Heavy Element Contribution to the X-ray Spectrum of Supernova Remnants: Plane Shock Model

Sean P. Hendrick, Kazimierz J. Borkowski (*North Carolina State University*)

Abstract

As supernova remnants evolve, the source of the X-ray emitting plasmas changes from the shocked ejecta to the swept up interstellar medium (ISM). The spectra of young remnants are dominated by the heavy elements in the ejecta. The spectra of mature remnants are dominated by the swept up ISM, but can also include a contribution from the reverse shock traveling through the ejecta. Current non-equilibrium ionization (NEI) models used to determine X-ray spectra consider the full ionization of hydrogen and helium as the only source of electrons in the plasma, and ignore the contribution of heavy elements such as C, N, O, Mg, Ne, Si, S, Fe, and Ni to the electron density. Plane shock NEI models also assume that electron temperature and shock temperature are constant over the entire post shock region, which cannot be the case. A new model has been created which includes the contribution of the heavy elements to the electron density. This model assumes a parallel-plane shock traveling through the plasma and Coulomb heating of the electrons in the post shock region. We can include arbitrary amounts of non-Coulomb heating at the shock front. Ionization fractions for each element are calculated over a range of ionization timescales, and the temperature of the electrons is determined at each step. The spectrum is the sum of the contribution of each ion of each element for each temperature. This model was compared to existing NEI models by fitting it to simulated spectra created by the NEI models, and by fitting archival ASCA data with each model. With this new tool, one can perform spatially resolved spectroscopy and determine the velocity of the reverse shock. This model has been written to work with the XSPEC spectral fitting software.

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