Theoretical Spectra of Unmagnetized Neutron Stars

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Abstract

We have developed new models for the atmospheres of unmagnetized or weakly magnetized ($B \leq 10^{10}$ G) neutron stars with effective temperatures, T_{eff}, in the range of 4×10^6 K $\leq T_{eff} \leq 1 \times 10^7$ K. Our model calculations include a full and accurate treatment of Compton scattering effects. We consider both pure hydrogen/helium atmospheres and atmospheres containing substantial amounts of iron (i.e., iron abundances at least as high as the solar value). Using our model atmospheres, we are able to determine the thermal X-ray emission spectrum of an unmagnetized neutron star as a

function of T_{eff}, surface gravity, and atmospheric chemical composition. We find, in particular, that the spectra of unmagnetized neutron stars with iron-rich atmospheres will feature absorption lines with complex structure that can, in principle, be at least partially resolved in observations that utilize the Chandra transmission gratings.

We also find that the spectra of iron-rich atmospheres exhibit substantial flux deficits, relative to the spectra of hydrogen/helium atmospheres or simple blackbodies, at photon energies higher than the bound-free absorption edges of lithium-like and beryllium-like ions of iron at ~ 2 keV. This latter result provides a method of determining the presence and abundance of iron and/or other heavy elements in a neutron star atmosphere, without the need to resolve individual spectral

lines. As described in a companion paper (Stage and Joss, these proceedings), we are currently using our results to fit Chandra observations of the point source in Cassiopeia A and other possible cases of thermal radiation by weakly magnetized neutron stars.

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