First Results on the X-ray Burst Atmosphere Simulations

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With the collaboration with LANL we have developed an implicit Monte Carlo solver to model the atmospheres of X-ray bursters. Named `ZCODE`, the code solves the energy transfer problem, simulating the full radiation transfer of three particle species: *radiation*, *electrons*, and *ions*. `ZCODE` evolves their temperatures over time according to the (LTE) radiation and material energy equations. A 1D (i.e., one non-symmetry direction) slab geometry is used. Radiation transfer, electron conduction, absorption and emission, Compton scattering, and electron-ion coupling are considered.

`ZCODE` takes as input several physical quantities such as: relative luminosity, chemical composition, and surface gravity. The code outputs the full atmospheric model for the desired physical conditions in terms of of the surface's flux, and the atmosphere's opacities, densities, and temperatures in terms of frequency or radius (reference to Fig. 1).

An important step in the reconstruction of the atmosphere is to have a correct opacity table for the desired chemical composition of the problem. `ZCODE` performs this task by generating an output file for the chemical mixture that can be inserted into the LANL TOPS Opacities website (insert reference for website?). This creates an opacity table that is used when we execute `ZCODE`. Several examples of the compositions table we have generated can be seen in the Fig. 2.

We are able to generate a range of X-ray burst atmospheres. In the Fig.

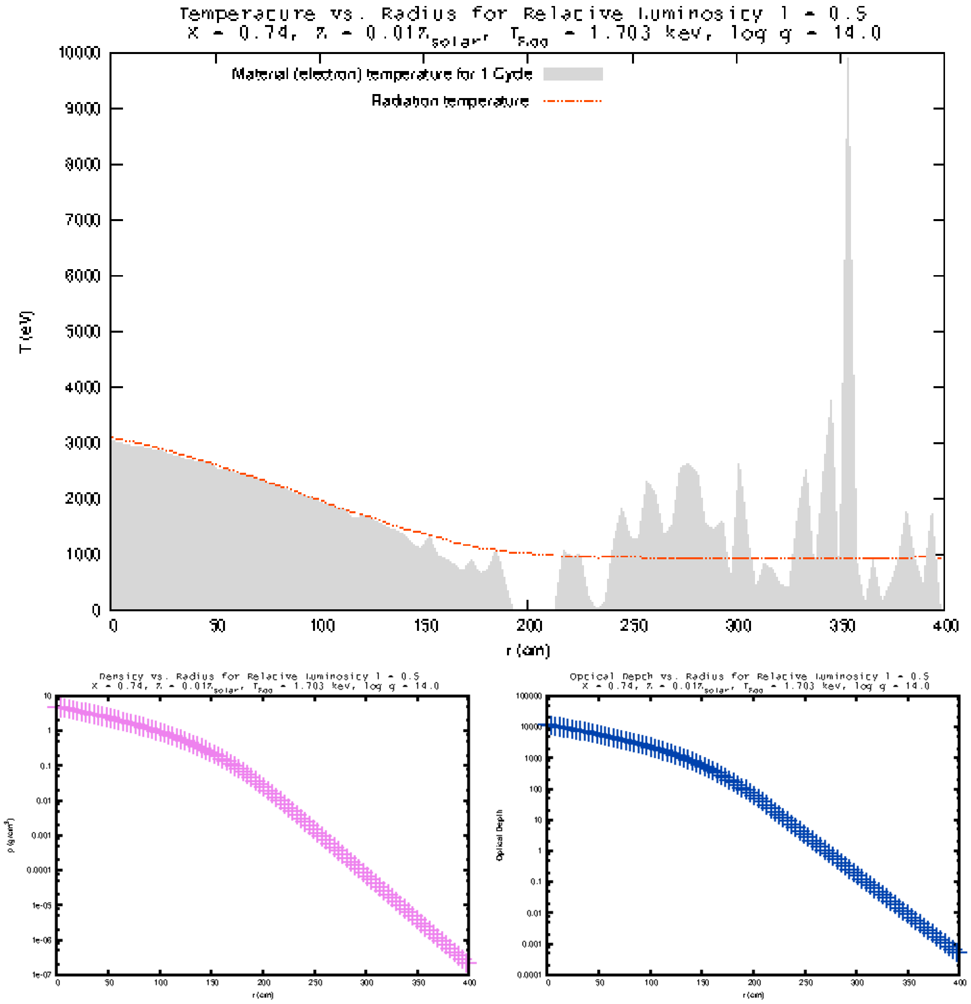

Figure 1: The variation of the different temperatures with the atmosphere radius of the X-ray atmosphere we simulate. This model has Z = 0.01 $Z_\odot$, performed with the Implicit Monte Carlo code, for relative luminosity equal to 0.5. In the bottom, we see the variation of density and opacity with the radius.

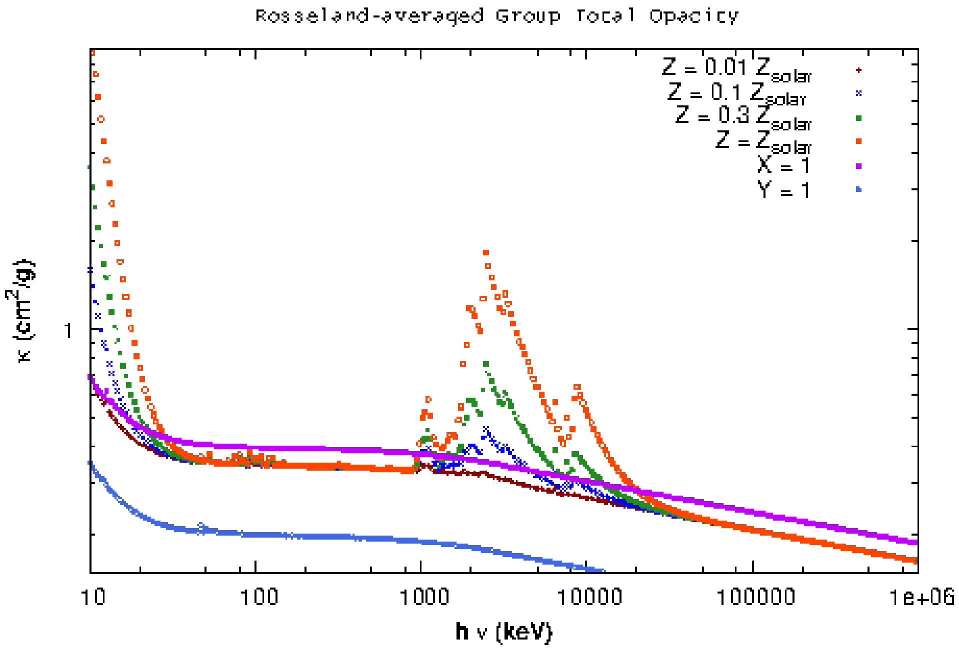

Figure 2: Rossekand-averaged Group local and Planck-averaged Group Absorption opacities, generated at LANL TOPS website, with inputs from our code.

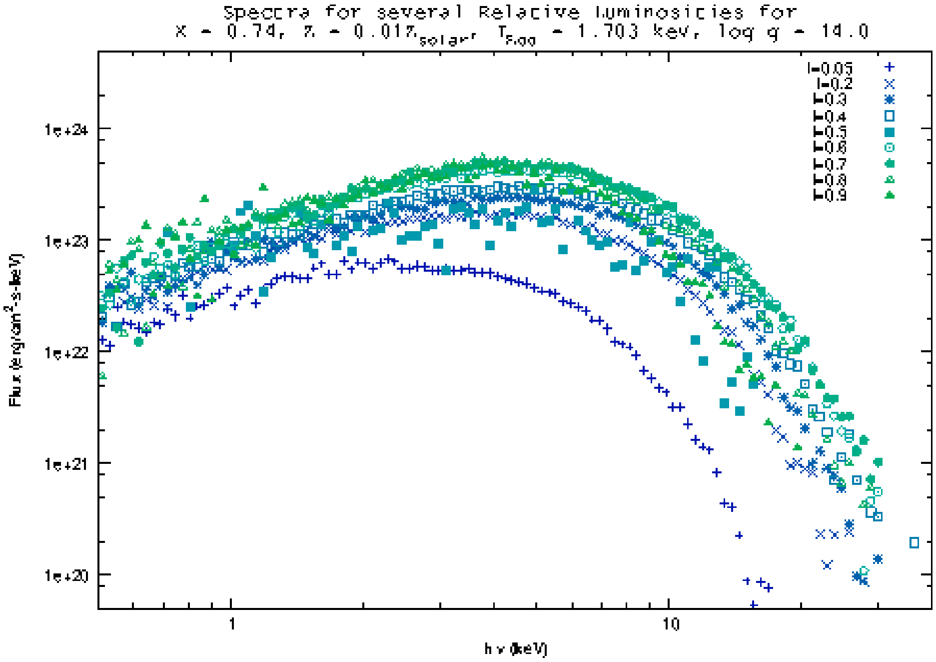

Figure 3: Model atmosphere calculation at Z = 0.01 $Z_\odot$ and $T_{\rm eff} = 1.432$ keV performed with the Implicit Monte Carlo code, for many relative luminosities.

3, we show several simulations of an atmosphere with surface gravity $g = 10^{14}$ cm s^{-2} , composition $Z = 0.01 Z_\odot$, $T_{\rm Edd} = 1.703$ keV, radius = 14.80 km, and surface redshift $z = 0.18$, for many different luminosities ($l = F/F_{\rm Edd}$).

We compare our results with recent atmosphere models available in the literature. As an illustration, we chose one case from the example above, with relative luminosities equal to $l = F/F_{\rm Edd} = 0.5$, *i.e.* surface flux $F = 0.5 F_{\rm Edd} = 4.3 \times 10^{24}$ erg cm^2 s^1 (reference to Fig. 4).

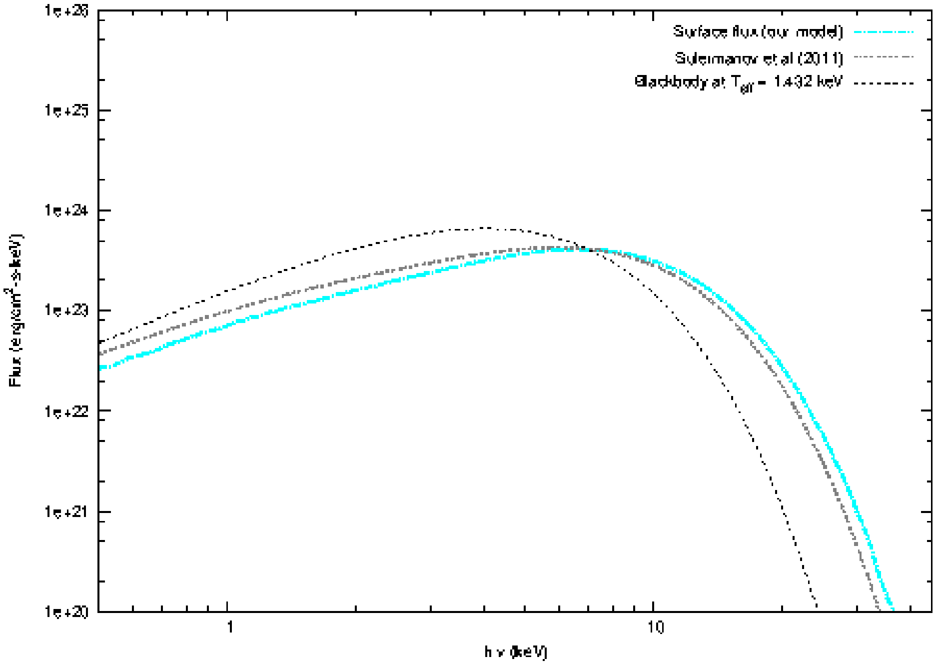

Figure 4: Model atmosphere calculation at Z = 0.01 $Z_\odot$ and $T_{\rm eff}$ = 1.432 performed with the Implicit Monte Carlo code, for relative luminosity equal to 0.5. Also shown are the model of Suleimanov et al. (2011) and a blackbody spectrum.