P2.31 Dust Destruction by Supernova Shocks

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Massive stars are born and often end their lives in molecular clouds, returning their outer layers to the interstellar medium (ISM). The shock waves produced by supernovae have a dramatic effect on the ISM with which they interact, and they are responsible, for example, for the size distribution of interstellar dust and the abundances in both dust and gas.

We review recent Infrared Space Observatory (ISO), near-infrared and millimeter observations of a number of supernova remnants which are interacting with clouds. Atomic fine-structure lines of [C II], [N II], [N III, [O I], [O II], [O III], [Si II], [P II], [Fe II], and two lines of shocked molecular hydrogen S(3) and S(9), were detected for three remnants using ISO. Virtually all existing atomic lines are detected. No single shock model can account for all of the observed lines. To explain the detected lines requires both moderate (10^2 cm^{-3}) and high ($\sim 10^4$ cm^{-3}) pre-shock densities, with the moderate density shocks producing the ionic lines and the high density shocks producing the molecular lines. The inferred high density and warm temperatures are from heated dense clumps due to supernova shocks, and the principal coolants of radiative shocks are [O I] 63um and [Si II] 34.8um lines. Shock-excited far-infrared emission of molecular hydrogen, OH, and CO are also detected, which is consistent with collisional excitation in warm, very dense (2x10^5 cm^{-3}) gas. We also took high resolution images of the significance coolants molecular hydrogen and [Fe II] using ground-based observations, which reveal how shocks develop around clouds. We found strong correlation between broad CO and shocked molecular hydrogen lines. Displacements between molecular hydrogen and [Fe II] structures are often observed, showing that a single primary shock is present on large scales.

The bright [Si II] and [Fe II] lines we observed require partial destruction of the dust. The required gas-phase abundance of Fe suggests 15–30% of the Fe-bearing grains were destroyed. Adding the Si and Fe gas mass, and correcting for the mass of other elements normally found in dust, we find $\sim 0.5 M_\odot$ of dust vapors from the shocked clump in 3C 39. The infrared continuum brightness requires $\sim 1 M_\odot$ of dust survives the shock, suggesting about 1/3 of the dust mass was destroyed, in agreement with the depletion estimate and with theoretical models for dust destruction.