Dust Destruction in Expanding Circumstellar Envelopes

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A model of a two-component wind (gas and dust) driven by radiation pressure on dust is developed. Equations of motion for the gas and dust are coupled through a collision term which accounts for the transfer of momentum between the two components. Spherical amorphous carbon grains are assumed to form instantaneously near the sonic point of the flow with either a power law or log-normal size distribution. The grain size distribution is then modified by physical and chemical sputtering. Physical sputtering of grains occurs when the dust drift velocity exceeds a velocity threshold which depends upon the surface binding energy of the dust material as well as the the mass of the impinging gas atoms. Chemical sputtering is the removal of atoms from the surface of a grain by chemical reactions with atoms in the gas phase.

To study the effects of physical and chemical sputtering the size distribution of dust grains is calculated at every point in the flow. Results show that physical sputtering can be important in modifying the grain size distribution when the luminosity of the central star exceeds few $\times 10^4 L_\odot$ and only acts on the largest grains. The smallest grains are closely coupled to the gas and are not modified by physical sputtering. Chemical sputtering is important in modifying the grain size distribution for stellar effective temperatures $\sim 2000$ K and stellar luminosities $\lesssim 10^4 L_\odot$. This allows the grains to remain in the region where the density is high and have their temperatures near $\sim 600$ K. All grain sizes are modified by chemical sputtering, however it affects the small grain sizes the most.

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