# Detailed Fitting of Coronal X-Ray Spectra with Loop Models: Model Characteristics and Simulations

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## 1. Introduction

It is widely accepted stellar coronae are entirely made by plasma magnetically confined in loops, as on the Sun, which determine crucially their structure and characteristics. Nevertheless oversimplified one- or two-temperature isothermal slab models have been used so far to fit virtually all stellar X-ray spectra. It is our contention that observations with the newest instruments, on board ROSAT, ASCA, and the future mission XMM, might require an interpretative model more refined than the models with few isothermal components.

We used an upgraded version of the hydrostatic coronal loop model of Serio et al. (1981, ApJ, 243, 288), along with the Analysis System for Astrophysical Plasmas (Maggio et al. 1994, CPC, 81, 105) (a) for comparison between loop model spectra and spectra of isothermal plasma models (b) to study the influence of loop cross-section expansion on the predicted spectra and on the effective temperature, (c) to explore the extent to which coronal loop models provide diagnostics when fitting coronal X-ray spectra observed with various instruments (ROSAT/PSPC, ASCA/SIS), and for realistic photon counting statistics. We refer the reader to Ciaravella, Peres, Maggio, & Serio (1995) and Maggio & Peres (1995), both in press on A&A, for an extensive discussion of the results pertaining to all these topics. In the following, we briefly report only on the main results of the simulations performed to address the last issue above.

## 2. Hydrostatic Loop Model, Spectral Synthesis, and Simulations

The coronal plasma is described as a fluid in hydrostatic equilibrium under the effect of gravity, and with energy balance among heat input, optically thin radiative losses and thermal conduction.

The synthesis of the predicted loop spectrum, as it would be observed from a given instrument, is performed by integrating the plasma emission over the loop volume and by folding it with the instrument spectral response. In this way we obtain a folded model spectrum binned in the same detector energy channels as for a real observed spectrum.

We have synthesized the spectra of model stellar coronae assuming that the emission is dominated by a single class of loops, and then we have performed a spectral fitting over a grid of loop models, to evaluate the statistical confidence regions for the determination of the input loop parameters. We have performed several simulations in order to test the sensitivity of the fitting results to the

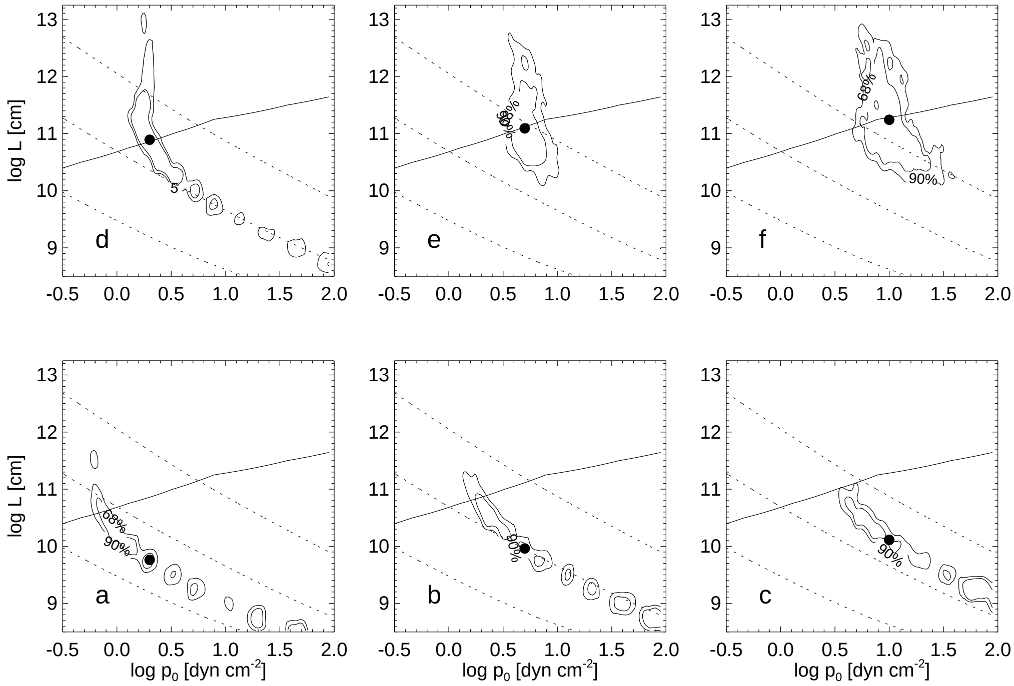


Figure 1. Probability contour levels at 68% and 90% in the $p_0 - L$ loop parameter space, obtained from simulations of six input loops (indicated by filled circles), assuming $10^3$ counts in each ROSAT/PSPC input spectrum. The solid line marks the $L = s_p$ locus. The dotted lines are contour levels of equal maximum plasma temperature, log $T_{max} = 6.3$, 6.7, and 7.1, from bottom to top of each panel.

specific input loop parameters, to the observing instrument, and to the total number of photons in the spectrum.

In Fig. 1 we show, as an example, results from six simulations (six different input loop models, marked by a filled circle in each panel) of ROSAT/PSPC loop spectra with $10^3$ counts. For each simulation, 1000 spectra have been generated and then fitted, and the derived 68% and 90% probability contour levels, in the parameter space of plasma base pressure, $p_0$, and loop semi-length, $L$, are shown in each panel.

The results of these and other simulations (Maggio & Peres 1995) indicate that: (a) for loops with $L$ significantly below the pressure scale height, $s_p$, it is possible to constrain well the plasma peak temperature and hence the product of the base pressure with the loop semi-length, but not each of the two separately, due to scale invariance of the equations describing the hydrostatic loop model of uniform pressure; (b) for $L \geq s_p$ the spectral fitting yields closed confidence regions in the parameter space, allowing to constrain the loop parameters, with different levels of discrimination depending on photon counting statistics, instrument energy response, and spectral resolution.