

## Introduction

PSR B1259-63 (PSR 1259) is a radio pulsar with a spin period of  $\sim 48$  ms, in a binary system with a massive, emission-line star of spectral type O9.5Ve (Figs 1 and 2). The star, LS 2883, is commonly referred to as a Be-type star, with optical spectra revealing a dense equatorial outflow and isotropic wind that forms an equatorial disk, purportedly inclined with respect to the orbital plane [1,2]. The pulsar is in a highly eccentric orbit ( $e \sim 0.87$ ,  $P \sim 3.38$  years), around LS 2883, plunging through this circumstellar twice at about 16 days and 13 days before and after periastron, respectively. This interaction of the pulsar wind with the stellar outflow, produces TeV gamma rays as a result of highly energetic particles being efficiently accelerated, producing synchrotron radiation in the X-ray and soft gamma-ray bands, in a time-varying shock [3]. **X-ray polarization to be aligned perpendicular to the magnetic field for synchrotron radiation.**

## IXPE Observations

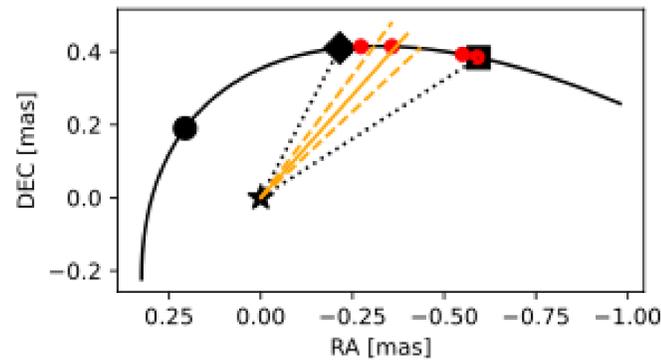
We observed the TeV binary PSR 1259 with the Imaging Polarimetry Explorer (IXPE [4]) as the pulsar passed through the disk after periastron from July 14, 2024 (MJD 60505.417) through July 29, 2024 (MJD 60520.163). This resulted in a total live time of 794.9, 794.5 and 794.6 ks for DU1, DU2 and DU3, respectively [1].

**Fig 1.** shows the observed polarization degree (PD) from the source region for the full IXPE observation is  $8.31\% \pm 1.45\%$  at a confidence level of  $5.3\sigma$ . The electron vector position angle (EVPA) is  $-41.3^\circ \pm 5.0^\circ$ .

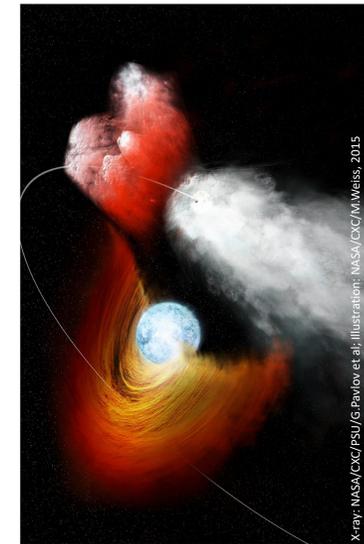
**Fig. 3** shows the IXPE and Swift XRT light curves binned to 19.6 and 86.4 ks, respectively. An absorbed power law with constant polarization was found to fit the IXPE spectrum well, with a photon index of  $\Gamma = 1.602 \pm 0.013$  and observed flux of  $1.6 \times 10^{-11} \text{ erg cm}^{-2} \text{ s}^{-1}$  in the 2-6 keV band [1]. There is probable though inconclusive evidence for variability in the data.

## NuSTAR Observations

Contemporaneous observations of PSR 1259 were acquired by the Nuclear Spectroscopic Telescope Array (NuSTAR) in four, 25 ks snap shots over the IXPE observation (summarized in **Table 1**). The source spectrum is above the background in the 3-79 keV, the energy band used for the NuSTAR analysis. The live times are 24.0, 23.7, 25.2 and 28.2 ks for observations 3002, 3004, 3006 and 3008, respectively. The  $n_H$  was fixed to  $0.7 \times 10^{22}$  (see [5]). The variable hard X-ray source 2RXP J130159.6-635806, 10 arcmin away from PSR 1259, was not found to be flaring and did not contribute significantly to the hard X-ray flux as in Ref [6].



**Fig 1:** The orbital motion of PSR B1259-63. The pulsar moves clockwise around the solid curve, with periastron (black circle), the IXPE start and stop times (black diamond and square), the four NuSTAR observations (red circles), shown. The star represents the system barycenter. The X-ray polarization angle (PA) and uncertainties (solid and dashed orange lines), appears aligned with the directions between the pulsar and star. The black dotted lines show the shock cone of the pulsar.

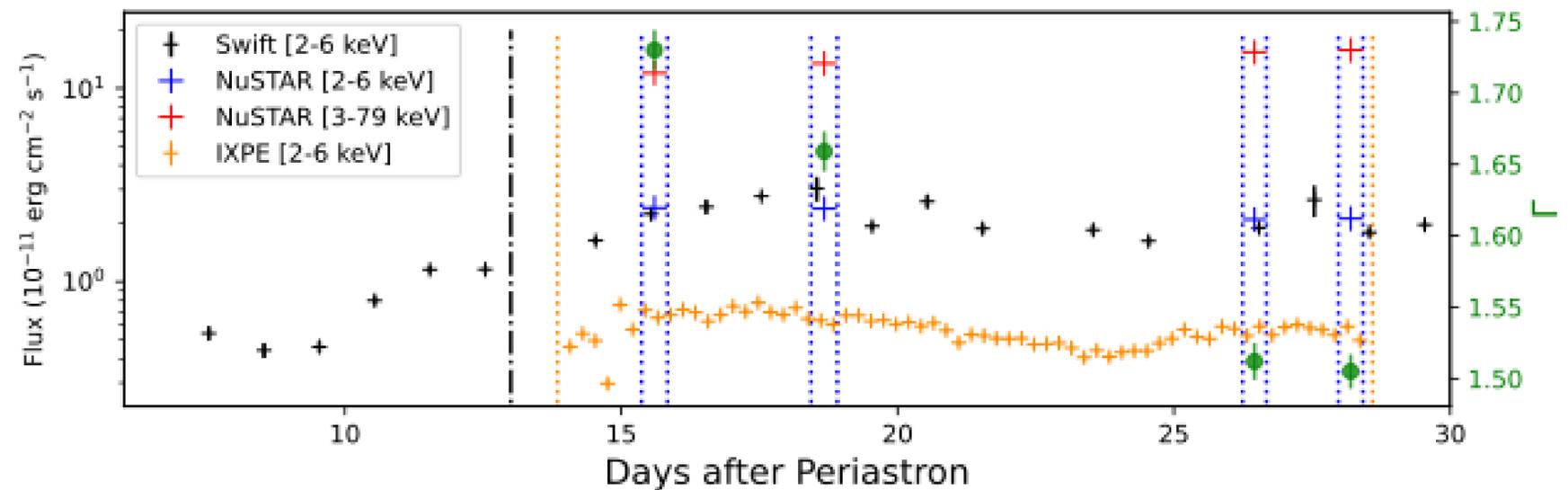


**Fig 2:** An illustration showing the pulsar passing through the disk.

## Results

**First polarization detection of PSR B1259-63 reveals the dominant component of the magnetic field to be perpendicular to the shock axis of symmetry (axis between the pulsar and star), in agreement with PD and PA.**

**Spectral hardening over the NuSTAR observations similar to what was found in Ref. [6], likely due to the energy loss timescale being longer than the acceleration time of the electrons and therefore the X-rays produced by synchrotron emission (See Ref [3] for full derivation).**



**Fig 3:** The Flux for the Swift (black), IXPE (gold) and NuSTAR observations (blue and red) plotted against days after periastron. The dashed-dotted line marks when the pulsar crosses the disk. The spectral indices from the NuSTAR observations (green) are also shown. the dotted lines mark the start and stop of the IXPE and NuSTAR observations.

Obs Id	Start Time (UTC)	Exposure (ks)	t-t <sub>p</sub> (days)	NuSTAR Flux ( $10^{-11} \text{ ergs cm}^{-2} \text{ s}^{-1}$ )		$\Gamma$
				(2-6 keV)	(3-79 keV)	
31002003002	2024-07-15T22:26:09	24	15.3	2.41	11.97	$1.730 \pm 0.014$
31002003004	2024-07-19T00:06:09	24	18.4	2.39	13.44	$1.659 \pm 0.014$
31002003006	2024-07-26T19:26:09	25	26.2	2.10	15.38	$1.512 \pm 0.013$
31002003008	2024-07-28T13:06:09	28	28.0	2.12	15.75	$1.505 \pm 0.012$

**Table 1.** NuSTAR observations of PSR B1259-63. Errors are at the 90 % confidence level.

## References

- [1] P. Kaaret, O.J. Roberts, et al. (2024), ApJL, 974, L1
- [2] M. Chernyakova, et al. (2009), MNRAS, 5231
- [3] M. Tavani and J. Amos. (1997), ApJ, 477, 1, 439.
- [4] M.C. Weisskopf et al. (2022), JATIS, 8, 026002
- [5] M. Chernyakova, et al. (2024), MNRAS, 528, 5231.
- [6] M. Chernyakova, et al. (2015), MNRAS, 454, 2, 1358.

## Acknowledgements

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