Fast and easy computation of radiative accelerations in stellar interiors

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ABSTRACT

A new parametric method that approximates the radiative accelerations of bound-bound and bound-free transitions at large optical depths is presented here. The parameters found in these new equations are calculated for the following trace elements: C, N, O, Ne, Na, Mg, Al, Si, S, Ar, Ca and Fe and are made available to potential users. This method can be easily implemented in existing codes in order to study atomic diffusion without needing large computing resources or access to large atomic and opacity data bases.

INTRODUCTION

The aim of this poster is to summarize a new parametric method that is extremely numerically efficient for calculating radiative accelerations (g_{rad}), which is a major ingredient in the study of atomic diffusion. Results for a T_{eff} = 8080 K stellar model will be shown for the 12 elements considered here.

THEORY

It was shown (Alecian & LeBlanc 2000, 2002 and LeBlanc & Alecian 2004) that the radiative acceleration due to lines of an ion i can be approximated by the following expression:

$$g_{i,\,line} = q\square_i^*(1+\square^* C_i)(1+\frac{C_i}{b\square_i^{*2}})^{\square_i}$$

Here C_i is the concentration of the ion under consideration relative to hydrogen and the values of q and b depend on the local physical properties of the medium. The following parameters have various physical meaning:

$\square_i$: *related to the oscillator strenghts of the lines*

$\square_i$: *related to the line widths*

$\square_i$: *appears when monochromatic opacities are used*

$\square_i$: *related to the slope of* g_{rad} *versus* C_i

These first three parameters are calculated using the atomic data from the Opacity Project database (Cunto et al. 1993). While the last parameter is found by fitting our g_{rad} to those found by Seaton (1997). It should be noted that these last three parameters control the saturation effects.

We use a single value for these parameters for each ion. They are calculated in each stellar model, close to where the ion has its maximum population (see equation 8 of LeBlanc & Alecian 2004). Once these parameters are calculated, the evaluation of the radiative accelerations is extremely numerically efficient and can then be easily implemented in astrophysical applications.

Another similar equation for the bound-free transition was also developed (see LeBlanc & Alecian 2004) with two parameters that are found by a fitting procedure.

RESULTS

We calculated the various parameters for the elements considered in several stellar models using the atomic data from the Opacity Project database (Cunto at al. 1993). Shown here are the results for a T_{eff} = 8080 K (2 solar masses) model. We see that our approximate method gives results close to the ones obtained by Seaton (1997) via the opacity sampling method.

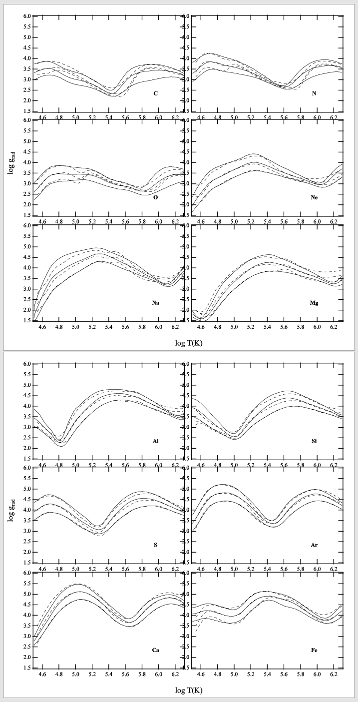

Figure 1. Radiative accelerations for all of the elements considered in a T_{eff} = 8080 K model. The logarithm of accelerations are plotted versus log *T(K)*. The solid lines represent the g_{rad} found by Seaton (1997), the dashed lines represent those found with our parametric formulae.

CONCLUSION

We showed that the newly developed parametric formulae for radiative accelerations give relatively accurate results while being very numerically efficient. The parameters calculated here and those for other stellar models can be found at http://www.umoncton.ca/leblanfn/grad . These parameters give an average error of less than 0.1 dex for most elements within the range of abundances from 0.01 to 10 times their solar value.

REFERENCES

Alecian, G., LeBlanc, F., 2000, MNRAS, 319, 677
Alecian, G., LeBlanc, F., 2002, MNRAS, 332, 891
Cunto, W., Mendoza, C., Ochsenbein, F., Zeippen, C., 1993, A&A, 275, L5
LeBlanc, F., Alecian, G., 2004, MNRAS (in press)
Seaton, M.J., 1997, MNRAS, 289, 700