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EDITORIAL

UV spectropolarimetry for stellar, interstellar, and exoplanetary astrophysics with Polstar

Paul A. Scowen[1] · Carol E. Jones[2] · René D. Oudmaijer[3]

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Over the past decade a series of relatively independent developments have now come to fruition to provide an opportunity for the astrophysics community to pursue.

Scientifically there has been an entire body of work that has focused on the complexities of massive stellar environments, starting at the stellar photosphere and moving outward into both the wind and magnetospheric zones. This work has identified a number of mechanisms that can not only change and channel mass loss from massive stars but as a direct consequence can affect the ultimate evolution of the star. Such processes include mass exchange between binaries, and their impacts can alter the schedule for energy and delivery of processed materials, and how anisotropic that delivery can be at the end of the star's life. The work performed to date has been primarily based on spectropolarimetry in the optical band from facilities like the Canada-France-Hawaii Telescope (CFHT), and an entire community now advances the state of both theory and numerical modelling based on the data acquired.

Over the same period, investment by agencies such as NASA has improved dramatically the performance of optical mirror coatings, dispersive gratings, solid state detectors and polarimetric crystals in both the near and far ultraviolet. These advances are vital because the ultraviolet has often been handicapped by low optical reflectivity, inefficient gratings, and poor quantum efficiency detectors that reduce large collecting areas to only a few square centimeters of effective area for science use. These emerging technologies now realize improvements of factors of 2–3 in each case and combine to enhance performance and observing efficiency. This opens a very real opportunity for a dedicated mission that can bring these advances to bear upon the demands of the science questions and provide very real innovative insight into the problem of how stellar environment ultimately affects stellar evolution. Such insight will inform the role massive stars play in the baryonic life cycle of galaxies, and open doors for a better understanding of the interstellar dust environment and the accretion mechanisms at play in the inner reaches of protoplanetary disks.

This field now stands at an important point where the addition of diagnostics from the ultraviolet band can map the structure and dynamics of material both close to the stellar surface and farther away. For example, the ultraviolet offers far more numerous resonant transitions which can provide vital new information about the processes and their impact. This demands for high spectral resolution combined with polarimetric accuracy at the 0.1% level, in order to deliver signal-to-noise ratios of 1000. As a result, this will provide high fidelity insight into the physical environments and the processes that dominate in those regions, for the scientific analysis of massive stars.

In addition to this, a fundamentally clearer understanding of the nature of interstellar dust can be achieved with a better understanding of the interstellar ultraviolet radiation field. Dust originates primarily in the condensing gas phase of supernova remnants that mark the end of massive star lives, but how the alignment of interstellar grains to magnetic fields is achieved, as well as understanding how the heating of those same grains happens, can be intimately informed via polarimetric measurement. The limitations of previous ultraviolet

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✉ R.D. Oudmaijer
R.D.Oudmaijer@leeds.ac.uk

P.A. Scowen
paul.a.scowen@nasa.gov

C.E. Jones
cejones@uwo.ca

1 NASA Goddard Space Flight Center, Code 667, 8800 Greenbelt Road, Greenbelt, MD, 20771, USA

2 Department of Physics and Astronomy, The University of Western Ontario, 1151 Richmond Street, London, N6A 3K7, Canada

3 School of Physics and Astronomy, University of Leeds, Leeds, LS2 9JT, UK

missions have only sampled the kinds of data needed to address these questions and a fundamental leap in performance is necessary to make such advances.

Finally, a better understanding of accretion mechanisms in protoplanetary disks can be achieved by splitting the degeneracy in possible paths that can set the stage for planetary formation in such systems. The unique diagnostic lines in the ultraviolet can provide this improvement in understanding across a variety of target conditions.

This Topical Collection in the *Astrophysics and Space Science* journal captures and lays out the science drivers inspired by these goals and objectives. The ensemble makes the case for how the delivery of a far (122–200 nm) and near (180–320 nm) ultraviolet spectropolarimetric mission like *Polstar* can provide the necessary sensitivity and performance to allow these questions to be answered. The science drivers demand a combination of polarimetric accuracy of 0.1% in both ultraviolet bands, high spectral resolution spectroscopy in the far ultraviolet, and low resolution spectroscopy combined with high throughput in the near ultraviolet. A discussion of the initial technological design to provide these capabilities is also presented, as was proposed to NASA under the 2021 Mid-sized Explorer (MIDEX) opportunity.

Declarations

Competing Interests The authors declare no competing interests.

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