DEATHSTAR

A new hope for accurate mass-loss-rate estimates for AGB stars

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Context

Through their dusty outflows, Asymptotic giant branch (AGB) stars are major contributors of newly synthesized elements and dust to their host galaxy. Accurate characterization of this phenomenon is therefore key to advancing our understanding of the chemical enrichment of the Galaxy and evolution.

DEATHSTAR stands for DEtermining Accurate mass-loss rates of THermally pulsing AGB stars. The project aims to improve the accuracy of measurements of stellar wind parameters of AGB stars.

Immediate objectives

Significant uncertainty is related to assumptions made regarding **the size and shape of the circumstellar envelope (CSE)** created by the wind.

Method

Using ALMA observations, we directly and systematically measured the sizes of the CO envelopes created by the winds.

- Sample: 27 C-type, 16 S-type, 25 M-type AGB stars
- Observations: CO J = 2 - 1 and 3 - 2 line emissions with ALMA ACA in stand-alone mode
- The 4 largest sources were also observed with total power
- The size estimates were done in the *uv*-plane using the CASA task *uvmultifit* [1].

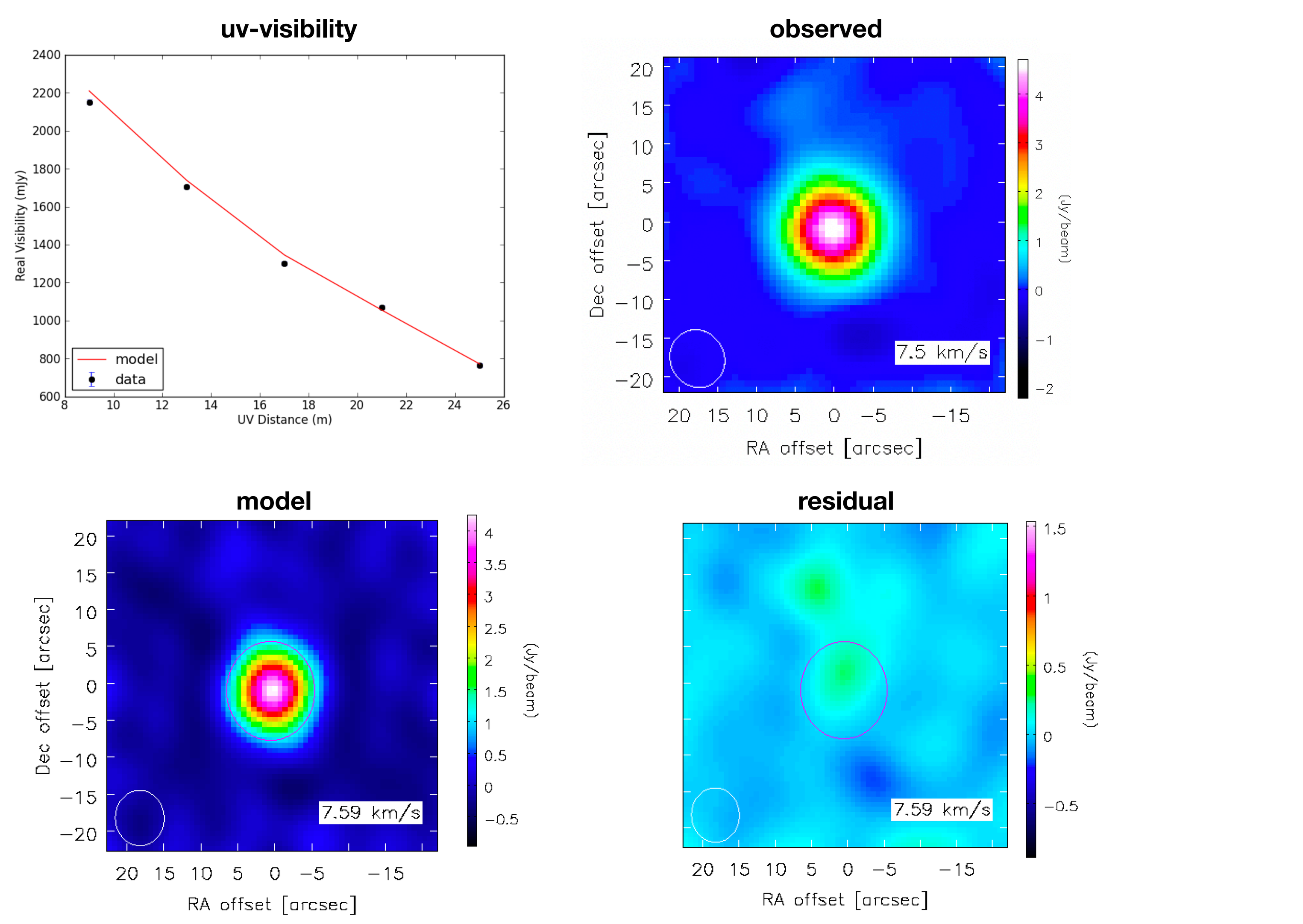

Fig 1. Example of measurement of the CO(2–1) size using *uvmultifit* for the S-star TT Cen. **Top left:** Azimuthally averaged real amplitude of the visibility, the red line shows the best-fit Gaussian model. **Top right:** Color map of the observed CO(2–1) line at the central velocity. **Bottom left:** map of the best-fit model, and **bottom right**: map of the residual at the central velocity.

Results

The ratio between the minor and major axes of the best Gaussian fit obtained from *uvmultifit* was an indication of the degree of sphericity of the CSEs. Axis ratios that lay away from one and/or ratios that are very different in the two CO transitions indicate that the CSEs are not consistent with a spherical shell (see Fig. 2).

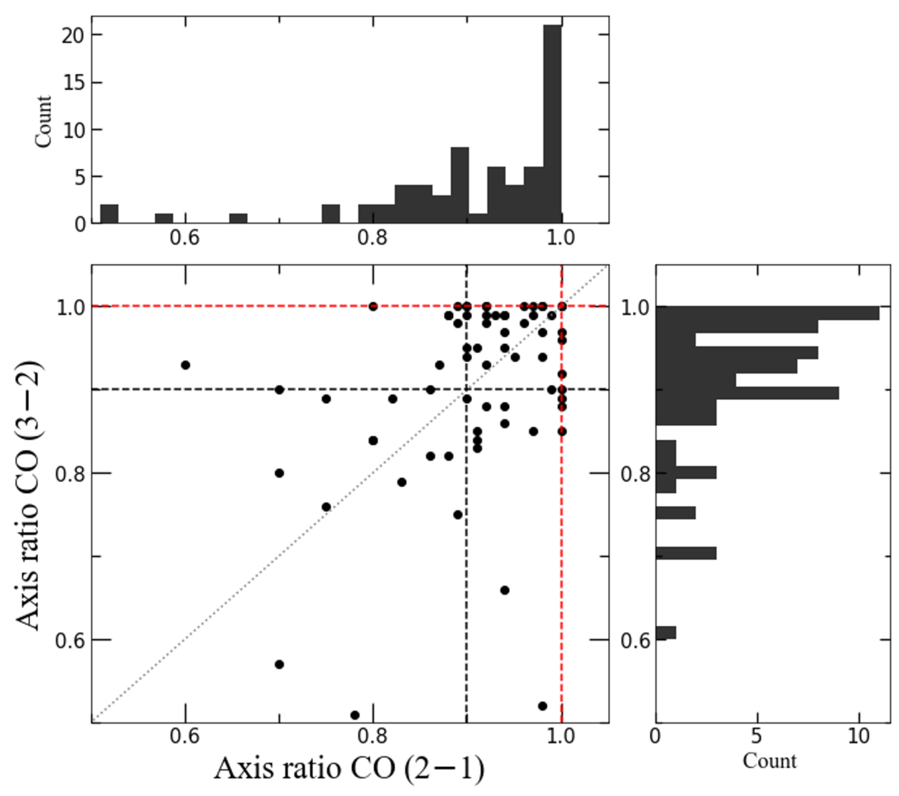

Fig. 2. **Degree of sphericity.** Minor/major axis ratio in CO(2–1) and CO(3–2). The dotted line represents the 1-to-1 relation. The black dashed lines show the limits of an axis ratio equal to unity within 10 percent, and the red dashed lines highlight an axis ratio equal to 1.

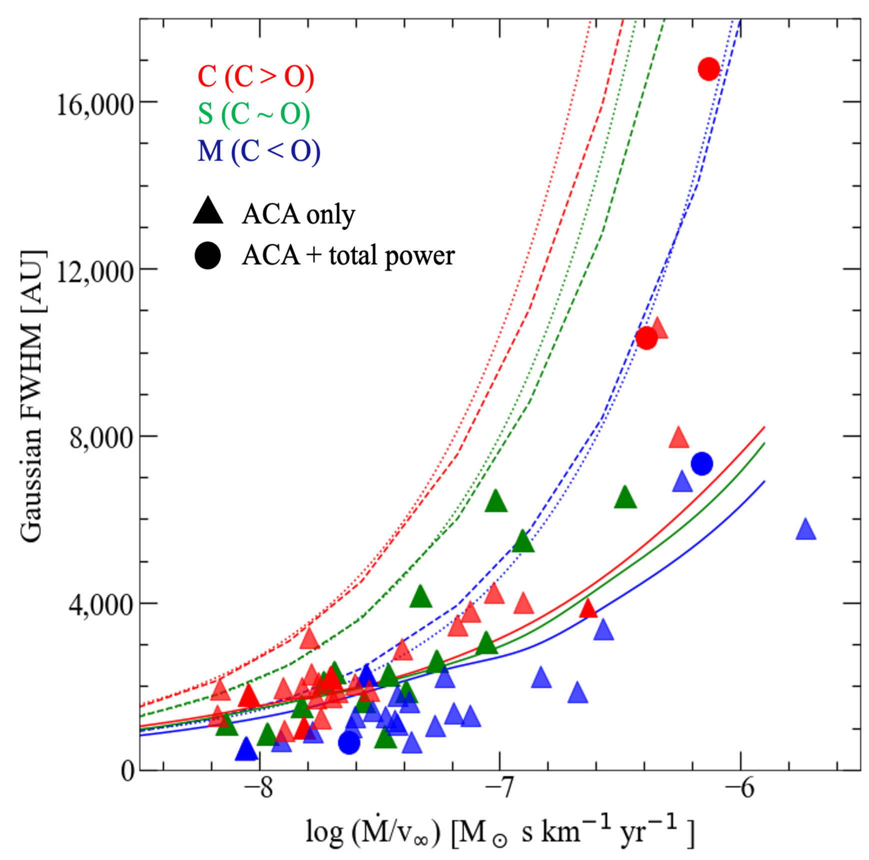

Fig. 3. **Size estimates**. Derived major axis of the CO (2–1) emission vs. density. The dashed and dotted lines show the **photodissociation diameters** from [2] and [3], respectively. The solid lines show the expected diameter of the CO(2–1) line.

Conclusions

- About **one-third** of the sources in our sample are likely **aspherical** (Fig. 1).
- < 20 % of the envelopes of the C-stars show signs of asymmetric features, while ~ 60 % of both M- and S-type stars show some signs of deviation from spherical symmetry. This suggests that the **wind properties likely differ for the 3 chemical types**.
- The CO envelopes of the C- and S-type stars are almost all larger than expected by photodissociation theory [2]. In particular, a number of the envelopes of **the high-mass-losing S-type stars are larger than expected based on their CO abundances** when compared to the M- and C-type envelopes (see Fig. 3).

Current work

The spatial information from the ALMA observations provide important constraints to 1D radiative transfer models of the CSEs of AGB stars. We extracted azimuthally-averaged radial profiles along all signal-bearing velocity channels and compare them with modelled line profiles taken at different offset values from the centre. Fig.4 shows an example of radial profile from the CO(3-2) line of the carbon star R For.

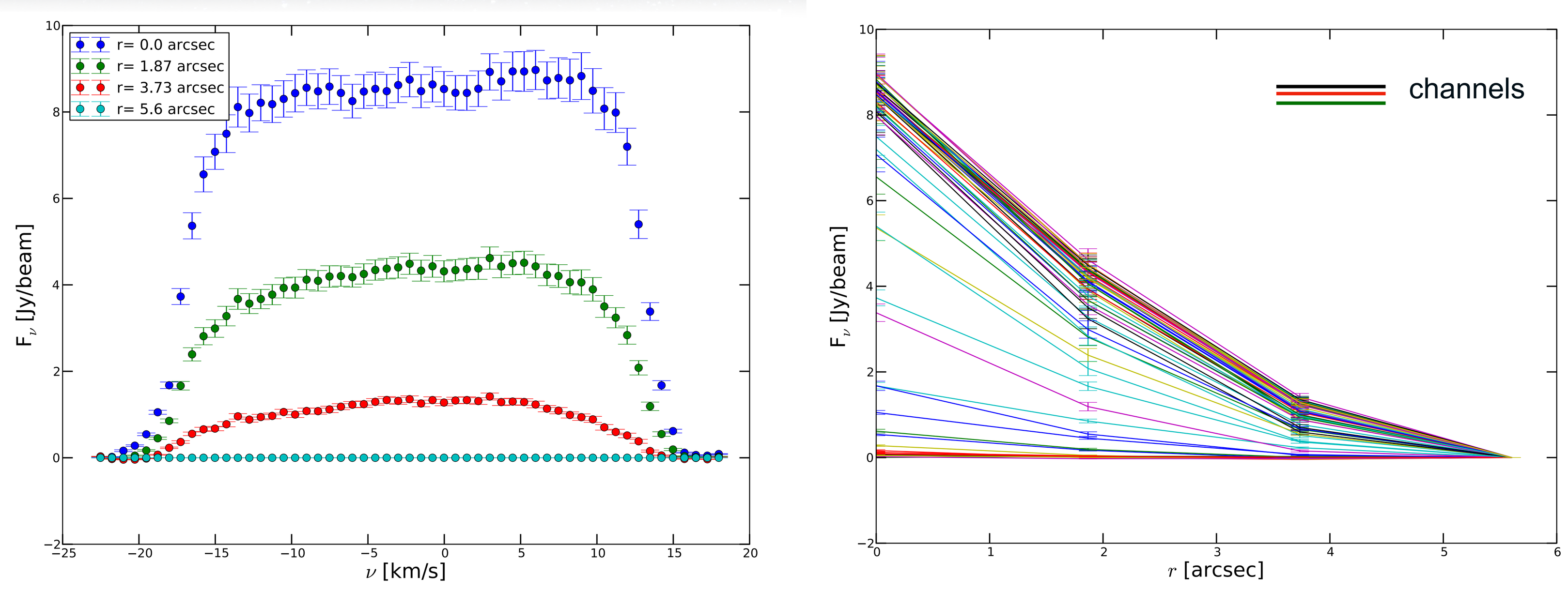

Fig. 4. Two ways to visualise the extracted radial profile at each velocity channel, used to constrain the CO radiative transfer models. This example shows the CO (3-2) emission of the C-star R For.

References

[1] Martí-Vidal, I., Vlemmings, W. H. T., Muller, S., & Casey, S. 2014,A&A, 563, A136;
[2] Saberi , M., Vlemmings, W. H. T., De Beck, E. 2019, A&A 625, A81;
[3] Mamon, G. A., Glassgold, A. E., Huggins, P.J. 1988 ApJ, 328, 797.

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