MAP-fis Essay Proposal, 2013-2014

Supervisor

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Title

Developing 1D Formulations of Convection for Energy Transport in Stellar Physics

Area

Hydrodynamics, Radiative Transport

Summary of Proposal

In order to model the impact of convection on the transport of energy in stellar physics it is required to develop ways to parameterize convection for 1D models. In doing so most of the complexity of convection is overlooked (especially if the regime is turbulent), and we are left with a very crude approximation (subject to several choices of parameters) to model the stratification inside stellar convective zones. Different approaches have been considered in the last decades, but due to the near adiabatic stratification in most of the convective layers, these have never been properly explored and/or validated. Therefore, several major simplifications have been adopted, which are still in use in current state-of-the-art stellar models.

Those assumptions have been made when using a crude definition of convective transport did not have a measurable impact. Due to the new generation of space data available for many solar-like stars, we have been forced to face the inadequacies of how convection in implemented in stellar models. The time is now ripe to revisit the options made to reduce convection to 1D formulations. To this end, a reanalysis of the closure assumptions, made to convert 3D hydrodynamical equations to a 1D formulation, is in order

The project will revisit the approach by Grossman et al. (1993a and 1993b) in order to identify the critical assumptions done in their theory of Boltzmann transport theory for turbulent fluid elements. Starting from this formulation, the project will focus on retaining the critical parameters that could be used to produce a generalized formula for the convective flux that can be implemented in stellar physics. This alternative formulation for convective transport will be tested against high quality observations (as attempted for the Sun by Monteiro et al. 1996, or Deng & Xiong 2008). The goal will be to account adequately for the discrepancies found in regions of low-efficiency convection and convective overshoot in stellar interiors, including our Sun.

References

Grossman S.A., Narayan R., Arnett D., 1993a, "*A theory of nonlocal mixing-length convection. I. The moment formalism*", ApJ 407, 284

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Monteiro M.J.P.F.G., Christensen-Dalsgaard J., Thompson M.J., 1996, "*Seismic properties of the Sun's superadiabatic layer. I. Theoretical modeling and parametrization of the uncertainties*", A&A 307, 624

Deng L., Xiong D.R., 2008, "*How to define the boundaries of a convective zone, and how extended is overshooting?*", MNRAS 386, 1979