Dynamics of Supernova Remnants with Ejecta and Circumstellar Bubbles

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Abstract

Progenitors of core-collapse supernovae (SNe) blow bubbles in the ambient medium and sweep it into shells with their powerful stellar winds. After the explosion, SN ejecta initially collide with the stellar wind, then with the wind-blown bubble, and finally with a dense wind-swept shell. This collision is particularly energetic for SNe whose progenitors lost most of their outer envelopes just prior to explosion: the brightest galactic supernova remnant (SNR), Cas A, is a prime example of such an interaction with the circumstellar medium (CSM). The SN ejecta are far from being smooth for such remnants, because of vigorous turbulence and mixing of heavy-element ejecta immediately after the explosion and subsequent growth of Ni-Fe bubbles powered by the radioactive decay.

We study the interaction of "bubbly" SN ejecta with a CSM bubble and a swept CSM shell, using hydrodynamical simulations in 2 and 3 dimensions with the VH-1 hydrocode. We compare our simulations with analytic self-similar (Chevalier & Liang 1989) solutions and with our previous simulations of interaction of bubbly ejecta with a uniform ambient medium. When compared with these simulations, the impact of bubbly ejecta with the shell results in a more vigorous turbulence and mixing. Dense and cool ejecta at the boundaries of adjacent bubbles may penetrate the shell, leading to plume-like and ring-like features. We examine whether such an interaction is responsible for the observed morphology of Cas A as seen by the *Chandra* X-ray Observatory and the *Hubble* Space Telescope, and for the different expansion rates seen at X-ray and radio wavelengths.

CATEGORY: SUPERNOVAE, SUPERNOVA REMNANTS AND ISOLATED NEUTRON STARS