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Identification of three new protoplanetary nebulae exhibiting the unidentified feature at 21 μm

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Abstract. Since its discovery, the feature at 21 μm has been detected in all C-rich proto-PNe of intermediate spectral type (A–G) and – weakly – in a few PNe and AGB stars, but the nature of its carriers remains unknown. In this paper, we show the detection of this feature in the spectra of three new stars obtained with the Spitzer Space Telescope. In the attempt to relate the unidentified feature to other dust features, we retrieved mid-IR spectra of all the 21 μm sources currently known from ISO and Spitzer archives and noticed a correlation between the flux emitted in the 21 μm feature and that emitted at 7 and 11 μm (PAH bands and HAC broad emission). Such a correlation may point to a common nature of the carriers.

Keywords. Stars: AGB and post-AGB, circumstellar matter; infrared: stars

1. Introduction

One of the major results of the *Infrared Astronomical Satellite* (IRAS) mission came from its Low Resolution Spectrometer with the detection of a new broad feature around 21 μm (Kwok *et al.* 1989) in the spectra of proto-Planetary Nebulae (PPNe). Since then, the feature has been detected in 16 C-rich PPNe, intermediate-mass stars (1–8 $M_{\odot}$) transiting from the asymptotic giant branch (AGB) to the Planetary Nebula (PN) stage, and weakly in three PNe (Hony *et al.* 2001; Volk *et al.* 2003) and three AGB stars (Volk *et al.* 2000).

Many different molecules have been considered as possible carriers of the 21 μm feature. The main issues that arise with almost all of the proposed carriers are the presence of secondary features that are not detected in the astrophysical spectra, or the anomalous abundances necessary to account for the observed intensity of the feature.

Within a program aimed at characterizing the dust emission in objects transiting from the AGB to the PN stage, we detected three new sources showing the unidentified 21 μm feature.

2. Observations

We carried out observations of post-AGB stars with the Infrared Array Camera (IRAC; Fazio *et al.* 2004) and the InfraRed Spectrograph (IRS; Houck *et al.* 2004) on-board the

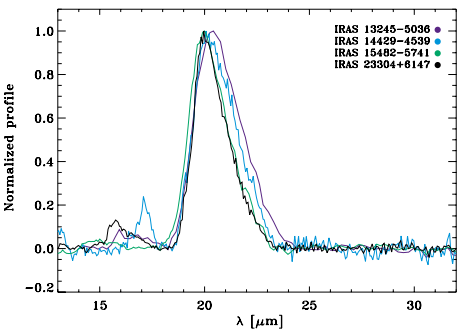

Figure 1. Normalized profiles of the 21 μm feature in our targets compared with that in IRAS 23304+6147.

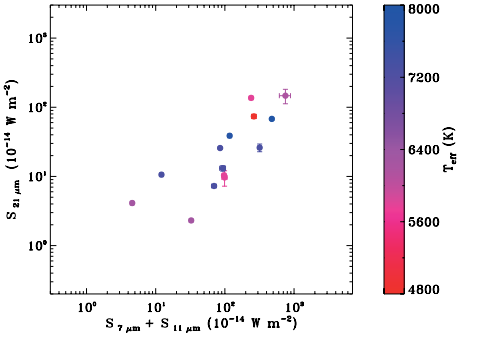

Figure 2. Integrated flux between 5 and 18 μm versus that in the 21 μm feature. The color coding is proportional to T_{eff}.

Spitzer Space Telescope (Werner *et al.* 2004), within Program 50116 (PI: G. Fazio) in March and April 2009.

IRAC observations were performed in high dynamic range mode, while IRS data were typically acquired in low resolution mode, except when saturation could be expected at longer wavelengths. The IRS data were reduced following the standard recipe in the on-line IRS Cookbook.

3. Results

We detected the 21 μm feature in IRAS 13245−5036, 14429−4539 and 15482−5741. Low resolution observations were performed for IRAS 13245−5036 and 15482−5741, while low and high resolution data were collected for IRAS 14429−4539. Figure 1 shows a comparison of the feature in our targets and that detected in IRAS 23304+6147, which can be considered as a typical one. As expected, the features have relatively smooth profiles with no hints for substructures.

We have collected all of the available mid-IR spectra for the so-far known 21 μm PPNe. For each source, we fitted the underlying continuum as a linear combination of gray bodies, then subtracted this continuum and integrated the spectrum over the 18.5–23.5 μm range, dominated by the 21 μm feature, and the 5–18 μm range, where features of Polycyclic Aromatic Hydrocarbons (PAHs) and Hydrogenated Aromatic Carbon are present.

In Fig. 2, we plot the flux in the 5–18 μm range (PAH at 7 and 11 μm) versus that in the 21 μm feature. A correlation is evident, with a linear correlation coefficient of 0.79±0.07. The colors of the dots in Fig. 2 are proportional to the temperatures of the central stars. No clear correlation is observed between the intensity of the features and the stellar temperature. The correlation found between the 5–18 and 21 μm fluxes can point to a common origin of the carriers of the features.

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