Why Galaxies Care About AGB Stars:
A Continuing Challenge through Cosmic Time
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Observing the mass-loss of nearby red supergiants through high-contrast imaging

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Abstract. We present observations of nearby red supergiants with SPHERE.

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1. Introduction

After massive stars ($M > 8\,M_\odot$) leave the main sequence, they undergo periods of enhanced mass loss before exploding as supernovae. This mass loss is a key factor in determining the further evolution of the stars (Georgy *et al.* 2013, Smith 2014, Meynet *et al.* 2015, Georgy & Ekström 2015). For stars with initial masses $\lesssim 30\,M_\odot$, a large fraction of the mass loss occurs during the RSG phase. The mechanisms driving mass-loss in this phase remain a matter of debate (van Loon *et al.* 2005, Harper *et al.* 2009), in particular the origins of mass-loss asymmetries, variability and eruptions. Answering outstanding questions regarding mass-loss from evolved massive stars requires a systematic approach, in which a large sample of supernova progenitors are homogeneously analysed. Hence, we are conducting a high-contrast imaging and polarimetry survey of nearby southern and equatorial evolved massive stars, primarily red supergiants, exploiting the capabilities of SPHERE. Some initial results of this survey are shown below.

2. Results

Optical polarimetry with ZIMPOL allows high-contrast imaging of extended emission, particularly dust scattering. Two examples of ZIMPOL observations are shown here. VY CMa (see Fig. 1) has clear extended emission in V- and I-bands which is strongly polarised. Fitting the polarisation data with a dust model can reveal the grain size; we find an average size in one region of $\langle a \rangle = 0.56\,\mu$m, and $\langle a \rangle = 0.42\,\mu$m in a second region. This provides direct confirmation of previous suggestions of $\sim \mu$m size grains in RSGs.

On the other hand, VX Sgr is less extended in intensity (Fig. 2). However, clear extension is seen in polarisation, with a centrosymmetric pattern characteristic of a shell or torus. Like VY CMa, the polarisation is higher in I band, suggesting similar grain sizes.

As RSGs emit the bulk of their radiation in the near-IR, sub-micron dust grains can receive a significant amount of radiation pressure by scattering the stellar emission rather

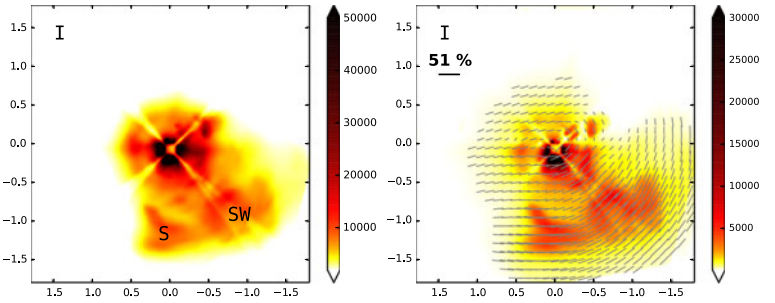

Figure 1. ZIMPOL observations of VY CMa based on Norris *et al.* (2012), with offsets in arc seconds and intensity scale in arbitrary units. *Left*: Total intensity. The locations of the South Knot and Southwest Clump are marked with 'S' and 'SW' respectively. *Right*: Polarised intensity. The overlaid vectors show the polarisation fraction and direction.

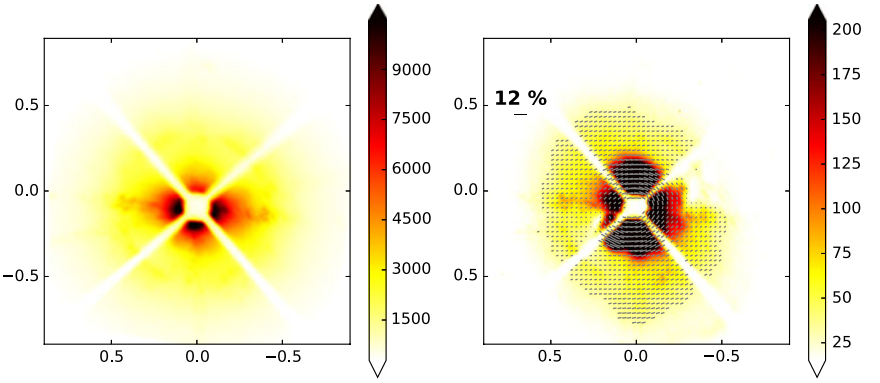

Figure 2. As above, for VX Sgr in the continuum 820 μm filter. The absolute orientation of the instrument has not been corrected for, but both images are given in the same orientation.

than absorbing it (Höfner 2008, Bladh & Höfner 2012). This has been found to be an effective mechanism for driving mass loss in oxygen-rich AGB stars (Norris *et al.* 2012).

3. Conclusions

SPHERE is a powerful tool for detecting extended dust-scattered light around bright evolved stars, including red supergiants. The full sample contains a further 18 red supergiants - the analysis of this data is ongoing, and will place strong constraints on the detectability of extended emission in sources with lower mass-loss rates. In addition, this dataset will reveal distant main-sequence companions over a large mass range.

References

Bladh, S., Höfner, S. 2012, *A&A*, 546, A76
Georgy, C. *et al.* 2013, *EAS Publications Series*, 60, 43
Georgy, C., Ekström, S. 2015, *EAS Publications Series*, 71, 41
Harper, G. M. *et al.* 2009, *ApJ*, 701, 1464
Höfner, S. 2008, *A&A*, 491, L1
Meynet, G. *et al.* 2015, *A&A*, 575, A60
Norris, B. R. M., *et al.* 2012, *Nature*, 484, 220
Scicluna, P. *et al.* 2015, *A&A*, 584, L10
Smith, N. 2014, *ARA&A*, 52, 487
van Loon, J. T., Cioni, M.-R. L., Zijlstra, A. A., Loup, C. 2005, *A&A*, 438, 273

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