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Silicon Carbide as the Carrier of the 21μm feature

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Some proto-planetary nebulae (PPNe) exhibit an enigmatic feature in their infrared (IR) spectra at $\sim$21μm. PPNe which display this feature are all C-rich and all show evidence for *s-process* enhancements in their photospheres, indicative of efficient dredge-up during the ascent of the asymptotic giant branch (AGB). Furthermore, this 21μm feature is not seen in the spectra of either the precursors to PPNe, the AGB stars, or the successors of PPNe, planetary nebulae (PNe). However the 21μm feature has been seen in the spectra of PNe with Wolf-Rayet central stars. Therefore the carrier of this feature is unlikely to be a transient species that only exists in the PPNe phase. It is more likely that the physical conditions in the AGB stars and PNe conspire against the observation of an IR feature at 21μm. This feature has been attributed to various molecular and solid state species, none of which satisfy all constraints, although TiC and PAHs have seemed the most viable.

We have presented new laboratory data for silicon carbide (SiC) and show that it has a spectral feature which is a good candidate for the carrier of the 21μm feature. The SiC spectral feature appears at the same wavelength and has the same asymmetric profile as the observed astronomical feature. We suggest that processing and cooling of the SiC grains known to exist around C-rich AGB stars are responsible for the emergence of the 21μm feature.

In AGB stars, the SiC grains are relatively large ($\sim$ 1μm) and warm (300–1000K). These physical characteristics of the grains suppress the 21μm feature and thus it remains unseen in AGB star spectra. In the post-AGB phase the dust shell drifts away from the star, and thus the dust cools to typically 50–150K. There is also meteoritic evidence that the latest SiC grains to form are smaller than the earlier grains. The combination of grain-size change and cooling allows the 21μm feature to be seen in the post-AGB phase. At the onset of the PN phase the increasing energy of the stellar photons provides enough energy to destroy some of the very small grains. A combination of the removal of small grains and expansion of the dust shell decreasing the column density means that we no longer see the 21μm feature in the PN phase. Therefore, SiC is a good candidate for the carrier of the 21μm feature.

see Speck & Hofmeister, 2002, in prep.