Massive Stars Near and Far
Proceedings IAU Symposium No. 361, 2024
J. Mackey, J. S. Vink, & N. St-Louis, eds.
doi:10.1017/S1743921322003167

Polstar : a FUV Spectropolarimetry Mission

Nicole St-Louis[1] **and the Polstar consortium**

[1]Département de physique, Université de Montréal,
Campus MIL, 1375 ave. Thérèse-Lavoie-Roux, Montréal (Qc), H2V 0B3, Canada
email: nicole.st-louis@umontreal.ca

Abstract. In this paper, we give a brief description of the Polstar instrument, an ultraviolet (UV) spectropolarimetric, Midex-class mission proposed to NASA to study the winds of massive stars as well as interstellar medium and protoplanetary discs topics.

Keywords. polarization, ultraviolet: stars, ultraviolet: ISM, Intrumentation: Polarimeters, techniques: polarimetric, techniques: spectroscopic

1. Introduction

Polstar (Scowen et al. 2021) is a Midex-class mission proposed to NASA that will offer the benefit of combining spectroscopy with polarimetry in a wavelength range critical for the study of hot, massive stars, the ultraviolet (UV). This will enable us to probe the intricacies of massive-star winds and in particular their large and small-scale structure, either from magnetic activity, instabilities or fast rotation. Its innovative combination of effective area and time coverage will allow us to study the great diversity of targets necessary to transform our understanding of many science areas in stellar astronomy as well as interstellar medium and proto-planetary disks studies.

Polstar will map stellar wind and magnetospheric structures by uniting time domain, polarimetry and spectroscopy capability in the near- and far-UV (NUV and FUV), which are densely populated with high-opacity resonance lines encoding a rich array of diagnostic information. The science program will be made possible thanks to an instrument that combines advances in high reflectivity UV coatings and delta-doped CCDs with high quantum efficiencies to provide dedicated FUV spectropolarimetry for the first time in 25 years. The planned 3 year mission is 100 times longer that of the *WUPPE* satellite, corresponding to orders of magnitude gains in stellar and interstellar observations.

2. The Instrument

The proposed satellite (Fig. 1) is a combination of the spacecraft, a classic 60-cm all reflective Cassegrain telescope and a 2-channel UV spectropolarimeter that will provide all 4 Stokes parameters. The modulator consisting of a stack of MgF_2 crytals, optimized for the 122–320 nm waveband and placed in a rotary mechanism, as well as the analyzer (a Wollaston prism) (Fig. 2) are placed in line with the output of the telescope near its Cassegrain focus. The modulator serves to isolate the entrance light's polarization and to pass it through the optical system. It is the multiple positions of the rotating modulator that provide the means to fully characterize the input light beam.

The spectropolarimeter will be equipped with 2 distinct channels. The FUV channel, covers 122-200 nm at a resolution of R=30k. This is more than 30 times better than that of WUPPE, with 10 times better effective area, while reaching shorter wavelengths. This will be crucial to gain the ability to access strong lines of species such as N IV and

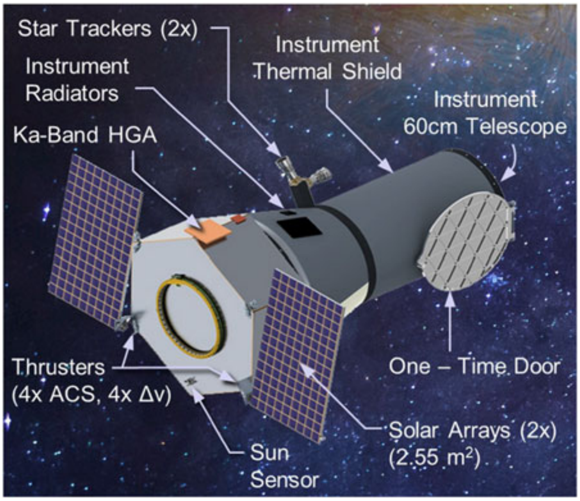

Figure 1. Polstar including the spacecraft, 60-cm Cassegrain telescope and the spectropolarimeter.

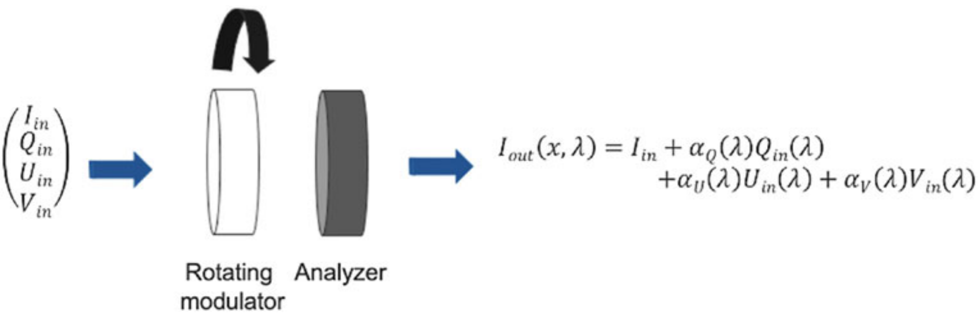

Figure 2. Simplified representation of the principles of the Polstar polarimeter showing the measured intensity (I_{out}) encoding of the input polarization in the 4 Stokes parameters of the incoming beam. Adapted from Figure 4 of Scowen et al. (2021) with permission.

SiIV. The NUV channel covers 122-320 nm at R 140–4k. It will be crucial to enable us to monitor fainter targets at a modest spectral resolution but at a high cadence.

The instrumental polarization stability in both channels is designed to provide signal-to-noise ratios (SNR) corresponding to UV polarimetry precision of $1\text{x}10^{-3}$ per exposure, per resolution element. The precision can be further improved with spectral binning and/or stacking multiple exposures.

3. Main Science Objectives

The science enabled by Polstar is wide ranging and covers 3 broad objectives. The first is *Massive Star Winds* and aims to study how magnetic fields, structured winds and rapid rotation are capable of significantly affecting their evolution. Strong fields will impart magnetic braking on the star and plasma in the magnetosphere will be trapped (ud Doula et al. 2022), altering its mass loss and spin-down rate (Schultz et al. 2022). Clumping and non-spherical winds will alter mass and angular momentum loss (Gayley et al. 2022). The structure of these winds can be probed using selective wind eclipses and colliding winds in binaries (St-Louis et al. 2022). Finally, rapidly rotating stars in massive binaries (Jones et al. 2022) can help understand dynamics at

https://doi.org/10.1017/S1743921322003167 Published online by Cambridge University Press

birth and evolution due to conservative or non conservative mass transfer (Peters et al. 2022). Polstar will also address topics in *Interstellar Medium* research, particularly the nature of UV interstellar extinction (Andersson et al. 2022), and *Protoplanetary Disks*, namely the processes governing the assembly and evolution of star and planetary systems (Wisniewski et al. 2022).

Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S1743921322003167.

References

Andersson, B.G., Clayton, G.C., Doney, K.D. et al. 2022, *Ap&SS*, Topical Collection, in press
Gayley, K.G., Vink, J.S., ud-Doula, A. et al. 2022, *Ap&SS*, Topical Collection, in press
Jones, C.E., Labadie-Bartz, J., Cotton, D.V. et al. 2022, *Ap&SS*, Topical Collection, in press
Peters, G.J.,Gayley, K.G., Ignace, R. et al. 2022, *Ap&SS*, Topical Collection, in press
Schultz, M.E., Casini, R., Cheung, M.C.M. et al. 2022, *Ap&SS*, Topical Collection, in press
Scowen, P.A., Gayley, K., Neiner, C. et al. 2021, *SPIE Conf. Series*, Vol. 11819
Scowen, P.A., Gayley, K., Neiner, C. et al. 2021, *SPIE Conf. Series*, Vol. 11819
St-Louis, N., Gayley, K.G., Hillier, D.J. et al. 2022, *Ap&SS*, Topical Collection, in press
ud Doula, A., Cheung, M.C.M., David-Uraz, A. et al. 2022, *Ap&SS*, Topical Collection, in press
Wisniewski, J.P., Berdyugin, A., Berdyugina, S. et al. 2022, *Ap&SS*, Topical Collection, in press