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Imaging shock fronts in Mira atmospheres

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Abstract. One of the most rewarding observations for probing Mira atmospheres is the imaging and determination of the position of the schock-front. The hot post-shock material is seen in the spectrum by typical emission lines, in particular the Balmer series of hydrogen. The hot zone is very narrow (Fox & Wood 1985), and its influence on atmospheric temperatures and photon fluxes is usually neglected in Mira models (Bessell, Scholz, & Wood 1996, Hofmann, Scholz, & Wood 1998, see also Beach, Wilson, & Bowen 1988 and Bessell et al. 1989). Balmer line fluxes are, however, strong enough to be accessible to high-precision interferometry (from Scholz 2003).

Key words. instrumentation: interferometers – techniques: interferometric – stars: late-type – stars: AGB and post-AGB – stars: fundamental parameters – stars: individual: Mira

1. Introduction and Aim

Imaging at the highest spatial resolution is a major thrust of modern astronomy. Until recently, high resolution imaging at visible wavelengths has been the exclusive domain of space telescopes. The advent of high performance Adaptive Optics (AO) has opened fertile new opportunities for astronomical investigations with ground based telescopes with much larger apertures than can be deployed in space. Combining the new advances of AO with Non-Redundant Aperture Masking (see, e.g., Haniff et al. 1987), the Zero Optical Redundancy with Adaptive Optics (ZORAO) instrument, which is funded by the NSF/AFOSR Astronomy program, aims to achieve unprecedented spatial resolution in optical bandpasses. The advantages in using a Non-Redundant Mask lie in the rejection of atmospheric noise, the precision calibrations of the data using the AO wavefront telemetry and the possibility of image reconstruction with closure phase techniques that is immune to phase errors introduced by the atmosphere, telescope and AO system.

We intend, among other science projects, to image in successive observations the outward motion of a shock-front inside the stellar atmospheres of Mira LPVs. According to models (see Scholz 2003 and references therein) the outward motion of the spherical shock-front

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will produce in its wake an observable, ring-shaped, thin emission zone.

Imaging will be attempted with the ZORAO instrument and the 3.67 m AEOS telescope on Mt. Haleakala, Hawaii using the Hα emission line near minimum visual phase, where the line is most prominent (see Gillet, Maurice, & Baade 1983) and the contrast ratio is less of a problem due to the diminished brightness of the star. Consecutive measurements approximately three weeks apart should be attempted to fully characterize the shock-front, yielding line strength evolution and, given the distance to the object, the shock speed.

The strength of the Hα line varies strongly not only with pulsation phase but also with cycle (see, e.g., Gillet, Maurice, & Baade 1983). In addition it is surrounded by TiO absorption lines and other molecular features, making the observation of the narrow Hα line a technical challenge. In order to characterize the line and it's background, and to minimize the signal to noise ratio, we will scan the spectrum around the Hα using a narrowband filter (bandwidth 1.5 Å). The scanning will be performed by tilting the Fabry-Perot Etalon based filters against the optical axis. The filter is sensitive to the angle of incidence, thus allowing us not only to "sweep" through various central wavelengths, but also to adjust for Doppler shifts due to shock front speeds and barycentric motion of the observed Mira stars. So far, only one observational project was designed for the purpose of imaging the shock front in Miras, and encountered technical problems due to filters that did not match the rigorous requirements arising from the need for extremely high spatial resolutions (tens of milliarcseconds) and dynamic range (P.R. Wood, contact wood@mso.anu.edu.au).

Summarizing, we will be using state of the art AO, which combined with aperture masking in optical bandpasses will provide the necessary tool to investigate the shock front in the atmosphere of a Mira LPV. Together with a tunable filter, we will probe the spectrum around the Hα line and, for the first time, image such a shock wave. With consecutive measurements a few weeks apart, the speed of such a front can be determined, helping better understand the elusive nature of the Mira star atmosphere.

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