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AIP

Diffuse X-ray emission of wind-driven bubbles with chemical gradients

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Abstract

As a tool helping to interpret diffuse X-ray emission of planetary nebulae, and as a supplement to our radiation hydrodynamics simulations, we have started computing a grid of theoretical X-ray spectra of wind-blown bubbles with temperature and density profiles according to thermal conduction theory. We investigate how the X-ray spectra depend on chemical composition (e.g. H-rich vs. H-deficient) and how temperature and abundance determinations reflect gradients of temperature and chemical composition within the bubbles. These synthetic models shall allow to quickly perform detailed parameter studies without the need for dedicated hydrodynamical simulations. We report on ideas and goals.

Motivation

The first high-resolution X-ray spectroscopy of a planetary nebula, viz. BD+30° 3639 (Yu et al. 2009), opens the possibility to study plasma conditions and chemical compositions of X-ray emitting regions of PNe in much greater detail than before. The data quality enabled Yu et al. to show that a single-component (isothermal) plasma model is insufficient to explain several features of BD+30° 3639's X-ray spectrum simultaneously, demonstrating the existence of temperature variations within the hot bubble.

Central questions

1. How does evaporation of H-rich matter into the hot bubble formed by a wind of a H-deficient CSPN influence the bubble's X-ray spectrum and abundance determinations based on it ?

2. How are important diagnostic line ratios, such as O **VIII** / O **VII** or Ne **X** / Ne **IX**, influenced by temperature gradients and chemical gradients ?

3. Is a "two-component" - model, such as the one of Yu et al., sufficient ?

4. Do abundance determinations of the central star (CS), the hot bubble, and the nebula tell the same story ?

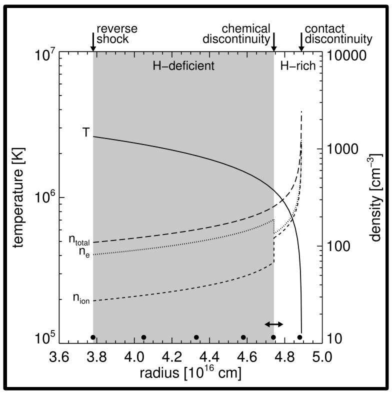
Tools of choice

We employ the self-similar solutions for hot bubbles of spherically symmetric interacting stellar winds of Zhekov & Perinotto (1996) which include **heat conduction** but no radiative cooling. Their Ansatz allows for time-dependent CS winds. The X-ray emission of these bubble models is computed by means of the well-documented CHIANTI code (v6.0.1, Dere et al. 1997, 2009).

Current task

Building the database of models with widely explored parameter space of fast-wind models, "slow-wind" properties, evolutionary ages (sizes), abundance distributions, positions of chemical discontinuities, that will be subsequently restricted by their mean X-ray luminosities and temperatures.

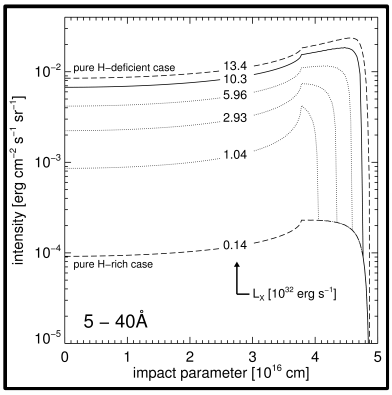
Illustration of a hot bubble model



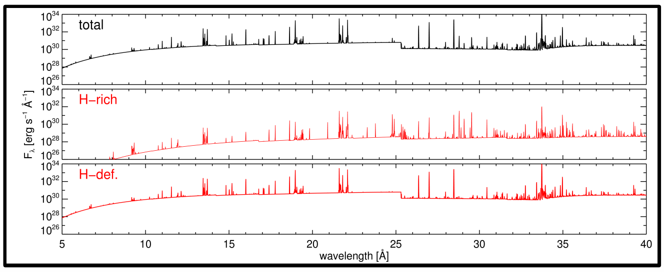
Bubble formed by interaction of a H-deficient fast wind with a H-rich wind. The bubble extends from the wind reverse shock to the contact discontinuity. The temperature distribution of the isobaric bubble is fixed to determine ion & electron densities for the different chemical compositions.

Radial X-ray brightness distributions

Radial X-ray brightness distributions for the bubble structure above. The chemical discontinuity is located at different positions within the bubble (marked by dots above the abscissa in the figure above). Note the range (about factor 100) between the cases of pure composition!



Spectrum



Example of a spectrum of a hot bubble with a chemical discontinuity (model from top figure; solid line in the brightness plot, resp.). Next to the total spectrum we show the single contributions from the two spherical shells of different chemical compositions. Next to diagnostic line ratios we study whether the two different chemical compositions produce distinct or unique features. For instance, the N **VII** 24.77Å feature will be of particular interest since it originates only from the H-rich matter. (However, note the logarithmic scale in these plots!)