Evolution of Carbon-rich Proto-Planetary Objects

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Abstract:

The circumstellar envelopes of evolved stars are important objects for the stellar evolution. As proved by ISO, these objects are very good targets for FIRST (large quantity of dust, molecules...). and it will fill the gap between the mm and ISO. HIFI will allow the study of the inner layers where dust and wind formation occur, to trace shocks, to study the intern photodissociation (PDR), and more especially the mass loss history. HIFI will provide informations about the velocity structure of the envelopes. Black-bodies with temperatures between 10 K and 50 K peak in this wavelength range. Gases with temperatures between 10 K and a few hundred K emit their brightest molecular and atomic emission lines here. The observation of new transitions of H_2O and CO with a high velocity resolution will allow the study of the circumstellar envelopes at intermediate temperatures. Naturally new molecular emissions will be discovered, and fine-structure lines will be observed, as low-lying ro-vibrational transitions of complex species such as PAHs. We will present an example of what ISO teached us about the transition of an AGB star to the PN stage. We compare ISO LWS observations of three C-rich objects typical of each step of the fast transition of an AGB star to the Planetay Nebula stage: CRL 2688, a very young Proto-Planetary Nebula, CRL 618 a Proto-Planetary Nebula, and NGC 7027 a young Planetary Nebula. We underline the violent changes that occur in the chemical composition of these objects due to the increasing UV radiation field and the strong shocks generated by fast stellar winds. The importance of these mechanisms depends on the degree of evolution of the star. This is clearly indicated by the atomic and ionic fine-structure lines appearing in CRL 618, and predominant in the spectrum of NGC 7027. On the other hand, shocks are less important as the evolution goes on. We confirm that O-bearing species other than CO are produced in the innermost region of the circumstellar envelope: the UV photons from the central star photodissociate most of the molecular species produced in the AGB phase and allow a chemistry dominated by standard ion-neutral reactions. Indeed, in CRL 618 H_2O and OH appear; CO molecules are reprocessed. HCN molecules are also reprocessed, leading to strong HNC emission close to the PDR. At this point, CO lines and [OI] atomic lines are the dominant coolants. As the star reaches the PN stage, all the old AGB material has been reprocessed: the CO and other molecules are constantly produced and destroyed. The spectra is now dominated by atomic and ionic lines. New species appear like CH^+; the abundance of OH has increased. There is only weak HCN, and quite no water detected. H_2O has then probably been reprocessed and is only an intermediate molecule of the Proto-Planetary Nebula stage.