

# The carbon star R Sculptoris sheds its skin

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**Abstract.** We describe near-IR  $H$ -band VLTI-PIONIER aperture synthesis images of the carbon AGB star R Sculptoris with an angular resolution of 2.5 mas. The data show a stellar disc of diameter  $\sim 9$  mas exhibiting a complex substructure including one dominant bright spot with a peak intensity of 40% to 60% above the average intensity. We interpret the complex structure as caused by giant convection cells, resulting in large-scale shock fronts, and their effects on clumpy molecule and dust formation seen against the photosphere at distances of 2–3 stellar radii. Moreover, we derive fundamental parameters of R Scl, which match evolutionary tracks of initial mass  $1.5 \pm 0.5 M_{\odot}$ . Our visibility data are best fit by a dynamic model without a wind, which may point to problems with current wind models at low mass-loss rates.

## 1. Introduction

Mass loss becomes increasingly important during the AGB phase, both for the stellar evolution, and for the return of material to the interstellar medium. Some carbon-rich AGB stars are known to exhibit a clumpiness of their circumstellar environment (e.g., [Weigelt et al. 1998](#)). R Scl is a carbon-rich semi-regular pulsating AGB star with a period of 370 days at a distance of  $370 \pm 100$  pc. ALMA observations in CO revealed a spiral structure, indicating the presence of a previously unknown companion ([Maercker et al. 2012](#)).

The near-IR imaging results of the stellar disc presented here are based on [Wittkowski et al. \(2017\)](#). Further descriptions of our results are available in an ESO blog<sup>†</sup> and an ESO picture of the week<sup>‡</sup>.

## 2. Observations and results

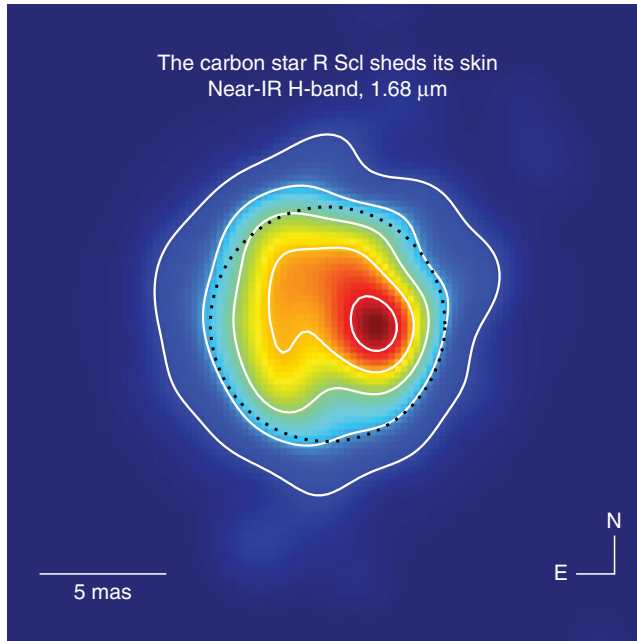
We obtained VLTI-PIONIER data of R Scl at three spectral channels in the near-IR  $H$ -band with baselines between 11 m and 140 m, providing an angular resolution of 2.5 mas. We reconstructed images with the IRBis package ([Hofmann et al. 2014](#)), using a best-fit model as a start image, a flat prior, and smoothness as regularisation. We investigated different start images, regularisations, priors, and image reconstruction packages, and obtained very similar reconstructions in all cases. The resulting images (1.68  $\mu\text{m}$  example in Fig. 1) show a complex structure within the stellar disc, including a dominant bright spot with a peak intensity of 40–60% above the average intensity.

We interpret the features in our images as dust clumps at radii of 2–3  $R_{\text{star}}$  seen against the photosphere. Such dust clumps may be caused by giant convection cells resulting in large-scale shock fronts and leading to clumpy molecule and dust formation, as modeled by [Freytag & Höfner \(2008\)](#) and [Freytag et al. \(2017\)](#).

We compared the VLTI-PIONIER, and VLTI-AMBER, data to a grid of dynamic atmosphere and wind models by [Eriksson et al. \(2014\)](#). We obtained a best fit with

<sup>†</sup> Available at <http://www.eso.org/public/blog/how-stars-die/>

<sup>‡</sup> Available at <http://www.eso.org/public/images/potw1807a/>



**Figure 1.** Image of R Scl at 1.68  $\mu\text{m}$ , reconstructed with the IRBis package. The estimated Rosseland angular diameter is indicated by the dashed black circle. Contours are drawn at levels of 0.9, 0.7, 0.5, 0.3, 0.1. From Wittkowski *et al.* (2017).

a model without a wind, which may point to problems with current wind models at low mass-loss rates. We estimated an angular Rosseland diameter of  $8.9 \pm 0.3$  mas, and derived further fundamental parameters of R Scl, which match evolutionary tracks (Lagarde *et al.* 2012, Marigo *et al.* 2013) of initial mass  $1.5 \pm 0.5 M_{\odot}$ .

## References

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