Radiative Shock Instabilities from the Laboratory to Cassiopeia A

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We report on laboratory investigations of hydrodynamic instabilities of radiative shocks. The Pharos laser in the NRL Plasma Physics Division launches a shock in a tube filled with various gases. The 1-D geometry allows us to study in detail the structure of the shock front. The aim is to understand with more precision the microphysical properties required for such shocks to develop corrugation or rippling instabilities/overstabilities (Vishniac 1983, Ryu & Vishniac 1987, Vishniac & Ryu 1989, Grun *etal.*, 1991, Mac Low & Norman 1993) that in their nonlinear phases can lead to the formation of knots or clumps of plasma by the shock.

Such phenomena have been discussed in the astrophysical literature in connection with the formation of stars, globular clusters or galaxies by interstellar or intergalactic shock waves. However the particular astrophysical application we have in mind is to the formation of the fast moving flocculi of the supernova remnant Cassiopeia A. These are nitrogen rich knots moving away from the explosion center with speeds $\sim 10,000$ km s^{-1} (Fesen 2001). Being nitrogen rich places them in the outer layers of the progenitor and rules out instabilities associated with nuclear burning of the otherwise oxygen-rich ejecta i.e. Rayleigh-Taylor or Richtmeyer-Meshkov instabilities. We speculate that the early phase of the reverse shock was sufficiently radiative to allow these knots to form.

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