Why Galaxies Care About AGB Stars: A Continuing Challenge through Cosmic Time
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Modelling gas and dust around carbon stars in the Large Magellanic Cloud

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Abstract. In order to investigate the effect of dust production on the molecular absorption, we model the dust continuum and the 7.5 and 13.7 μm acetylene absorption features in the *Spitzer* IRS spectra of 148 carbon stars in the Large Magellanic Cloud (LMC). Our preliminary investigation does not find a strong correlation between the dust-production rate and the column density of acetylene for the LMC sample. However, we will construct more models at high optical depths and probe a larger range of dust properties for more robust results.

Keywords. stars: AGB and post-AGB, stars: mass loss, (stars:) circumstellar matter, radiative transfer

1. Background

Acetylene (C_2H_2) is among the most abundant molecules formed around C-rich asymptotic giant branch (AGB) stars (Olofsson 2005). It is a building block for more complex carbonaceous molecules, and may be an important precursor for dust formation. In the mid-infrared, the most obvious signatures of C_2H_2 are its absorption bands at ∼7 and ∼14 μm. Observations indicate that the absorption features persist in heavily dust-obscured carbon stars, the C_2H_2 abundance is independent of metallicity, and that the absorption strength correlates with the mass-loss rate (*e.g.*, Yamamura *et al.* 1999; Matsuura *et al.* 2006). A self-consistent radiative transfer model for the circumstellar gas and dust is required to fully address this problem. In this work, we present an initial step towards such modelling, by investigating correlations between the DPR and the gas column density.

2. Data and analysis

We model the 148 LMC carbon-star spectra obtained by the SAGE-Spec program (Kemper *et al.* 2010; Woods *et al.* 2011; Jones *et al.* 2017). We use the GRAMS carbon-star grid (Srinivasan *et al.* 2011; 12 243 models) to model the dust, and the latest HITRAN line lists for C_2H_2 (Gordon *et al.* 2017; models for 615 pairs of column density and excitation temperature values) to generate the normalised flux from the C_2H_2 slab, using the method described in Cami *et al.* (2010). By convolving the synthetic spectra from the gas and dust, we generate over 7.5 million models. We then compute χ^2 fits to each

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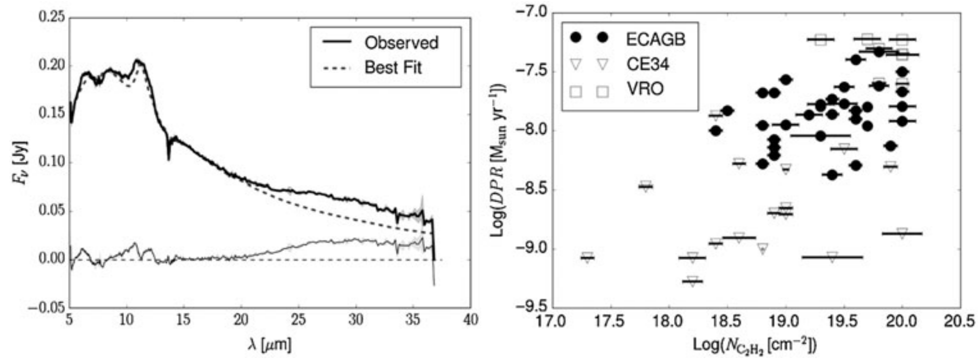

Figure 1. *Left*: best-fit model (thick dashed) to the IRS spectrum of IRAS 04473−6829 (thick solid), along with the fit residual (thin solid). *Right*: DPR as a function of C_2H_2 model column density for optically thin carbon stars (ECAGB; circles), stars with strong SiC emission (CE34; triangles), and for very red objects (VROs; squares).

observed spectrum. The GRAMS models only include amorphous carbon and SiC dust species, and do not account for the 30 μm feature, so we mask out this wavelength range when computing the fits.

3. Results and discussion

Fig. 1 compares the SAGE-Spec spectrum for the LMC carbon star IRAS 04473−6829 with its best-fit model. The molecular features are reproduced, but the shape of the SiC feature isn't. As the long-wavelength edge of this feature blends with the 13.7 μm C_2H_2 feature, it is important that we include a proper treatment in our modelling. The GRAMS grid consists of a dust mixture with a fixed SiC fraction (10% by mass), which affects the fit quality in many cases. We will vary the composition in future modelling.

Fig. 1 also shows the variation of DPR as a function of the best-fit C_2H_2 column density for three types of carbon stars – those lacking strong dust features (ECAGB), those with strong SiC emission (CE34), and the very red objects (VROs). The plot shows no strong trend in the DPR. However, this is partly due to the fact that we are only able to fit a small number of VROs, owing to the sparsity of very optically thick GRAMS models.

In the future, we will extend the GRAMS grid to higher optical depths and also explore a larger range of dust properties (including the 30 μm feature) in order to improve our analysis.

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