DUST FEATURES OF VISUALLY BRIGHT AGB VARIABLES AS SEEN BY ISO AND IRAS

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Abstract. [1]
ISO-SWS spectra of two Mira variables (R Cas and T Dra), taken at two different pulsational phases, are presented. We describe the reduction of the data and the encountered problems. The dust features observed by ISO at different phases and with the Low Resolution Spectrometer of IRAS are compared. We briefly discuss the results in terms of current models for the circumstellar dust shells of AGB variables.

1. ISO Observing Program

We have an ongoing ISO observing program to obtain spectra of several carbon- and oxygen-rich AGB variables at various phases of the pulsation cycle. All observations use AOT 1 with a speed of 2, i.e. full grating scans with a typical resolution of about 600. Here we concentrate on two Miras and two observations for each target. Both objects can be considered as typical Miras.

R Cas: period = 430 [d], spectral type: M6e–M10e, LRS-class: 24,
observed dates: 96/7/21 (phase 0.45) and 97/2/2 (phase 0.90)
T Dra: period = 421 [d], spectral type: C6,2e–C8,3e, LRS-class: 45,
observed dates: 96/3/7 (phase 0.64) and 96/7/21 (phase 0.96)

The phases were dervied from visual data kindly provided by the AAVSO.

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2. Reduction of the ISO-SWS Data

To reduce the spectra we mainly used the ISAP software, provided by the ISO Spectroscopic Data Center (ISOSDC) at MPE (Garching). ISAP starts from the Auto Analysis Results (AAR). However, some AAR data available to us were still preliminary and were therefore processed with the Interactive Analysis (IA) software available at MPE. A main problem in the data are the memory effects. Especially for band 2B (7–12 μm) the down-scan has a systematically higher signal level than the up-scan and has therefore been ignored. The spectra were then rebinned to a resolution of 100 to make them comparable with the LRS data. Since the strong dust features are mainly located within band 2C, we believe that the accuracy for a comparison of these features for a single object should be of the order of 10%.

3. The 11μm Emission of T Dra

The top panel of Fig. 1 shows the SWS spectrum near minimum light. We note that the small features near 9.2 μm and 11.1 μm also show up in the spectrum of R Cas and are likely to be artefacts (Lutz, private communication). The other panel gives the ratio of the maximum light and IRAS-LRS spectrum to the minimum light SWS spectrum. When comparing the ratio of the maximum light and the IRAS-LRS spectrum to the minimum light SWS spectrum, the red wing of the SiC feature seems to be slightly stronger near maximum light. The LRS spectrum looks similar to the maximum light ISO spectrum. The difference in the overall flux level between maximum and minimum light is somewhat smaller than what is found from ground-based mid-IR data (Le Bertre 1992). This could be due to the calibration uncertainties but also partly due to phase shifts between the visual and mid-IR light curve.

One has to keep in mind that there is probably strong C_2H_2 and HCN absorption on both sides of the SiC feature, so the observed variations in the emission can be both due to changes in the feature and in the molecular absorption. The larger ratios below 10μm could be due to stronger molecular absorption near minimum light but also due to a change in the overall continuum. From current dynamic models for carbon stars (Windsteig et al. 1997), one expects only small variations of the SiC feature, with complex phase shifts between the luminosity and feature strength variations. Thus our results are well within the predictions of these models.

4. The 10μm Emission of R Cas

The top panel of Fig. 2 shows the SWS spectrum near minimum light. One can notice the strong SiO and H_2O absorption in the wavelength region between 6 and 9μm which was not accessible with IRAS. The other panel again displays the ratio of the maximum light (full) and IRAS-LRS spectrum (dashed) to the minimum light SWS spectrum. The 10μm Silicate feature seems to be slightly stronger near maximum light. This is in agreement with recent ground based data (Creech-Eakman et al., 1997). The change in the mean flux level between minimum and maximum light is significantly smaller than for T Dra although the visual phases of the ISO observations are comparable for both stars. Ground based mid-IR photometry gives comparable amplitudes for C- and M-stars (Le Bertre 1993). Part of the discrepancy could be caused by the calibration uncertainties in the ISO data but probably also other effects must be involved. The changes in the LRS spectrum are almost the inverse of those in the maximum light spectrum.

An interpretation of the changes in the 10μm region in terms of changes in the dust emission is very difficult. First of all, there is the strong influence of the SiO absorption shortward of 9μm. The lower flux near maximum light would imply a stronger absorption, contrary to what one might expect for a Mira. The larger flux between 10μm and 12μm at maximum could be caused by weaker H_2O absorption. This is indicated by the fact that the feature is flatter near minimum light and water produces broad absorption features in this wavelength region. Further ISO data and improved model spectra for dust *and* gas should help to clarify this point.

5. Conclusions

- There is evidence from the ISO data of C-rich and O-rich AGB variables for variations in the dust features. This confirms ground based results.
- However, an analysis of the dust emission features from AGB variables has to take into account the effect of molecular absorption.

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References

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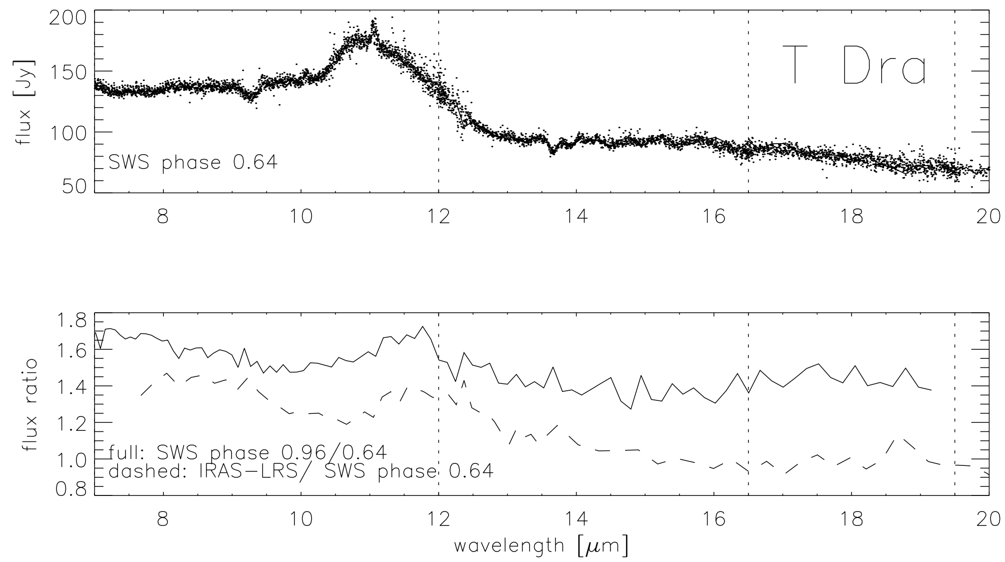

Figure 1. Observed spectrum of T Dra for near minimum light(upper panel) and ratios of the SWS spectrum near maximum and the IRAS-LRS spectrum relative to the SWS spectrum near minimum (lower panel, full and dashed lines). The dots are the individual data points, the full and dashed lines are the rebinned data. The dotted lines indicate the borders of the SWS bands.

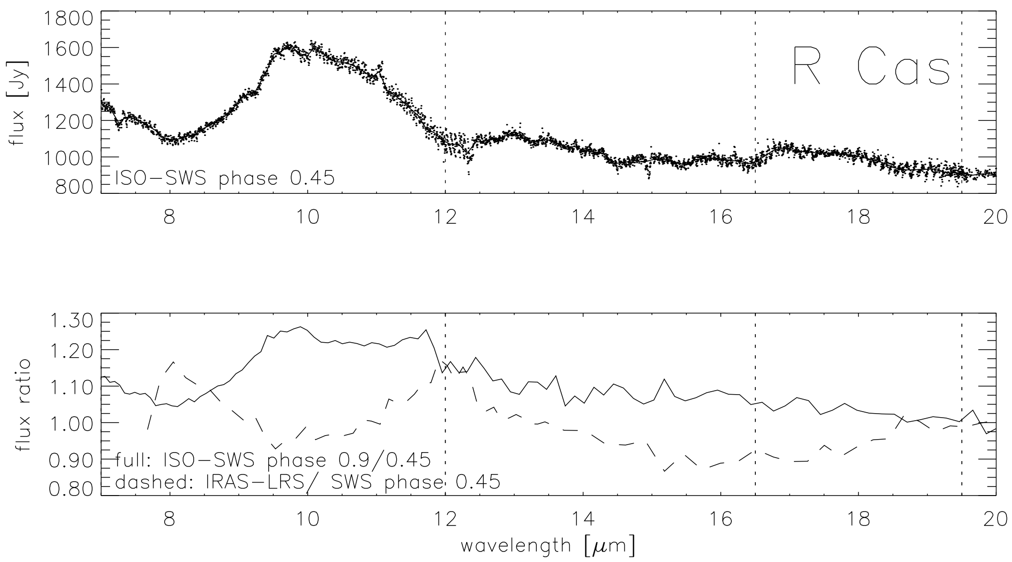

Figure 2. SWS and IRAS-LRS spectra for R Cas (see Fig. 1 for an explanation of the panels and lines)

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