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Imaging the circumstellar dust distribution around AGB stars with the NOT/PolCor instrument

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Understanding the mass-loss process and the shaping of the circumstellar outflow around AGB stars is of crucial importance for a proper description of the evolution of low- to intermediate mass stars. The mass loss from the star builds up a circumstellar envelope of dust and gas. The light from the star is scattered by the dust and polarized in a direction perpendicular to the source. Images of the circumstellar envelopes around AGB stars in polarized light can be used to map the dust distribution, search for asymmetries, and to achieve a better understanding of the mass-loss history and the different shaping mechanisms. The PolCor instrument is a combined imager, polarimeter, and coronograph providing images with a spatial resolution up to 0.″2. We have used it to map the dust distribution around three AGB stars; W Aql, DR Ser, and U Cam. W Aql is a binary and we find indications of a bi-polar dust distribution around the star. The observations of the later two clearly reveal the detached shells, likely the result of a strongly enhanced mass loss during the thermal pulse cycle connected to the late evolution of these stars. Mapping the detached shells gives us important clues of the symmetry of the mass-loss process and the late evolution in general.

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Abstract

Stellar light from an AGB star is scattered by the circumstellar dust and polarized in the direction perpendicular to the source. Therefore, images of circumstellar envelopes around AGB stars in polarized light traces the dust distribution and can be used to search for asymmetries, and to achieve a better understanding of the mechanisms at play when AGB stars are transformed into a planetary nebulae. The PolCor instrument is a combined imager, polarimeter, and coronograph providing images with a spatial resolution down to 0.2". We have used it to map the dust distribution around three AGB stars: W Aql, DR Ser, and U Cam. W Aql is a binary and we find indications of a bi-polar dust distribution around the star. The observations of the latter two sources clearly reveal the detached shells, likely the result of a strongly enhanced mass-loss during the late evolution of these stars. Mapping the detached shells gives us clues to the symmetry of the mass-loss and important mass-loss processes.

PolCor

The PolCor instrument is a combined imager, coronograph, and polarizer built for the Nordic Optical Telescope (NOT) by Göran Olofsson and Hans-Gustav Florén at Stockholm Observatory, Sweden. PolCor provides sharp images (with a resolution down to 0.2"), has a well-defined PSF (resulting in a higher image contrast) and a high-quality polarizer.

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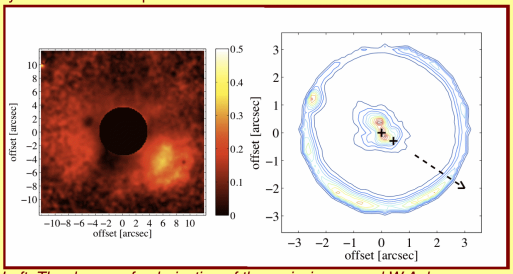
The dust around the S-type AGB star W Aql

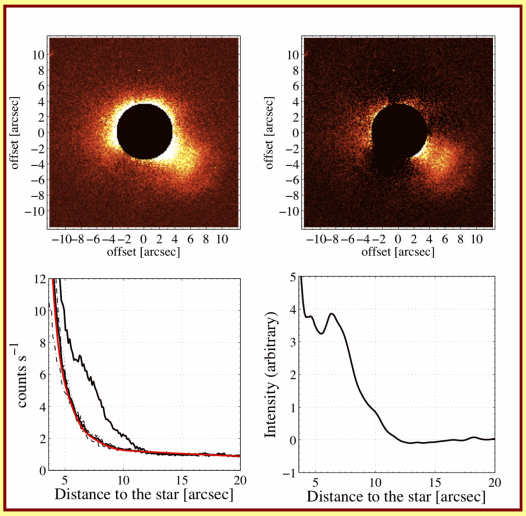
- The circumstellar dust distribution around the binary star W Aql is mapped and found to be asymmetric, both on large (~10") and on smaller (~1") scales. The large scale images show what appears to be a dust density enhancement on the south-east side of the star.

- The polarization degree is found to be consistent with what could be expected when the incident light is scattered 90° by optically thin dust, and the polarization angle is found to be symmetrically distributed around the central star.

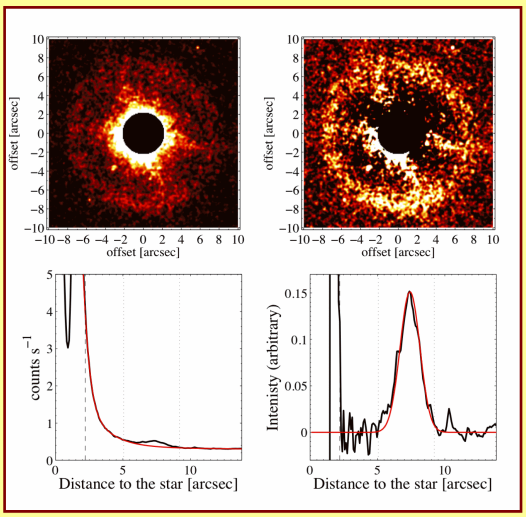
- The close circumstellar environment around W Aql exhibits what seems to be a bi-polar outflow from the AGB star. The dynamics and orientation of the outflow relative to the orbital plane of the binaries cannot be determined at this point, but further observations of the system would be required.



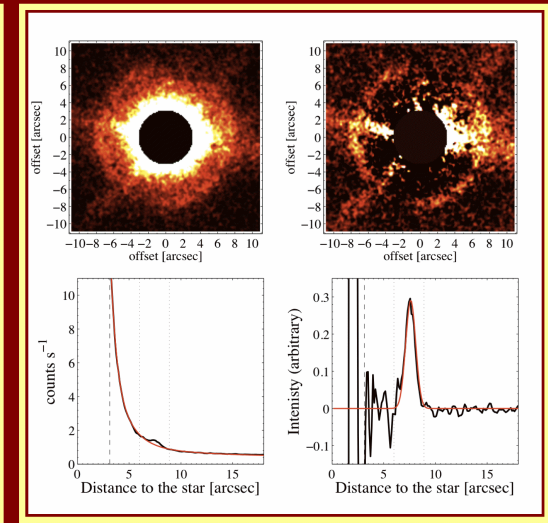
Left: The degree of polarization of the emission around W Aql.
Right: The polarized intensity from the inner 3" around W Aql as seen through the dampening coronographic mask.



Upper left: Total polarized intensity from the inner 10" around W Aql.
Upper right: The corresponding sharpened image.
Lower left: Radial profiles of the four different quarters of the upper image.
Lower right: Radial profile of the SE quarter of the sharpened image.



Upper left: Total polarized intensity of the detached shell around DR Ser.
Upper right: The sharpened image.
Lower left and right: The corresponding radial profiles.
The radius and width of the shell is 8.4x10^{16} cm and 2x10^{16} cm, respectively.



Upper left: Total polarized intensity of the detached shell around U Cam.
Upper right: The sharpened image.
Lower left and right: The corresponding radial profiles.
The radius and width of the shell is 5x10^{16} cm and 7x10^{15} cm, respectively.