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Detection of the 69 μm band of crystalline forsterite in the Herschel MESS-program

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Abstract. In this article we present the detection of the 69 μm band of the crystalline olivine forsterite within the MESS key program of Herschel. We determine the temperature of the forsterite grains by fitting the 69 μm band.

Results

Crystalline silicates are seen in many astronomical environments like disks around pre-main-sequence stars (Waelkens et al. 1996; Meeus et al. 2001), comets (Wooden 2002), post-main-sequence stars (Waters et al. 1996; Molster et al. 2002; de Vries et al. 2010) and active galaxies (Markwick-Kemper et al. 2007). The PACS instrument of Herschel allows us to study the 69 μm band of forsterite with a better resolution and sensitivity than with ISO-LWS. Forsterite (Mg_2SiO_4) is the iron-poor end member of the solid solution of olivines. A broad range of evolved objects like AGB stars and planetary nebulae are observed in the MESS key program (Groenewegen et al submitted).

Forsterite shows several spectral bands, for example, at 11.3 μm and 33.6 μm . But the band at 69 μm is of particular interest because it is sensitive to the temperature of the crystalline olivine material. The central wavelength of the feature shifts to the red when the material has a higher temperature. Using temperature dependent opacities (Suto et al. 2006; Koike et al. 2006) the 69 μm band can be fitted in order to estimate the temperature of the circumstellar dust particles. Fig. 1 shows such a fit for the post-AGB star OH231.8+4.2 and the planetary nebula NGC 6543. These fits already show a different temperature for the dust grains in the envelopes of both objects.

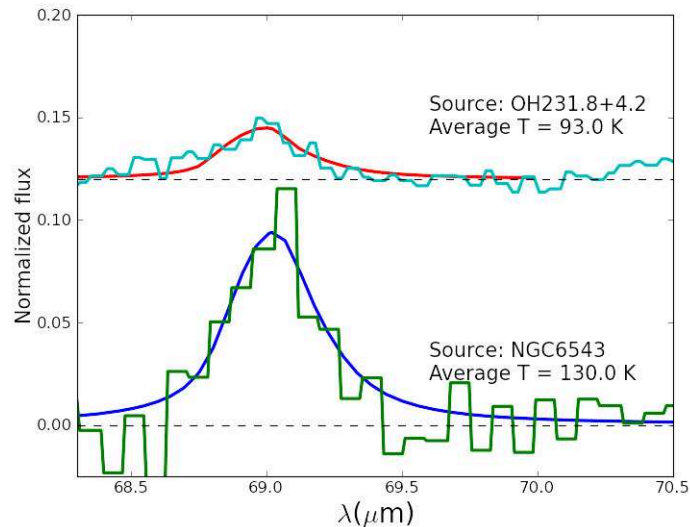


Figure 1. Fits to the $69\ \mu\text{m}$ band of forsterite using temperature dependent opacities (Suto et al. 2006). Fits are shown for the post-AGB star OH231.8+4.2 and the planetary nebula NGC 6543. From the fits we see that OH231.8+4.2 has somewhat colder forsterite than NGC 6543

The fits in Fig. 1 are made assuming crystalline olivine with no iron in its lattice structure. But when the lattice structure does contain some iron, the $69\ \mu\text{m}$ band also shifts to the red (Koike et al. 2003; Sturm et al. 2010). A shift due to a change in temperature of $\sim 100\text{K}$ can also be explained by including $\sim 1\%$ iron in the lattice structure of the crystalline olivine. So far there has not been any indication of crystalline olivines containing iron. By fitting the $69\ \mu\text{m}$ band in combination with mid-infrared features, we will be able to obtain compositional information of the crystalline olivines.

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