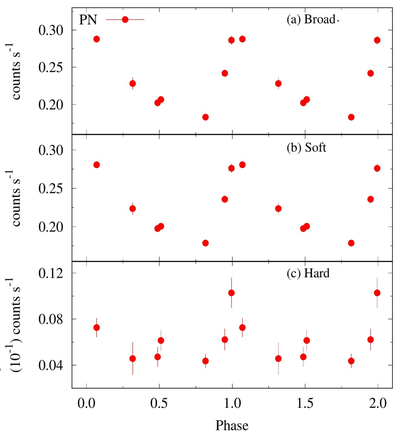

Figure 2: X-ray light curve of HD 93205 in different energy bands as observed by XMM Newton−PN.

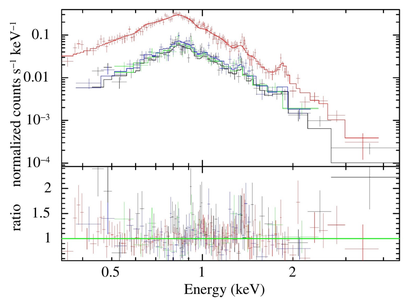

Figure 3: X-ray spectra of HD 93205 fitted with two components of thermal plasma emission model.

X-ray flux variability

- Fluxes F^S_{ism} and F^H_{ism} show deviation from the straight line on plotting with binary separation in Figure 4(right).
- The deviation could arise from anisotropic absorption of X-rays in an eccentric binary at different orbital phases.
- The presence of asymmetries and inhomogeneities in the stellar winds may add further deviations from the expected wind-wind collision behavior.

Figure 4: Variation of X-ray flux from HD 93205 with orbital phase (left) and binary separation (right).

Conclusions

- The maximum ISM corrected X-ray luminosity of HD 93205 is estimated to be 7.73×10^{32} erg/s in 0.3-5.0 keV energy band with $\log(L_X/L_{bol}) = -6.20$.
- Most of X-ray emission from HD 93205 comprises of the soft energy flux indicating comparatively less strong wind interaction in case of an O+O binary.
- A detailed quantitative analysis of wind collision in HD 93205 point toward departure from adiabatic interaction.