

Interstellar and intrinsic polarization of the High-mass X-ray Binary 4U 2206 +54

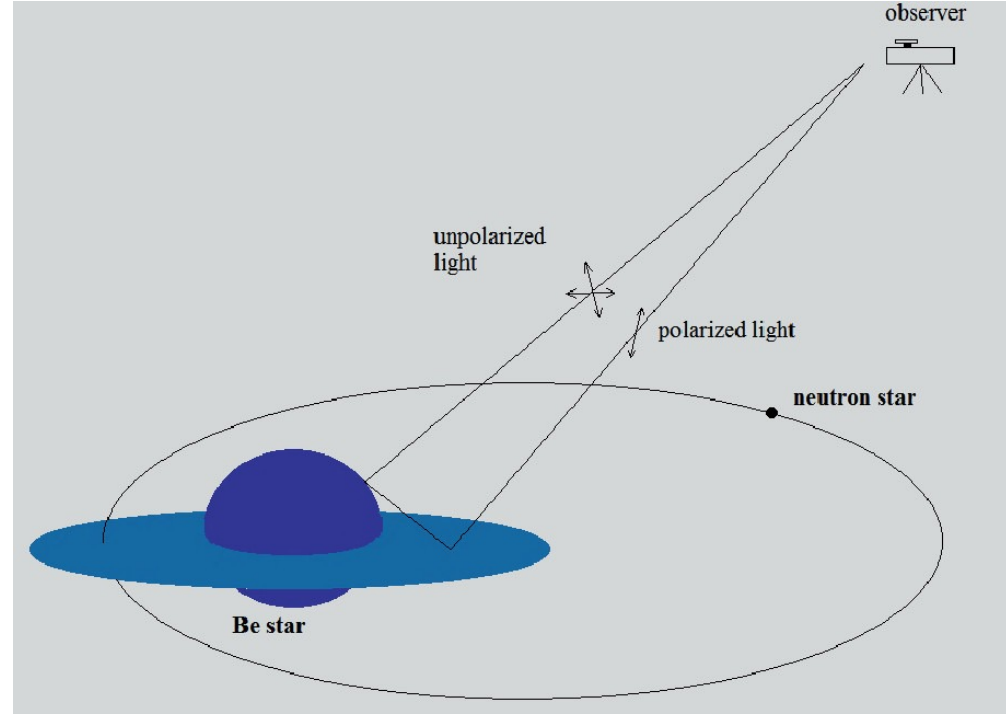


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Introduction

The Be/X-ray binaries consist of a compact object orbiting a Be-star. When unpolarized light undergoes scattering (Thompson scattering)¹ in the circumstellar disc around the Be-star, the scattered light is linearly polarized. The degree of polarization depends on the orientation of the disc relative to the line of sight.



Journal of observations

The observations were made from 2018 October 05 to 2019 October 24.

Table 1: Journal of spectropolarimetric observations of 4U 2206+54 and the stars of the direction of 4U 2206+54.

Object	Date	UT	Exp. ^a (s)	Angular distance	Distance ^b pc	P _V (obs.) (%)	P.A. _V (obs.) [deg.]
4U 2206+54	2018-10-05	18:30	1920			4.15 ± 0.05	38.4 ± 0.3
	2019-06-30	22:56	3200			4.03 ± 0.04	37.2 ± 0.3
	2019-07-02	22:42	3200			4.04 ± 0.04	38.8 ± 0.3
	2019-10-23	19:53	1920			4.05 ± 0.04	39.5 ± 0.3
	2019-10-24	19:54	1920			4.12 ± 0.04	37.3 ± 0.3
2MASS 22075650 +5432038	2019-10-23	20:42	2400	1'	6300 ⁺⁸¹⁴ ₋₈₁₁	3.16 ± 0.17	36.8 ± 2.4
2MASS 22074905 +5432344	2019-10-23	21:34	2400	1.8'	2602 ⁺²³² ₋₁₉₂	3.65 ± 0.13	36.4 ± 1.0

Note: ^a - Total exposure time; ^b Distance based on Gaia EDR3 (Bailer-Jones et al. 2021).

Observations and Data Analysis

Spectropolarimetric observations of 4U 2206+54 and the stars of the direction of 4U 2206+54 were secured with the FoReRo2, attached to the 2m RCC telescope at the Rozhen National Astronomical Observatory³. Polarized spectra are obtained at 8 retarder angles: 0°, 22.5°, 45°, 67.5°, 90°, 112.5°, 135° and 157.5° of the retarder. A beam swapping technique⁴ was used to minimize the instrumental polarization. A standard stars with zero degree of polarization were used for correction of the instrumental polarization. The offset between the position angle in the celestial and instrumental polarization is corrected using strongly polarized standard stars.

Observed degree of polarization and position angle of 4U 2206+54

The position angle has a flat behavior with no visible wavelength dependence and has a value of P.A._{obs} = 38.2 ± 0.5, where P.A._{obs} represents an average value of all observed position angle of 4U 2206+54 in a synthetic V filter.

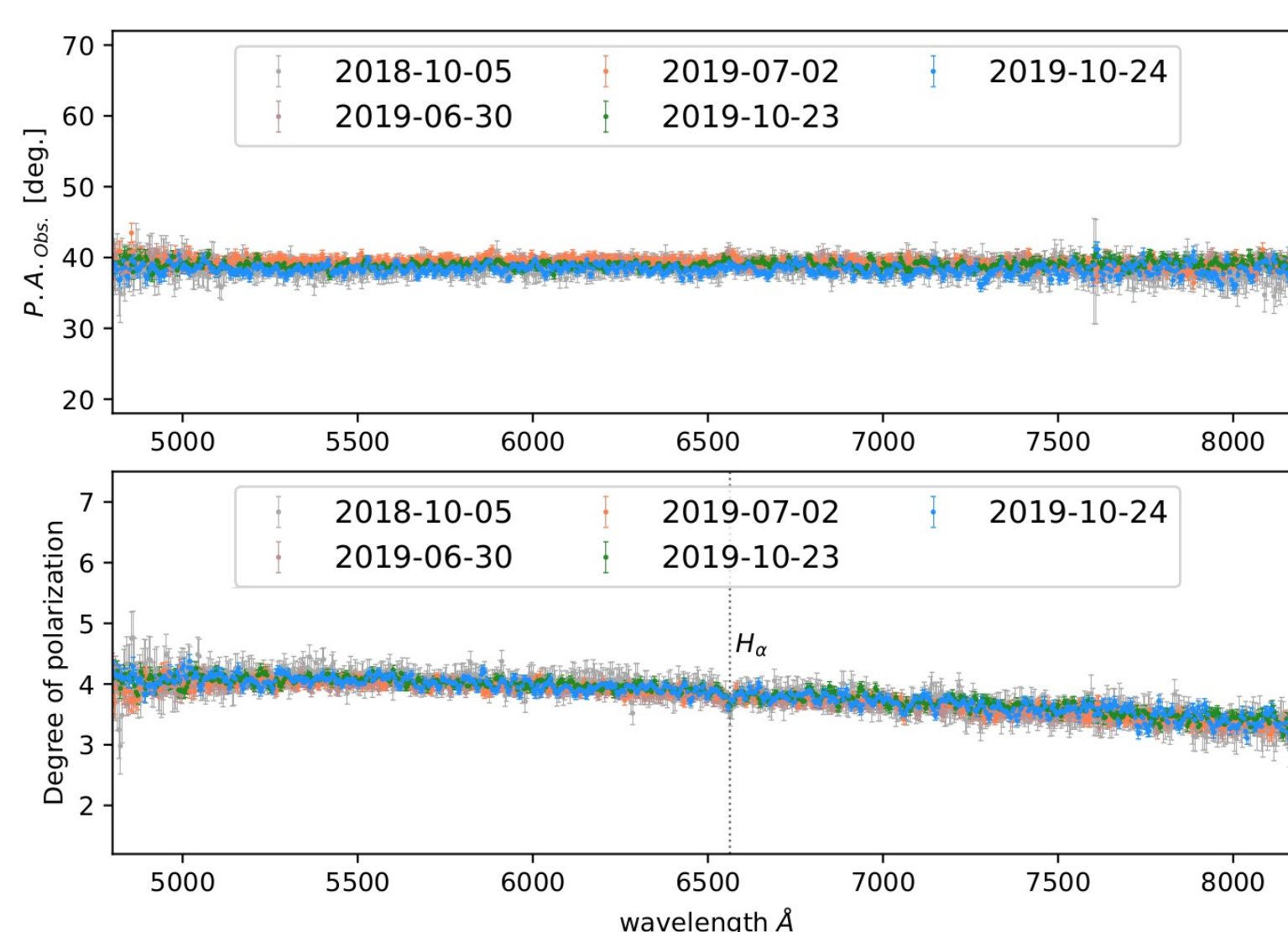


Fig. 1 Observed position angle and degree of polarization of 4U 2206+54.

Interstellar polarization

The 3D map of the linear polarization of the stars from the field of 10x10 deg. around 4U 2206+54. The position angle of 4U 2206+54 is aligned with the position angle of the stars of the direction of 4U 2206+54.

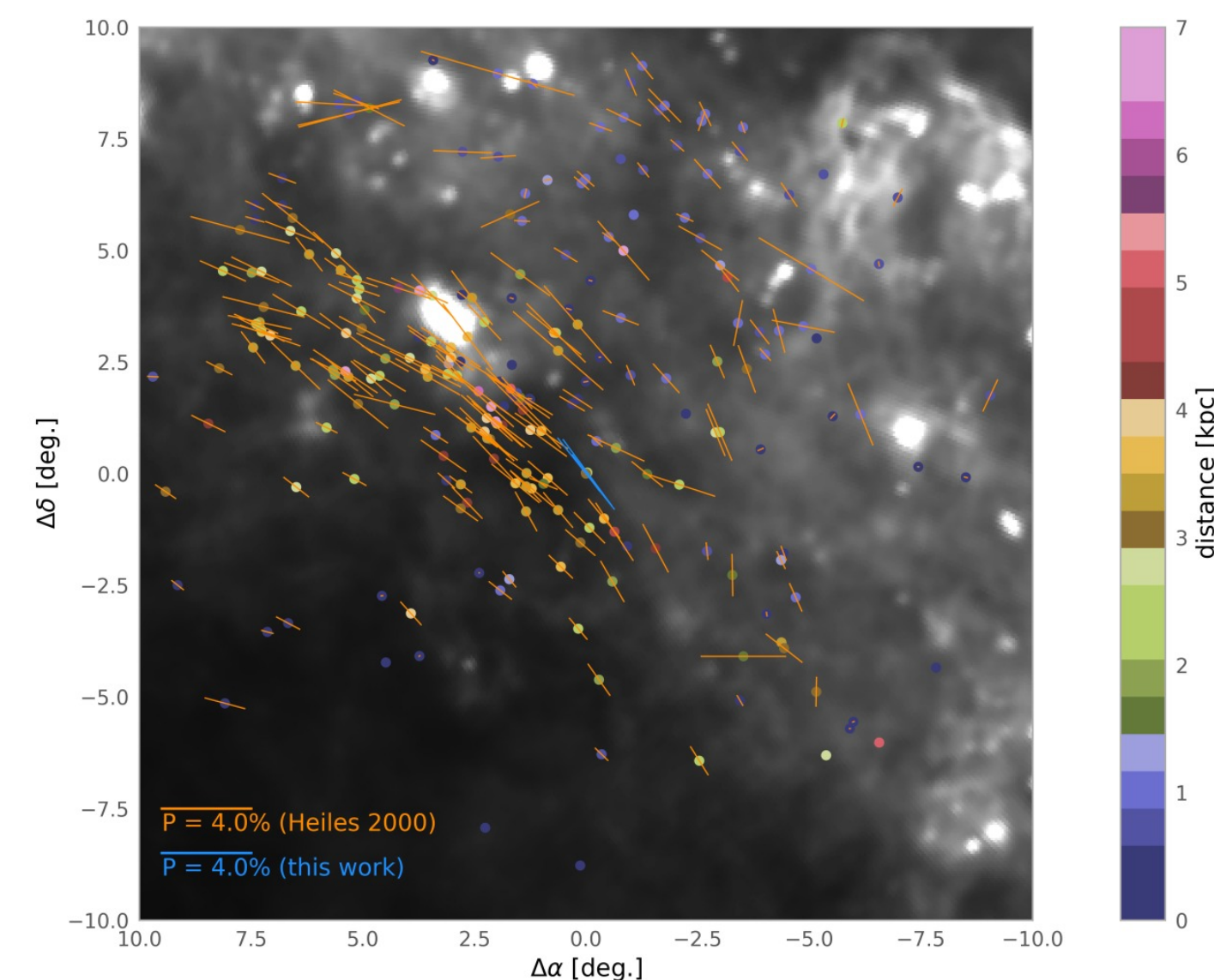


Fig. 2 The interstellar polarization of the field stars around 4U 2206+54 (Heiles 2000). The degree of polarization is proportional to the length of its bar. The horizontal bar of the bottom left presents 4.0% polarization. The color of every star corresponds to its distance. The background image represents 100 μm dust emission maps (Schlegel et al. 1998).

Two stars (2MASS 22075650+5432038 and 2MASS 22074905+5432344) in the direction of 4U 2206+54 were observed to determine the interstellar polarization toward 4U 2206+54.

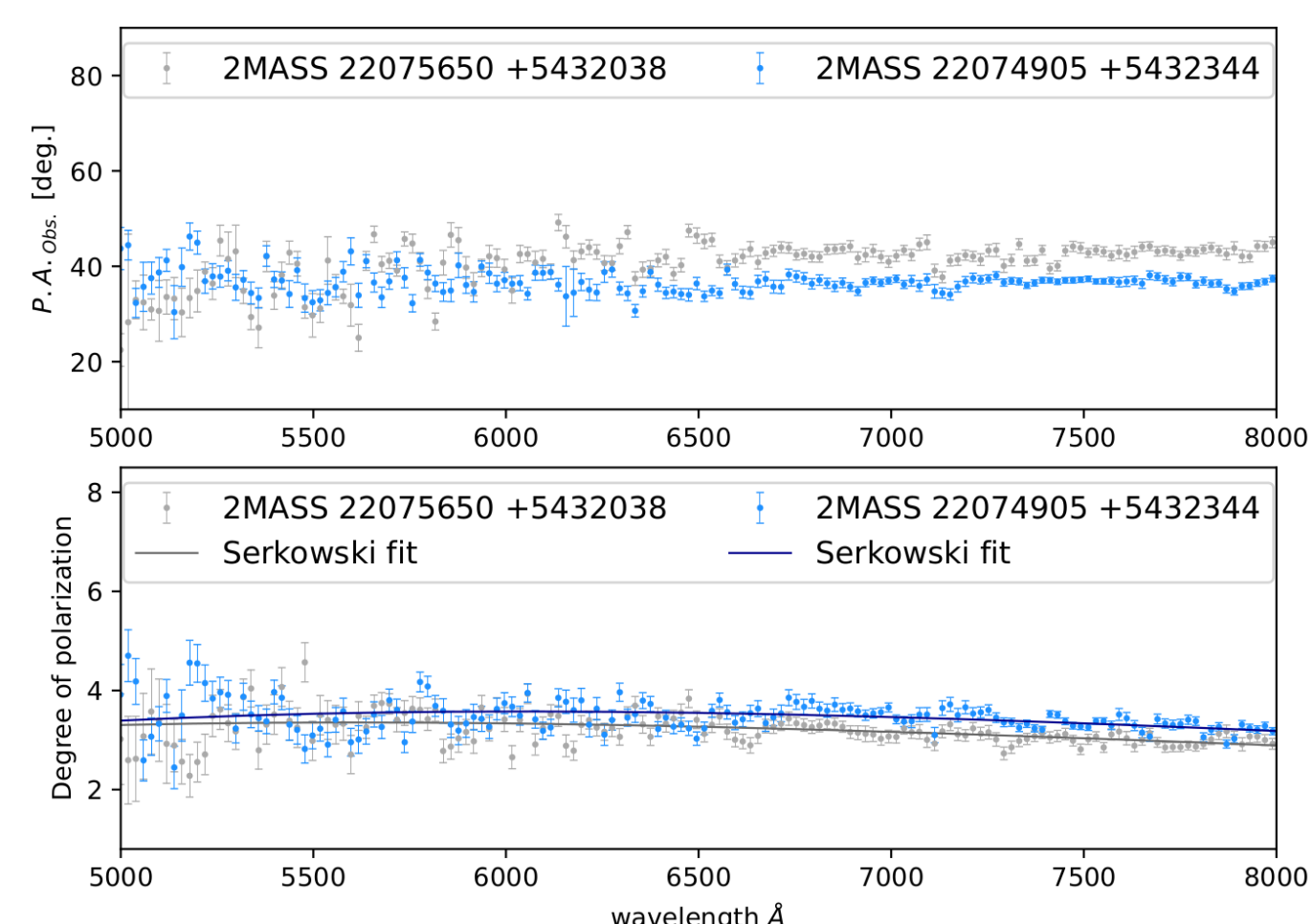


Fig. 3 Observed position angle and degree of polarization of the stars in the direction toward 4U 2206+54.

Depolarization effect in Hα emission line

The depolarization effect in 4U 2206+54 is well visible on the data obtained on 2019-10-23.

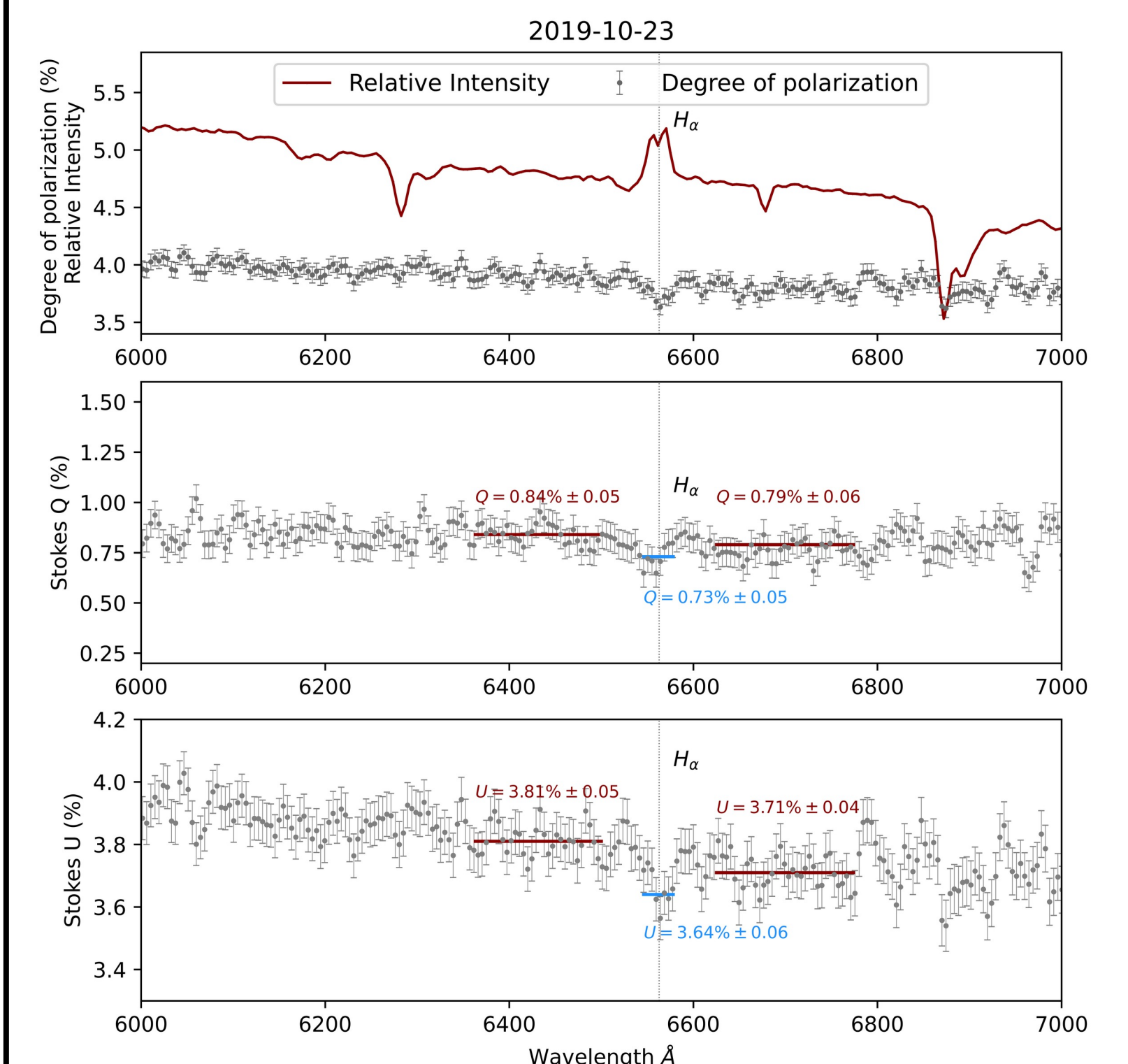


Fig. 4 Depolarization effect in Hα emission line of 4U 2206+54.

The depolarized effect with the values of the marked areas (with darkred and blue) was used to calculate the intrinsic polarization of 4U 2206+54. Based on the depolarization effect the intrinsic degree of polarization is P_{int} (%) ≈ 0.15 at position angle P.A._{int} ≈ 27°. On the other hand, the depolarized effect in Stokes Q (%) is not well visible, for this reason it is possible for the position angle to be P.A._{int} ≈ 45°, if the depolarized effect presents only in Stokes U. The differences of the values of degree of intrinsic polarization, obtained by the two methods can be explain with the intrinsic polarization of Hα emission line or inaccuracy of interstellar polarization, obtained from the stars in the direction of 4U 2206+54.

Conclusions

1. The dominant component of the observed polarization in 4U 2206+54 represents interstellar polarization. A depolarization effect in the Hα emission line is visible, indicating intrinsic polarization. Two methods for determining the interstellar polarization toward 4U 2206+54 - the so-called 'field star method' and a method based on the depolarization effect of the Hα emission line, yield similar results.

2. The intrinsic degree of polarization in the synthetic V-band is P_{int} (V) (%) = 0.5 ± 0.2 at position angle P.A._{int} (V) ≈ 47°.

References

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Acknowledgements

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