Why Galaxies Care About AGB Stars:
A Continuing Challenge through Cosmic Time
Proceedings IAU Symposium No. 343, 2019
F. Kerschbaum, M. Groenewegen & H. Olofsson, eds.

doi:10.1017/S1743921318006579

Imaging Red Supergiants with VLT/SPHERE/ZIMPOL

E. Cannon[1], M. Montargès[1], L. Decin[1] and A. de Koter[1,2]

[1]Instituut voor Sterrenkunde, KU Leuven, Leuven, Belgium
email: emily.cannon@kuleuven.be

[2]Anton Pannekoek Institute of Astronomy, University of Amsterdam, The Netherlands

Abstract. Using the VLT-SPHERE/ZIMPOL adaptive optics imaging polarimeter, images of a sample of nearby red supergiants (RSGs) were obtained in multiple filters. From these data, we obtain information on geometrical structures in the inner wind, the onset radius and spatial distribution of dust grains as well as dust properties such as grain size. As dust grains may play a role in initiating and/or driving the outflow, this could provide us with clues as to the wind driving mechanism.

Keywords. red supergiants, mass loss, winds, circumstellar matter, imaging

1. Introduction

During the red supergiant (RSG) phase, massive stars show powerful stellar winds, which strongly influence the supernova (progenitor) properties and control the nature of the compact object that is left behind. Furthermore, the material that is lost in the stellar wind, together with that ejected in the final core collapse, contributes to the chemical enrichment of the local interstellar medium. The mass-loss properties of RSGs are however poorly constrained. Moreover, little is known about the wind driving mechanism. To provide better constraints on both mass-loss rates and physics, high angular resolution observations are needed to unveil the inner regions of the circumstellar environment, where the mass loss is triggered.

2. The data

SPHERE/ZIMPOL is an adaptive optics imaging polarimeter (Beuzit, 2008) capable of achieving an angular resolution of 20 mas. Our sample consists of five RSGs (Antares, AH Sco, VX Sgr, UY Sct and T Cet) from two observing runs. Each of these RSGs, along with a corresponding calibrator star, were observed in four to six filters within the optical range. The reduced images were then deconvolved using the Lucy-Richardson deconvolution algorithm. A notable difference between Antares and the rest of the sample is that with an angular diameter of 37 mas (Ohnaka *et al.*, 2013), the photosphere is resolved by SPHERE. Though the photospheres of the other four stars, which have angular diameters ranging from 6 to 9 mas, remain unresolved we can still investigate their circumstellar environment.

3. Discussion

From the observations, we compute the degree of linear polarisation. This polarisation signal may be caused by anisotropic scattering on dust grains. Looking at Antares, we see a localised area with a significant signal in the degree of linear polarisation close to the surface of the star (Fig. 1). A similar observation has been obtained on Betelgeuse

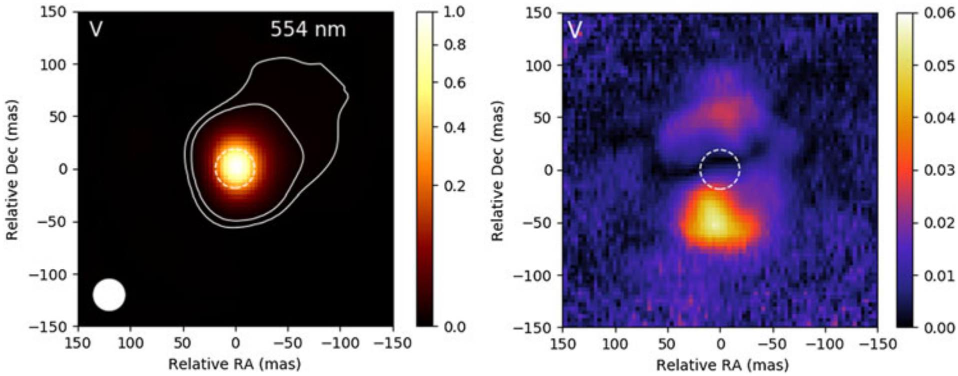

Figure 1. Left: Normalised intensity image of Antares in the V filter. The contours correspond to 20 and 50 times the noise. The dashed circle indicates the size of the photosphere and the filled circle is the beam size. Right: Degree of linear polarisation for Antares in the V filter.

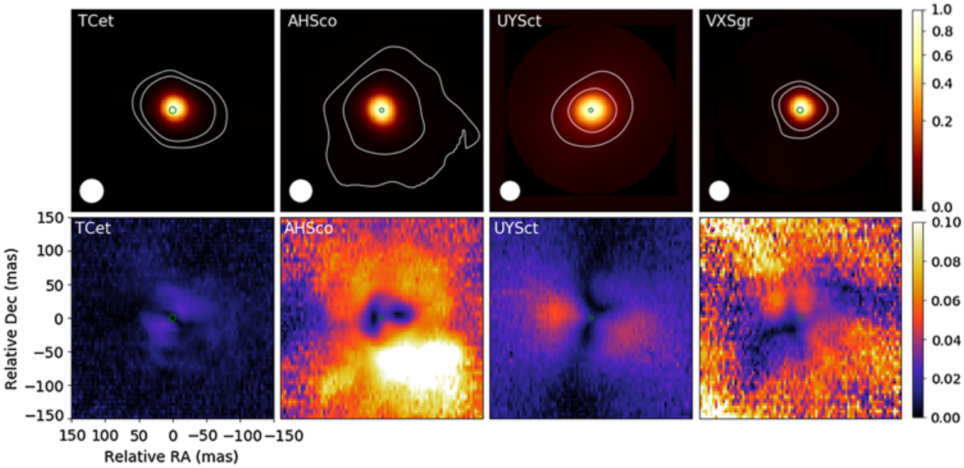

Figure 2. Top: Intensity images in the V filter. The dark circle corresponds to the photospheric diameters. Bottom: Degree of linear polarisation.

by Kervella *et al.* (2016). A significant linear polarisation signal is also seen in three out of four of the other RSGs in the sample (Fig. 2).

The asymmetries that are seen in the intensity images and the localised dust clump we see in Fig. 1 could be linked to processes on Antares' surface such as convection. Radiation pressure on dust grains that are this close to the star could have a significant influence on the mass loss mechanism, though whether this plays a role in driving the wind or perhaps makes a contribution to accelerating will require a detailed modelisation of the dust and its interaction with the radiation field.

4. Conclusions

SPHERE provides us with an unprecedented resolved view of the inner circumstellar environment of evolved stars. Thanks to linear polarisation, we are able to track dust very close to the star. This work will be continued by challenging numerical radiative dust models.

Based on observations made with ESO Telescopes at the La Silla Paranal Observatory under programme IDs 095.D-0458 and 099.D-0600

References

Beuzit, J.-L., Feldt, M., Dohlen, K., *et al.* 2008, *SPIE Conf. Ser*, 7014, 18

Kervella, P., Lagadec, E., Montargès, M., Ridgway, S.T., Chiavassa, A., Haubois, X., Schmid, H.-M, Langlois, M., Gallene, A., & Perrin, G. 2016, *A&A*, 585, A28

Ohnaka, K., Hofmann, K.-H., Schertl, D., Weigelt, G., Baffa, C., Chelli, A., Petrov, R., and Robbe-Dubois, S. 2013, *A&A*, 555, A24