*Stars and their variability observed from space*
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# STUDY OF CONVECTION IN ONE AND MULTI-DIMENSIONAL PULSATING MODELS

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**Abstract.** The handling of convection is one of the open questions in numeric modelling. Since convection is a genuine multi-dimensional phenomenon, one-dimensional simulations can only approximately (and inadequately) describe its complexity and effects. We investigated the accuracy of these approximations through the use of the multi-dimensional code SPHERLS.

Keywords: Convection, Hydrodynamics, stars: oscillations, variables: RR Lyrae

## 1 Introduction

In this study we compared selected results of two distinct hydrodynamical pulsation codes. For the first we used the one-dimensional (1D) Budapest–Florida code (Buchler et al. 1997) which contains 7 parameters to describe the effects of turbulent convection (Yecko et al. 1998). For the second (2D calculations) we used the multi-dimensional pulsation code SPHERLS (Geroux & Deupree 2011). The latter programme applies a hybrid technique to ensure that no free parameters are required to account for convection. We applied our calculations to an RR Lyrae model with the following parameters: $L = 50L_{\odot}$, $M = 0.7M_{\odot}$, $T_{\mathrm{eff}} = 6300\mathrm{K}$, $X = 0.75$, $Z = 0.0005$.

## 2 Comparing the 2D and 1D model results

The periodic boundary conditions at the edges of the computed sector might influence the nature of the convective cells in 2D; it is therefore mandatory to investigate its effects. In Fig. 1 we present a 6- and a 12-degree-wide 2D model with convective cells reaching down to a temperature of 50000 K. The convection alters the shape of the ionisation front at a temperature of 10000 K but the size of the convective cells remains the same in both cases. We can therefore conclude that the boundary condition has no effects on the convection.

We compared the light-curves of the two models, and found that the 1D model has higher amplitude by a factor of two (See Fig. 2, left panel). Note, however, that its parameters were adjusted to fit the observations instead of the 2D results. We also studied the pressure, temperature and radial-velocity profiles (See Fig. 2, right panel). In the first two cases the profiles are similar, with only slight differences in the temperature. On the contrary, the two models have very different radial-velocity profiles, while the 1D model has higher velocities in the partially ionized zones.

## 3 Conclusions

We investigated the 1D approximation of convection in the Budapest–Florida code compared to 2D computations. Our test case was an RR Lyrae type pulsator, and we found that the amplitude of the pulsation is greater in the 1D case. However, the 1D model is calibrated to observations, so we will check the results of the 2D model before further calibrations are made. Kupka & Muthsam (2017) suggested that time-varying $\alpha$ parameters throughout the calculations could be a better approximation for the 1D problem.

To get a better understanding of this problem and the relevant physical phenomena, we will continue the investigation of one and multi-dimensional computations, comparing different prescriptions for convection including, (e.g.) the hydrocode of Smolec & Moskalik (2008) since they use a different approach.

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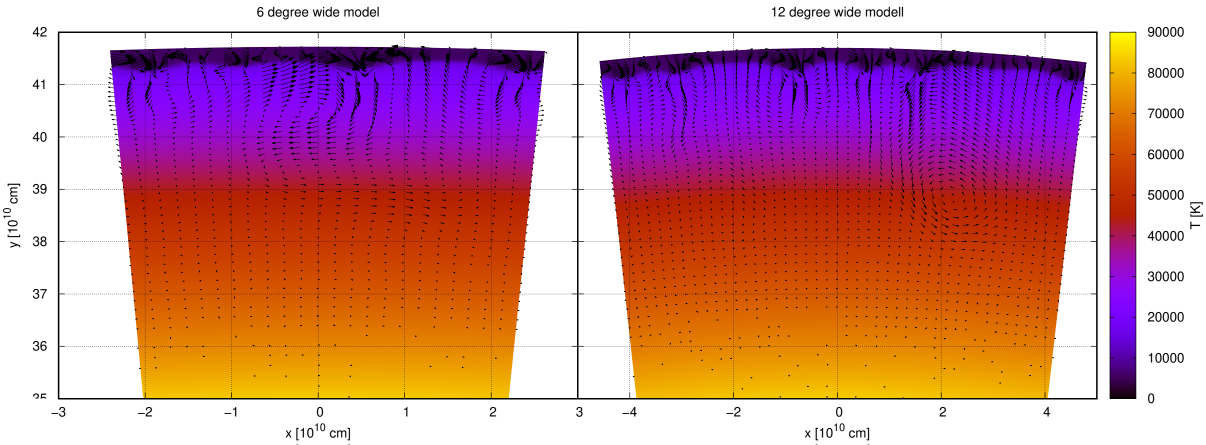

**Fig. 1.** A 6-degree (**left**) and a 12-degree (**right**)-wide 2D model computed by SPHERLS. The colour bar shows the temperature of the model at a given point; the arrows are the normalized velocity. As can be seen, the size of the convective cells are the same in both models.

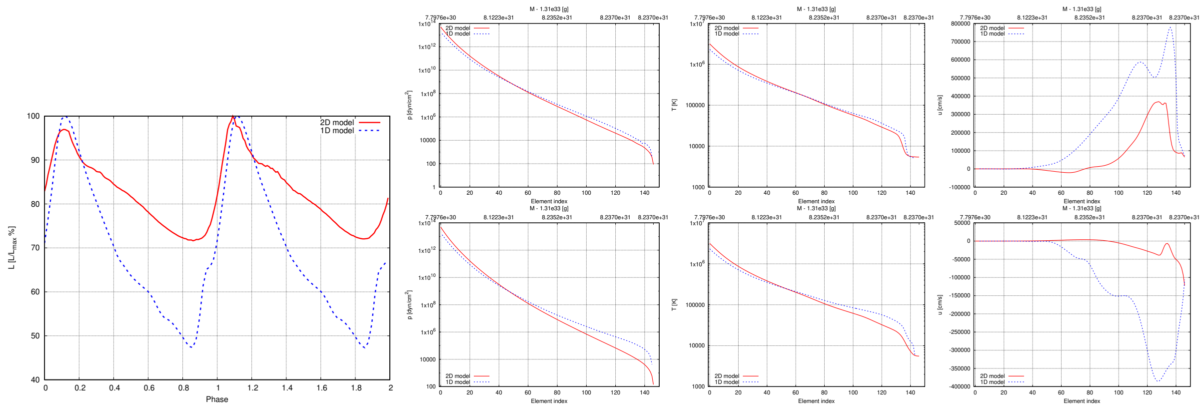

**Fig. 2. Left:** Phase-folded normalized light-curves of the SPHERLS (red) and Budapest–Florida (blue) models. It is clear that the former produces smaller amplitudes. **Right:** Profiles of the pressure, temperature and radial-velocity (from left to right) near the luminosity maximum (top row) and minimum (bottom row). The pressure and temperature profiles are similar, but the velocity profiles are very different in the two models.

## References

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