CHROMOSPHERIC NLTE-RADIATIVE-TRANSFER MODELING OF dMe STARS

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ABSTRACT:
The formation of the Lyman and Balmer lines of Hydrogen at densities typical in dMe stars is shown to be very dependent on the atomic model used viz. the number of levels and line transitions. The effect of increasing the number of levels and line transitions on the line fluxes and ionization fraction is also discussed.

We have computed theoretical line profiles for the Lyman and Balmer series of Hydrogen for a variety of model chromospheres and model atoms. The dMe chromospheres are essentially an extension of those used by Giampapa et.al. (1982) and extended to higher temperatures regimes. An electron temperature and density structure typical for late-type stars has been added at the base of the chromosphere, to mimic the photosphere, following Mould (1976). The computer code used was that of Carlsson described in Scharmer and Carlsson (1985), and modified by him to include the technique of collisional-radiative switching (Hummer and Voels 1988) to enhance the convergence properties; a severe problem when including the Lyα transition in detail. Symmetric Voigt profiles have been calculated under the assumption of complete redistribution. Stark broadening has been included using the approximation of Sutton (1978). All model computations assume a plane-parallel geometry and solar abundances.

For a given atmospheric temperature and density structure we computed mainly emission line profiles and fluxes for a variety of model Hydrogen atoms. Models with and without Lyα were used to observe the effects of the Lyα radiation field on the line fluxes.
The number of levels and line transitions was then varied up to a maximum of 16 levels and 60 lines.

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We present graphically the results from computations of one such model chromosphere in the figures.

RESULTS:

1. Effects of inclusion and omission of Lyα.

The inclusion or omission of Lyα in detail does not affect the Balmer line fluxes significantly, typically about 20%. In the computation of purely Balmer line profiles the assumption of Lyα in detail balance is therefore a reasonable approximation.

The line fluxes of the other computed Lyman series are however significantly changed. They decrease typically by a factor of five.

The neutral Hydrogen fraction, dominated by the ground state population, decreases at temperatures above 8000K, when Lyα is assumed to be in detailed balance. When Lyα is excluded, radiative decay from level 2 is inhibited, so that the ground state population is relatively depopulated. As a consequence the higher levels are overpopulated giving rise to stronger emission lines in the higher series members. The fraction of H II is relatively depleted at temperatures below 8000K, as are all the upper levels of H I. This will affect the ionization balance and subsequently the formation of other atomic lines, as Hydrogen is the main donor of electrons in the chromosphere.

2. Effects of including more levels.

The inclusion of more levels in the atomic model also has a marked effect on the line fluxes, particularly on the Balmer series fluxes which decreased by a factor of two for Hα to nearly a factor of ten for Hγ in all our models.

Increasing the number of levels gives rise to a relative depopulation of the levels from which these lines are formed, as there are then more excitation paths. The H II population is also relatively depleted, markedly at the lower temperatures. Again this will have a strong effect on the ionization equilibrium and formation of lower chromospheric lines.

We finally note that the frequency quadratures at which the the line profiles are calculated has also been found to be of importance. The inclusion of more extended wings tends to bring the line peak to a higher value, typically 10%, so that some wing photons are eventually trapped in the core.

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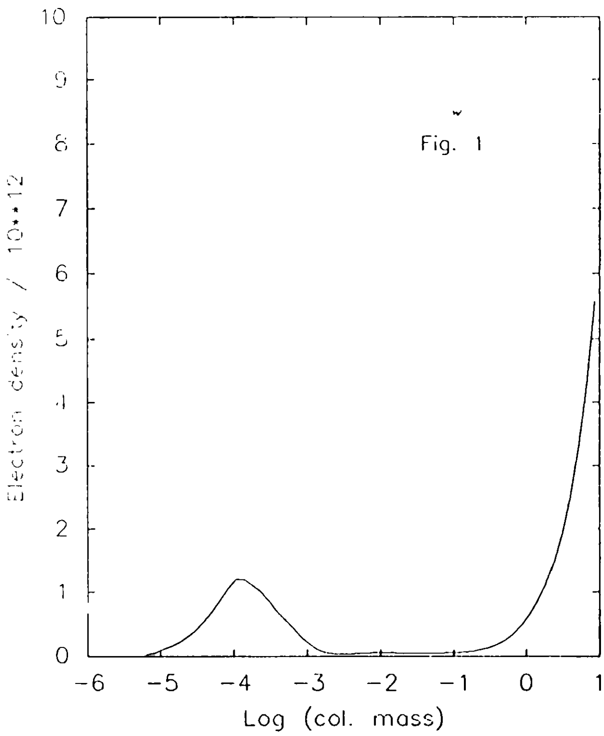

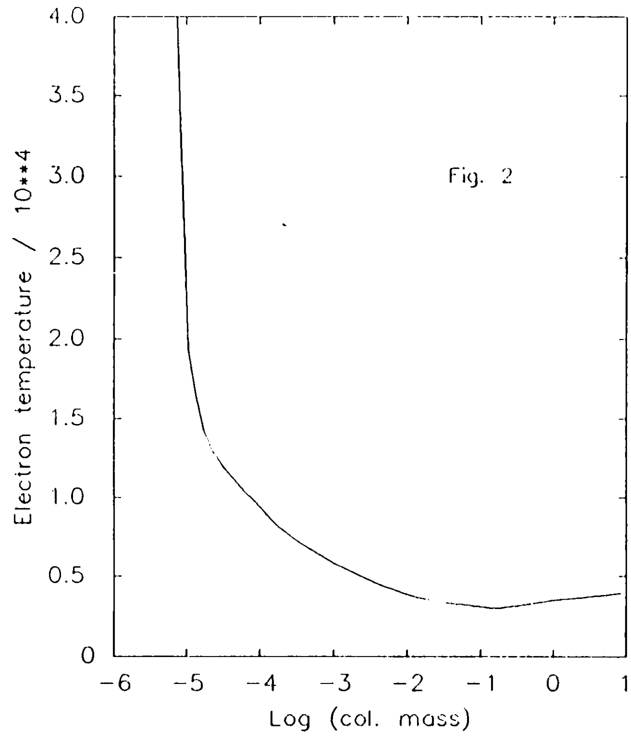

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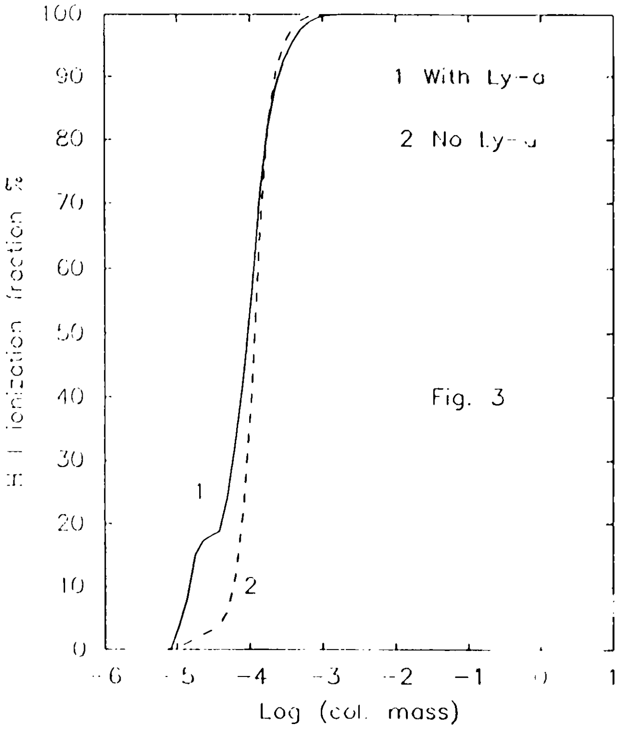

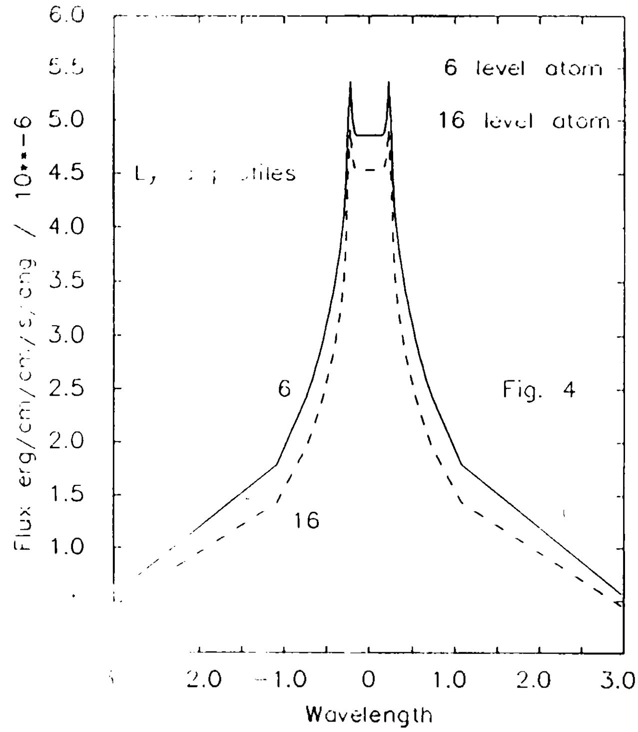

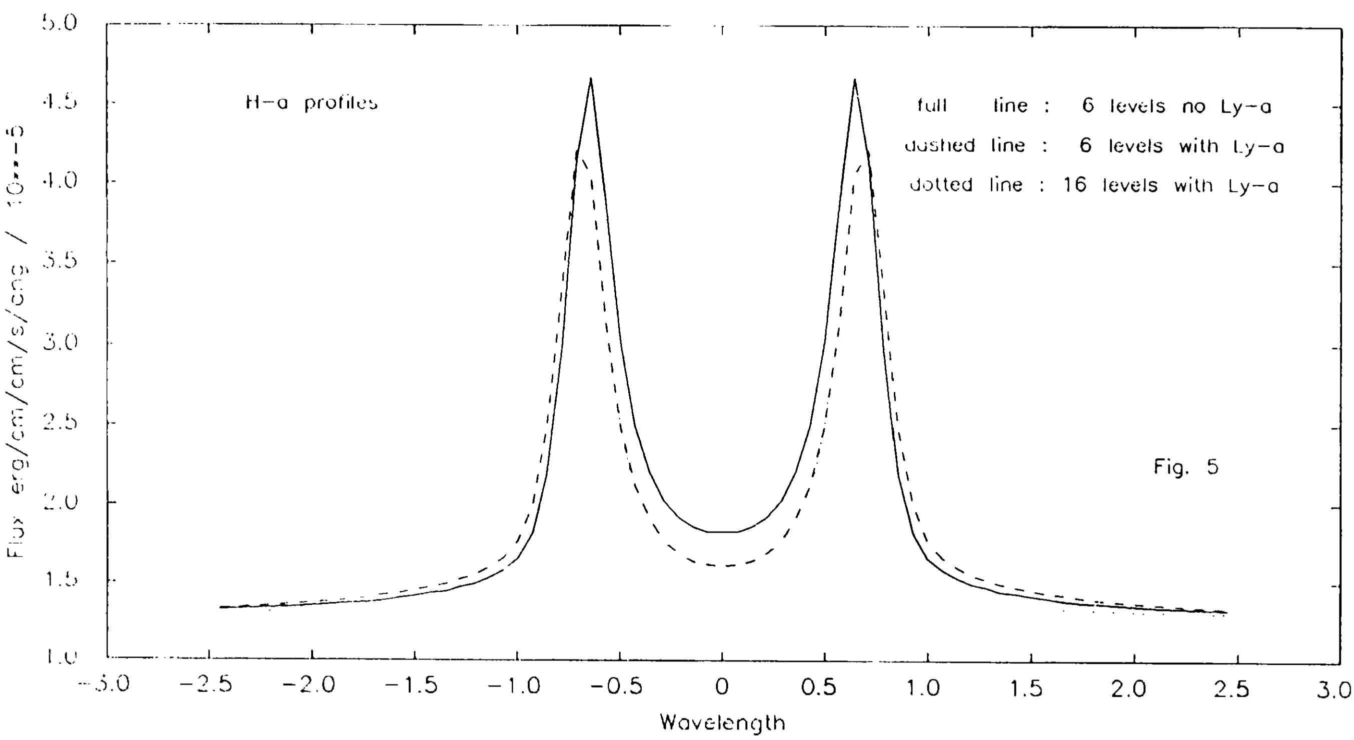

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