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Round table discussion of session E: oscillations, mass loss and convection

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Abstract. In order to initiate the discussion after the talks of this session, questions such as 'what seismology can teach us? Which seismic constrains are needed to test stellar modelling and particularly convection?' have been asked to the audience.

1. 3D simulation of turbulent outer layers

1.1. *The case of Procyon*

The discussion started with the case of Procyon. This star shows oscillation acoustic p-modes similar to the Sun. Several groups have modelled the outer layers of this star with 3 D simulations. Robinson and co workers find an oscillation of the SAL (superadiabatic layer) with a timescale of the order the turn over time of the granules. Ludwig and his collaborators do not observe this oscillatory behavior in their simulations of Procyon. What are the differences in the modelling of the two simulations which can be responsible for this disagreement? Helium in the outer layers whether it is depleted by gravitational dettling or not does not make much differences. The vertical size of the box can make some difference as in one case, the modeled region is shallower than in the other case. Also in one case assumes open boundaries whereas they are closed in the other case. Whether this makes a difference or not in en open issue. This star will be the target star of a multisite campagne in integrated radial velocity on January 2007 as advertised by T. Bedding. Oscillation of order 4 km/s ought to be detectable and this could represent a test of the simulations.

Subgrid scale models: F. Kupka pointed out another source of uncertainty and potentially responsible is the adopted subgrid scale model or equivalently the modelling of the small scale and the assumed spatial resolution which differ between the two types of simulations.The influence of the choice for a subgrid scale model has not been investigated for Procyon in as much detail as in the Solar case. It would indeed be worse to compute models with increasing spatial resolution to investigate such effects. Systematic studies of subgrid scale models with solid boundary have been performed but only a few studies exist in the case of open boundaries.

1.2. *Mode lifetimes*

Another issue, as mentioned by J.Christensen-Dalsgaard, concernes the comparison of mode lifetimes computed with a 3D simulation with observed ones either presently in the solar case or in the future for a few other stars observed with Corot. A direct comparison can be made possible as the scaling of the box lifetimes by the full star lifetimes should be the mode inertia which can be easily calculated with a 1D stellar model, and provided that excitation and damping of the mode take place inside the box. This can represent an additional seismic diagnostic of the quality of 3 D simulations. It could then be possible to use simpler models such that to Gough, Balmforth's approach to compute lifetimes to cover the HR diagram more broadly.

1.3. *Solarlike oscillations in red giants*

As mentionned by T. Bedding, solar like oscillations are now being discovered in giants . 3D simulations of convective outer layers for other stars such as red giants and supergiants are possible and have been computed in some cases. However for a direct comparison of the oscillation amplitudes, one needs to know the relationship between the amplitudes in a box and the real full star and this is not yet clear even in the solar case.

2. Patched models: including outer layers computed from a 3D simulation in a 1D stellar models

Given an effective temperature and gravity , a 3D simulation can provide the depth dependent convective flux of outer layers which is then implemented into the building of a 1D stellar model referred to a patched model. This would provide stellar models closer to the reality and more appropriate for seismological studies. In order to match the adiabat of the 1D model, one needs to know the stellar radius which usually is not well known. This is particularly true for extended stars such as giants. It might not be so important for small stars such as main sequence stars. In that case, it is in principle possible to build convective flux tables which can be interpolated so that evolutionary calculations can compute stellar models for a Sun for instance from PMS stages up to the giant branch. The computational effort is not so huge as one needs to compute only the superadiabatic layers which are not too deep and the calculation needs not to be long as the system relaxes quite fast. Actually such grids of 2D simulations such as H. Ludwig'one start to exist.

3. Opacity driven oscillations of red giants and Miras

Red giant stars such as Mira stars oscillate with one or two radial modes. Observed period ratios are not reproduced by hydrodynamical calculations from 1D stellar models. The main cause is believed to be the incorrect modelling of the convection in the stellar model and more importantly and its time -dependent interaction with the oscillations. As red giant stars have large convective envelopes, it could be useful to use output from 3D simulations in the modelling of red giant as it is done in the case for solar like oscillating main sequence stars. However, the convection in these stars extends so deep inward and the amplitudes are so large that it is necessary to model almost the whole star and this can be difficult to achieve with 3D simulations. One must also keep in mind that radii for these stars are not well known although VLTI observations, interferometry and model atmospheres can provide much better radius determinations nowadays. These stars are known to undergo significant mass loss. One ust then stress that 3D simulations of convection with mass loss have shown that the convective properties such as the geometrical pattern of the convective eddies are strongly affected by mass loss and mass loss, apart from changing the mass, can therefore have also an indirect effect on the oscillation period

4. Comparisons of amplitudes of solar-like p-mode oscillations

Several semi analytical expressions have been developed in order to compute the amplitudes of solar-like oscillations which are excited by turbulent convection. These

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calculations are compared with results from 3D simulations calculed with the code of Nordlund and Stein. On one hand, one comparison has been performed by Stein and his group and Houdek and collaborators using Balmforth's semi analytical approach and on the other hand a comparison has been performed by Samadi and collaborators and Nordlund and his group. The question then is how do the results of these two groups compare? Comparison between the semianalytical formulation developed by Samadi *et al.* and 3D simulations show that the excitation rates and therefore the amplitudes obtained with the 3D simulations lie between those calculated with the semianalytical approach using a lorentzian or a gaussian for the frequency spectrum associated with the eddy time correlation. The semianalytical calculation using the lorentzian provides the largest amplitudes which match well the solar observations without the need for amplitude scaling. The 3D simulations are found to underestimate the maximum amplitude compared to the observed one. Part of the discrepancy, as advocated by Samadi's group, could be due to the fact that fourth order velocity correlations are implicity modelled with a QNA (quasinormal approximation) in the 3D calculations and this is found to be a poorly approximation in the solar case.