OSC, a code for computing adiabatic stellar oscillations

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Introduction

The code OSC has been developed in our research group at the Institute of Astrophysics in Liège in the early 70s for computing adiabatic stellar pulsations. It has gone through minor updates and is still presently in use.

At Corot Week 3 which took place in Liège, Anwesh Mazumdar (2002) presented a poster comparing the frequencies obtained using different adiabatic oscillation codes. OSC was not included in this comparison. I have filled this gap and compared the frequencies obtained with OSC to those obtained with the Aarhus package (ADIPLS).

Short description

The set of variables used in the code and the corresponding equations have been described in a paper by Boury et al. (1975), unfortunately with a typo (an extra ℓ factor in the first term of the right-hand side of equation (9)).

With $x = r/R$, the radial component of the displacement, the lagrangian perturbation of the pressure and the eulerian perturbation of the gravitational potential, omitting the $Y_{\ell m}(\theta, \phi)$ factor, are written

$$
\begin{aligned}
x^{\ell-1} y &= \frac{\delta r}{R}, \\
x^{\ell} z &= \frac{\delta P}{P}, \\
x^{\ell} u &= \frac{R\Phi'}{GM}, \\
x^{\ell-1} v &= \frac{R^2}{GM}\frac{d\Phi'}{dr} + \frac{4\pi R^3 \rho}{M}\frac{\delta r}{R}.
\end{aligned}
$$

The differential equations read

$$
\begin{aligned}
\frac{dy}{dx} &= \frac{\ell+1}{x}\left\{-y + \frac{\ell}{\omega^2}\left(\frac{q}{x^3}y + \frac{RP}{GM\rho}z + u\right)\right\} - \frac{x}{\Gamma_1}z, \\
\frac{dz}{dx} &= \frac{GM\rho}{RP}\left\{\left(\omega^2 + 4\frac{q}{x^3}\right)\frac{y}{x} + x\frac{q}{x^3}z - \frac{v}{x} - \frac{\ell(\ell+1)}{x\omega^2}\frac{q}{x^3}\left(\frac{q}{x^3}y + \frac{RP}{GM\rho}z + u\right)\right\} - \frac{\ell}{x}z,
\end{aligned}
$$

$$\frac{du}{dx} = \frac{1}{x}\left(v - \frac{4\pi R^3\rho}{M}y - \ell u\right),$$
$$\frac{dv}{dx} = \frac{\ell+1}{x}(\ell u - v) + \frac{\ell(\ell+1)}{x\omega^2}\frac{4\pi R^3\rho}{M}\left(\frac{q}{x^3}y + \frac{RP}{GM\rho}z + u\right),$$

where $q = m/M$ and ω is defined in term of the angular frequency σ as $\omega^2 = R^3\sigma^2/GM$.

Regularity conditions are imposed at the center and the continuity of the gravitational potential at the surface is expressed by $v + (l+1)u = 0$. Another condition must be imposed on the perturbation of the pressure at the surface of the star. It may be a simple condition like $\delta P = 0$ or may take a more elaborate form.

The discretization scheme is a fourth order one.

Comparison with the ADIPLS package

We have not conducted very extensive comparisons. We have used model S of Jørgen Christensen-Dalsgaard (1996), more precisely the file fgong.l5bi.d.15c. From this file we have built a model in the format required by OSC and one in the format required by ADIPLS (with 4800 points). The frequencies of the p-modes were computed by both codes up to 5 mHz, for $\ell = 0$, 1, 2, and 3 with the boundary condition $\delta P = 0$.

Figure 1 shows the differences in the frequencies obtained by OSC and by ADIPLS with the Richardson extrapolation. The differences are of the order of a few hundredth of μHz, as it was the case for other codes in the comparisons done by Anwesh Azumdar (2002).

References

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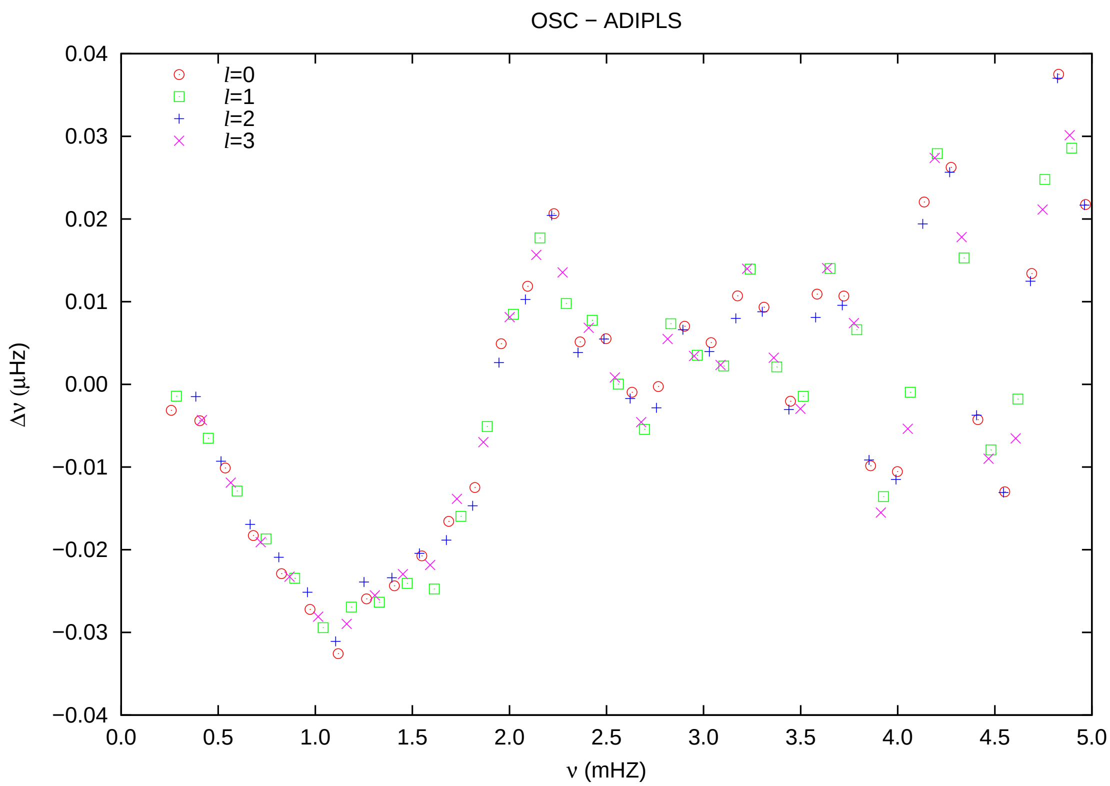

Figure 1: Comparison between the frequencies obtained with OSC and ADIPLS for model S of Christensen-Dalsgaard