Why Galaxies Care About AGB Stars:
A Continuing Challenge through Cosmic Time
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The discovery of an asymmetric detached shell around the "fresh" carbon AGB star TX Psc

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Abstract. We present ALMA observations of the circumstellar envelope around the AGB carbon star TX Psc in molecular CO(2–1) emission, and detect a previously unknown detached shell with filamentary structure and elliptical shape. Up to now, all observed detached shells are found around carbon AGB stars and are of remarkable spherical symmetry. The elliptical shell around TX Psc is the first clear exception to that rule, with TX Psc being classified as rather "fresh" carbon star, that most likely has only experienced very few thermal pulses yet. We investigate and discuss the 3D structure of the CSE and its most likely formation scenarios, as well as the link of this peculiar detached shell to the AGB evolutionary status of TX Psc.

Keywords. stars: AGB and post-AGB – stars: carbon – stars: evolution – stars: mass-loss

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TX Psc is a carbon-rich AGB star, with a relatively low C/O ratio (as summarised by Klotz *et al.* 2013). It has been observed in multiple wavelengths and spatial scales. At optical and infrared wavelengths, asymmetries and clumps have been detected close to the star (e.g. Cruzalebes *et al.* 1998, Hron *et al.* 2015). On much larger spatial scales, the interaction region between stellar wind and ISM has been mapped in thermal dust emission by *Herschel*/PACS observations during the Mass loss of Evolved StarS (MESS) observing program of AGB stars by Groenewegen *et al.* (2011). At these scales, Jorissen *et al.* (2011) have reported the detection of a ring-like structure around the star with a radius of $\sim 17''$ in addition to a well separated ISM interaction front. We present ALMA observations of the large scale structure of the circumstellar envelope (PI: M. Brunner, project ID 2015.1.00059.S), which show that the ring-like structure can also be seen in the submillimetre wavelengths in CO(2–1) emission, and in fact the previously observed structure is not spherically symmetric but represents an elliptical detached shell. This is the first detection of an elliptical detached shell, and we discuss the formation scenarios for such a structure in detail in Brunner *et al.* (2018), submitted.

Figure 1 shows an overlay of the ALMA ACA observations in CO(2–1) emission with the previously published *Herschel*/PACS dust emission. The elliptical CO(2–1) shell coincides with the ring-like dust structure, which we believe was formed through the high mass-loss event following a thermal pulse. A possible origin for the ellipticity of the detached shell is stellar rotation, increasing the wind velocity along the equatorial plane with respect to the poles of the mass-losing star. Following model calculations

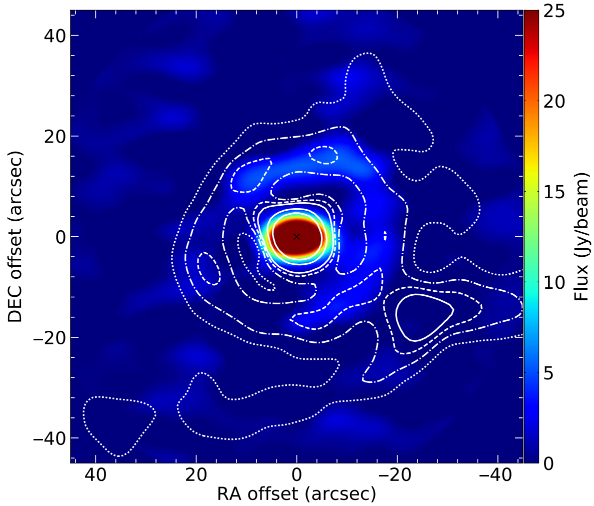

Figure 1. Integrated intensity ALMA CO(2–1) emission taken with the ACA in intermediate resolution (color scale) overlaid with *Herschel*/PACS dust emission at 70 μm (white contours).

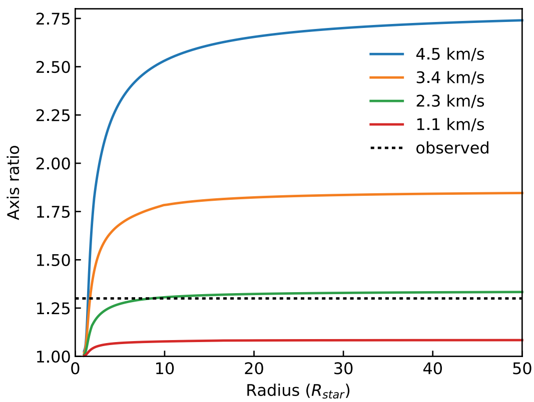

Figure 2. Model calculations of axis ratios for elliptical stellar winds generated through stellar rotation with different rotation rates (colored solid lines) compared to the observed axis ratio of 1.3 (dotted line).

by Dorfi & Höfner (1996), we calculate the stellar rotation rate that would create an elliptical shell with the observed axis ratio of 1.3 for a model star with the parameters of TX Psc. Figure 2 shows that a stellar rotation of ∼2 km/s is sufficient to create the observed ellipticity.

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