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CLOUDY modeling of weird far-IR emission in the central zone of the Helix Nebula

Stars like the sun will evolve into objects that are comprised of a very hot white dwarf central star surrounded by a cloud of gas and dust, known as planetary nebulae. In PNe, UV radiation from the star creates an ionized region bounded by neutral gas and molecules. Hence, they are expected to have an onion-layer structure of concentric shells in which the level of ionization decreases with distance from the central star. The central zone of the Helix Nebula appears as a hole in the classic optical image, yet has been found to produce both He II and [OIV] emission. Strong emission has been observed at 60-100 microns, but is not detected in the mid-IR, or at 160 or 180 microns. The emission in this region is suspected to be due to cool dust grains. We present the results of modeling using the photo-ionization code, CLOUDY, to match this observed emission. Our best fit models fill the central zone with 1 micron sized grains, with a gas-to-dust ratio of 500. These grains are composed of both graphite and astronomical silicate, with little sensitivity to specific grain composition. Additional models were run to limit the distribution of grain sizes. Grains between 0.5-2 microns, with a power law distribution of a^(-3.5) fit within error, as did Gaussian distributions centered at 1 micron, with FWHM up to 0.6 microns, indicating that the dust grains must fall within a fairly narrow range of sizes. As previously predicted, the resulting grain temperatures in the central zone were around 30K. The effects of radiation pressure and Poynting-Robertson drag on dust grains surrounding the central star were also calculated; however, these calculations cannot explain the predicted size distribution. Thus, we also discuss the nature and origin of the dust grains in this region.