Winds of Stars and Exoplanets
Proceedings IAU Symposium No. 370, 2023
A. A. Vidotto, L. Fossati & J. S. Vink, eds.
doi:10.1017/S1743921322004148

X-ray view of colliding winds in WR 25

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

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

[2]Space Sciences, Technologies and Astrophysics Research (STAR) Institute, University of Liège, Quartier Agora, 19c, Allée du 6 Août, B5c, B-4000 Sart Tilman, Belgium

Abstract. The long-term behavior of a colliding wind binary WR 25 is presented using archival X-ray data obtained over a time span of ∼16 years. The present analysis reveals phase-locked variations repeating consistently over many consecutive orbits of the source (with binary orbital period ∼208 days). A significant deviation of the X-ray flux with respect to the theoretical 1/D trend (D is the binary separation) close to periastron passage has been observed. This may occur due to the shifting of the adiabatic wind collision to the radiative regime in that part of the orbit. Further, no signature of X-ray emission in 10.0-79.0 keV energy range attributable to inverse Compton scattering is detected by *NuSTAR*.

Keywords. Stars:early-type; binaries:colliding-winds; X-rays:stars; stars:individual: WR 25

---

1. WR 25: An Introduction

WR 25 (HD 93162) is a bright (V = 8.1 mag) WR star located in the Carina Nebula region and is classified as O2.5If*/WN6+OB (Crowther & Walborn 2011). Gamen et al. (2006) studied the radial velocity profile of WR 25 and suggested that it has an eccentric binary orbit (eccentricity = 0.5) with an orbital period of about 207.85 ± 0.02 days. Previous X-ray studies of WR 25 were based on limited X-ray observations and suggested that it's a colliding wind binary (CWB) system (Pandey et al. 2014). Therefore, in order to investigate this system and the associated winds deeply, we have carried out its X-ray study using the observations made by *NuSTAR*, *Suzaku*, *Swift*, and *XMM-Newton* at 226 epochs during 2000−2016. It is one of the rare instances where a massive binary has been explored in the high energies up to 79 keV which was possible because of *NuSTAR* monitoring of WR 25 along with other X-ray observatories.

2. Results from X-ray exploration of WR 25

Below 10 keV, colliding stellar winds of the binary components of WR 25 results in the enhanced X-ray luminosity. The system approaches a brighter X-ray state as the two binary components move close to the periastron passage in all the broad (0.3−10.0 keV), soft (0.3−2.0 keV), and hard (2.0−10.0 keV) energy bands as shown in Figure 1. This is because the wind interaction is maximum at periastron as wind density is largest in that part of the orbit. However, it gradually becomes fainter when the line of sight passes through the denser wind of the WR star in front and/or when the two binary components move away from each other in the orbit.

The X-ray flux obtained from spectral analysis of WR 25 in 0.3-10.0 keV energy range reveals that the wind collision is mostly adiabatic in WR 25 but significant deviation from the adiabatic cooling is seen around the periastron passage. The main indicator of this effect is the deviation from the expected 1/D (D is the binary separation) dependence of

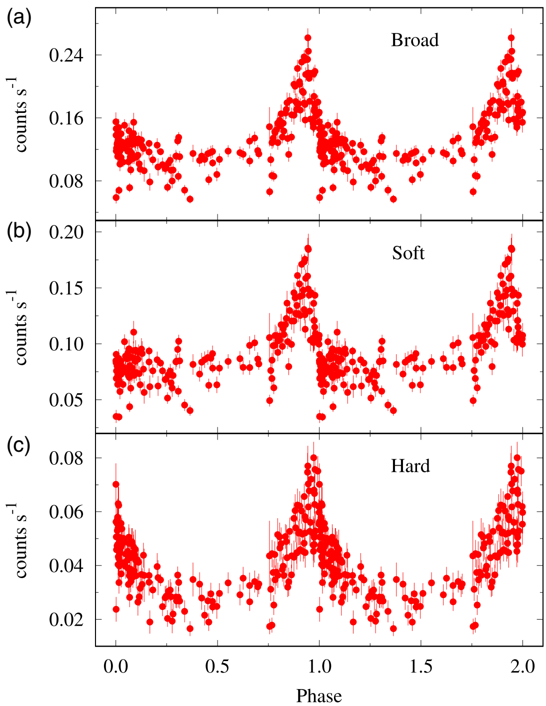

Figure 1. *Swift* observed X-ray light curves folded over the orbital period of WR 25.

the X-ray flux for the long period binaries. The inhibited acceleration of massive stars winds close to the periastron before interacting with each other might be a reason for the brief switch of wind plasma to the radiative regime. The sudden radiative braking of the wind of one component by another may further enhance the velocity drop. However, the temperature of post-shock plasma estimated by the spectral fitting of WR 25 at different orbital phases doesn't seem to support this interspretation. This study has significantly improved the orbital phase coverage of WR 25 as compared to previous studies and hence provided a deeper view of the wind properties (see Arora et al. 2019).

It has also been noticed that some CWBs also act as sources of particle acceleration in their wind collision region through diffusive shock acceleration mechanism (De Becker & Raucq 2013). The relativistic particles (mostly electrons) may inverse comptonize the photospheric stellar light to X-rays or even soft γ-rays. This opens up the possibility that some non-thermal X-ray emission might be measured in CWBs above 10 keV. However, no significant X-ray emission above 10 keV was observed from WR 25 by *NuSTAR* which provides evidence that no inverse compton scattering emission is produced by WR 25 above the background level. The upper limit, that we derived on the putative non-thermal X-ray luminosity, is of the order of 10^{32} erg s^{-1}. We argue that a sensitivity improvement of at least one order of magnitude is needed to access more constraining limits on the putative IC emission, or even have a chance to detect it for massive star systems with the most powerful winds.

References

Arora, B., Pandey, J. C., & De Becker, M. 2019, MNRAS, 487, 2624
Crowther, P. A. & Walborn, N. R. 2011, MNRAS, 416, 1311
De Becker, M. & Raucq, F. 2013, A&A, 558, A28
Gamen, R., Gosset, E., Morrell, N., et al. 2006, A&A, 460, 777
Pandey, J. C., Pandey, S. B., & Karmakar, S. 2014, ApJ, 788, 84

https://doi.org/10.1017/S1743921322004148 Published online by Cambridge University Press