Stellar Model Atmospheres with emphasis on Velocity Dynamics

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Recently a formalism for solving the open set of non-local hydrodynamic moment equations has been developed by Kupka and Montgomery. Tests on numerical simulations and selected features in stellar spectra have shown the applicability of this RSM model. Additionally a variety of improvements of existing standards were developed within and around the AMS group at the Institute for Astronomy in Vienna over the last years. Individual elemental abundance patterns (Piskunov and Kupka)[1] or stratification as an observed parameter (Shuliak et al.)[2] are taken into account in our model atmospheres. Once these stand alone tools are combined in a model atmosphere code, we get a powerful and efficient instrument which will allow us to investigate some most interesting questions.

? Where in the HR diagram is convection starting and when is it getting strong enough to compete against diffusion processes in stellar atmospheres ?

? The hotter Böhm-Vitense gaps ((B-V)=0.2-0.3mag) probably occur due to a sudden onset of strong convection in stellar atmospheres. The structure of these gaps depend on metallicity and age of the stellar sample. Do we have another way to independently derive these fundamental physical parameters, applying the new convection model ?

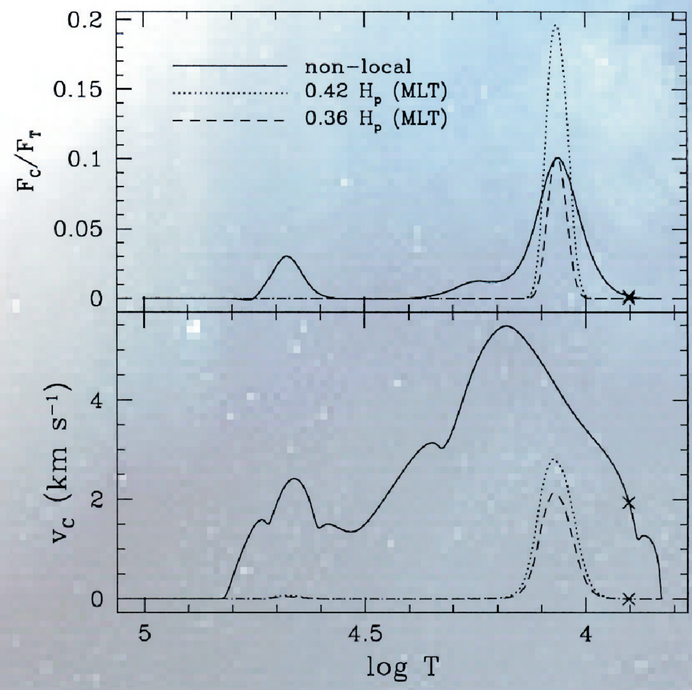
? Can we explain and thus model line bisectors and convective line broadening consistent over a large parameter space ?

We might also be able to address questions such as overshooting, Li depletion or the transition from fast to slow rotating Ap stars.

1 ... Piskunov, N., Kupka, F., (2001), ApJ 547, 1040
2 ... Shuliak, D., Tsymbal, V., Ryabchikova, T., Stütz, Ch., 2004, A&A submitted
3 ... Kupka, F., Montgomery, M.H., (2002), MNRAS 330, L6
4 ... Canuto, V.M., Dubovikov, M.S., (1998), ApJ 493, 834

An alternative to numerical simulations of convection are turbulence models based on the open set of non-local, hydrodynamic moment equations, the Reynold Stress models (RSM). Recently Kupka and Montgomery[3] expanded the Canuto and Dubovikov 1998 RSM model[4] to a stellar like scenario including realistic microphysics and compressibility for regimes of weak convection. First application on realistic models of A-type main sequence stars already showed:

The mean velocities in the photosphere are comparable with typical parameters for macro and microturbulence.



HeII and HI convection zones are thermally separated but dynamically connected and there is also considerable overshooting below the HeII convection zone.

Comparisons with MLT convective fluxes and velocities immediately show the shortcomings of such local models.

In regimes where convection is less prominent, local FST convection models by Canuto, Goldman and Mazzitelli have proved their worth in abundance analysis, pulsation research and investigation on magnetic fields, but we already found examples where we reach their limitations.

Opacity distribution functions are by far the fastest way to account for line opacities when modeling. ODF precalculation for individual elemental abundance patterns (Piskunov and Kupka)[1] increase the applicability of this approach considerably.

Including line opacities line-by-line each iteration naturally support individual element abundances, element stratification and depth dependent turbulent velocities. Shuliak et al.[2] managed to realize such a line-by-line model atmosphere code which is fast enough for everyday use (1h total calculation time on a 1.8GHz PC).

We are currently working on the inclusion of molecular line absorbtion to extend our models to cooler regimes.

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