Ionization-Gasdynamics Models and X-ray Spectra of Wind-Blown Nebulae around Massive Stars

Vikram V Dwarkadas[1] and Duane Rosenberg[2]

[1]University of Chicago
[2]NCAR

March 22, 2012

Abstract

Using a new code that employs a self-consistent method for computing the effects of photo-ionization on circumstellar gas dynamics, we model the formation of wind-driven nebulae around massive stars. Our algorithm incorporates a simplified model of the photo-ionization source, computes the fractional ionization of hydrogen due to the photo-ionizing flux and recombination, and determines self-consistently the energy balance due to ionization, photo-heating and radiative cooling, taking into account the effects of geometrical dilution and of column absorption of radiation. Shocks are treated using an artificial viscosity, and grid expansion is available. We take into account changes in stellar properties and in stellar mass-loss over the star's evolutionary lifetime. Our multi-dimensional simulations reveal the presence of strong ionization front instabilities, similar to those seen in galactic ionization fronts.

Using various X-ray emission models, we compute detailed X-ray spectra of wind-blown nebulae from our simulations, as would be seen with the ACIS-S instrument on Chandra. These are compared with observed X-ray spectra. We show that at certain epochs of the evolution, our synthetic spectra in the Wolf-Rayet (W-R) stage agree quite well with those obtained from observed W-R nebulae. Unlike other calculations, our detailed spectra indicate that diffuse X-ray emission from most main sequence and W-R nebulae would NOT be easily observable with currently available X-ray satellites, which is consistent with the observational data.