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On Expected Constraints on Stellar Transport Processes from Space Seismic Missions: EVRIS, COROT

M.J. Goupil[1], E. Michel[1], S. Cassisi[1], W.A. Dziembowski[2], Y. Lebreton[1], A. Baglin[1], M. Auvergne[1], and C. Catala[3]

[1] *Observatoire de Paris, URA 335, 92190 Meudon France*

[2] *Copernicus Astronomical Center, 00-716 Warsaw, Poland*

[3] *Observatoire de Midi-Pyrénées, 31400 Toulouse, France*

1. Introduction

The first space seismological experiment, EVRIS (Baglin 1991) will be launched in 1996 and will observe $\sim$ 10 stars over $\sim$ 20 days each. A second one, COROT (Catala et al., 1994), should follow soon after (1999-2000), which should monitore $\sim$ 5 stars over $\sim$ 5 months each. The observed stars will be main sequence stars. For an optimum scientific outcome of EVRIS mission, one must select the best possible target stars. The first step of this selection is outlined. What would be further gained with COROT project is discussed.

2. δ Scuti stars

Specifications of both missions imply that among possible target stars, δ Scuti stars should present a large number of self excited modes, likely many more than presently observed from ground based networks.

Convective core overshooting : Among the detected modes of a given star, one nonradial mixed mode - a mode having amplitude in the vicinity of the convective core and in surface - can reasonably be expected. The knowledge of such a mixed mode and two radial modes, for instance, yields the overshoot distance d_{ov}, mass and age of the star (assuming no other uncertainties in stellar modelling). In this specific case and taking into account expected frequency observational errors ($\sim$ frequency resolution) of the mission, the current uncertainty ($\sim$ 100%) on d_{ov} determination will not be much improved with EVRIS. COROT, in contrast, would yield d_{ov} with a $\sim$ 20% uncertainty (Lebreton et al., 1994). Radial modes are not much sensitive to core overshooting so that higher precision should be obtained with more than one detected mixed mode. One should then be able to test more sophisticated treatment of the overshooting process, effects of core rotation and of element diffusion on the core extension which may not be negligible at this level.

Rotation profile : With COROT, one expects to detect self excited, low radial order modes of degree up to $\ell = 6$. Assuming that among these modes, all (or a subset of) opacity driven modes are detected for a given star, inversion techniques can be used to obtain its rotation profile with depth. When COROT specifications are used, the rotation profile is remarkably well recovered both

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at the surface and above the convective core (Goupil et al., 1995). Specifically here, local conservation of angular momentum is assumed for building an artificial rotation profile. From this profile, frequency splittings are computed for a model of the $\sim 1.7 M_\odot$ δ Scuti star ϵ Cep, a suitable target star. These splittings are next contaminated with a white noise (variance $\sim$ the expected frequency uncertainty) and used as the 'observational' data. With EVRIS, one can hardly infer much more detailed information than detection of a non uniform rotation. But relative local variations of rotation as small as 10% could be detected with COROT. Noise in the data results in deviations from the real rotation rates within the error bars, which include observational uncertainties and error magnification of the inversion procedure.

3. Solar like oscillation

The star β Vir is a possible candidate for EVRIS experiment (Cassisi et al., 1995). With a mass in the range $[1.25, 1.35] M_\odot$, it is expected to exhibit detectable solar like oscillations. Because of uncertainties in its HR diagram position, one must first investigate whether high order $\ell = 1, 2$ p-mode frequencies can discriminate between models for this star with slightly different stellar parameters. Frequencies of a model A_*, the 'observational' data, are compared with frequencies of two models A_1 and A_2 falling very close to A_* in a HR diagram. A_1, A_2 differ from A_* respectively through overshooting distance ($\delta d_{ov} = 0.1$) and chemical composition ($\delta Z = 0.01, \delta Y = 0.02$). Frequency uncertainties depend on observing time duration, signal/noise ratio and mode linewidths. With these estimations (Catala et al., 1994) and assuming a conservative 3σ error, discrepancies between A_* and A_1, A_2 are detected with both missions. Further, COROT would detect smaller discrepancies in the second frequency differences (Gough, 1990) between model A_* and A_2.

4. Conclusions

The above few examples show that EVRIS will provide more information than a mere detection of solar like oscillations. However, to test with high precision theories of transport processes, the required frequency resolution and number of detected modes make COROT an essential step in the asteroseismological field.

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