The Herschel Planetary Nebula Survey (HerPlaNS); A Comprehensive Dusty Photoionization Model of NGC6781

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We performed a comprehensive analysis of the planetary nebula (PN) NGC6781 to investigate the physical conditions of each of the ionized gas, neutral (atomic and molecular) gas, and dust components in the nebula and the evolution of the central star based on our own Herschel far-IR data augmented with panchromatic archival data ranging from UV to radio. By comparing the empirical nebular elemental abundances with asymptotic giant branch (AGB) star nucleosynthesis models, the progenitor mass was determined to be 2.25-3.0 Msun. By fitting the luminosity of the central star as a function of the distance and effective temperature with the post-AGB evolutionary tracks of 2. 25-3.0 Msun initial-mass stars, we arrived at the best-fit distance of 0.46 kpc with corresponding ranges of stellar parameters: L□ = 104-196 Lsun and Teff = 110-140k K. The excitation diagram analysis of H2 lines indicated excitation temperatures of ~240-1300K. Comparison with theoretical shock models suggested that H2 was excited by shocks caused by two-wind interactions. We found the best-fit dusty photoionization model of the PN using Cloudy that reproduces all of the adopted observational data through iterative model fitting with the derived panchromatic and comprehensive constraints. However, to explain the observed H2 line fluxes, there must be extra heating sources of the photodissociation region (PDR) to keep the temperature of the PDR at ~1500K. Significant portions (~80 %) of the total gas and dust were found to exist in the PDR. The total gas mass estimated by us corresponds to the mass ejected during the last AGB thermal pulse episodes in an initial 2.5 Msun star. The amount of gas stored in the PDR demonstrates that this region is critically important to characterize PNe comprehensively.