Planetary Nebulae - An Exciting New Addition to the Family of X-ray Sources

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[Contributed talk, 15min.]

Abstract

Planetary nebulae (PNe), consisting of material shed by low- and intermediate-mass stars at late evolutionary stages, are formed by the current fast stellar wind sweeping up the previous slow AGB wind. The PN interiors are expected to be filled with shock-heated, over-pressurized gas that drives the current expansion of the nebular shell. Therefore, the diffuse X-ray emission from hot gas in PN interiors carries a vital piece of information needed to understand the formation and evolution of PNe. *ROSAT* observations showed hints of, but did not convincingly resolve, diffuse X-ray emission from PNe (Guerrero, Chu, & Gruendl 2000, ApJS, 129, 295).

Chandra observations of PNe, for the first time, have unambiguously resolved the diffuse X-ray emission from NGC 6543, NGC 7027, and BD+30°3639 (Chu et al. 2001, ApJL, in press; Kastner et al. 2000, ApJ, 545,L57; Kastner et al. 2001, ApJL, in press). Theoretical models can qualitatively explain the observed distribution of hot gas, but not the temperatures and abundances implied by the X-ray spectra.

Chandra observations have also revealed faint, hard X-ray emission from point sources at the central stars of NGC 6543 and NGC 7293 (Guerrero et al. 2001, submitted to ApJL). The source in NGC 6543 may represent the first detection of shocks in the fast stellar wind of a PN central star. Alternatively, these point X-ray sources may provide the best evidence for the unseen binary companions of the central stars (Gruendl et al. 2001, submitted to AJ) that have been proposed to be responsible for the point-symmetric morphology, bipolar outflows, and precessing jets commonly observed in PNe.

Clearly, *Chandra* has made PNe an exciting new addition to the family of X-ray sources. *Chandra* and *XMM-Newton* observations of PNe will help us understand not only the formation and evolution of PNe per se, but also the physical structure of wind-blown bubbles and evolution of binary stars in general.

CATEGORY: PLANETARY NEBULAE