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g Modes in γ Doradus Stars: a Theoretician's Quest for Instability

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Abstract. We present a new implementation of the Riccati method for the linear stability analysis of weakly non-adiabatic g-mode pulsations in γ Doradus stars.

More than a decade ago now, Gautschy & Glatzel (1990) introduced the Riccati integration technique to carry out the linear stability analysis for non-adiabatic, non-radial pulsations. In the following years, Gautschy, Glatzel and collaborators have demonstrated the advantages of this method in a number of applications to a whole range of different, *highly* non-adiabatic pulsation problems.

It turns out, however, that the method as implemented by Gautschy (1996) is not very well suited for the analysis of the only *weakly* non-adiabatic g-mode pulsations in low-mass main-sequence stars with convective stellar envelopes, e.g. γ Doradus stars (Löffler, 1999). Initial attempts to remedy the situation and to improve the numerical accuracy of the method (Löffler, 1999, 2000) were not very successful and mostly produced what is now known to be numerical artifacts.

We have now carried out an extensive in-depth analysis of the numerical aspects of the Riccati method, which demonstrates that the past problems to compute reliable g-mode eigenvalues and eigenfunctions for the γ Doradus stars is not an insufficiency of the method per se, but a consequence of the actual algorithmic and numerical implementation.

The main differences between our new and the original implementation of the Riccati method (Gautschy & Glatzel, 1990; Gautschy, 1996) are the choice of integration variables (Lagrangian vs. Eulerian, temperature vs. entropy perturbation, normalisation), integration strategy (check for singularity of the Riccati matrix) and root finding method (complex secant versus Muller (1956) method).

To check the numerical integrity, stability as well as efficiency of our new implementation of the Riccati method, we analysed a $1.8\,M_\odot$ δ Scuti model very similar to the one presented by Pamyatnykh (2000) as well as a $1.5\,M_\odot$ γ Doradus model roughly similar to the one used by Wu (in these proceedings) and find a reasonably good agreement in the mode periods as well as in the differential work integrals.

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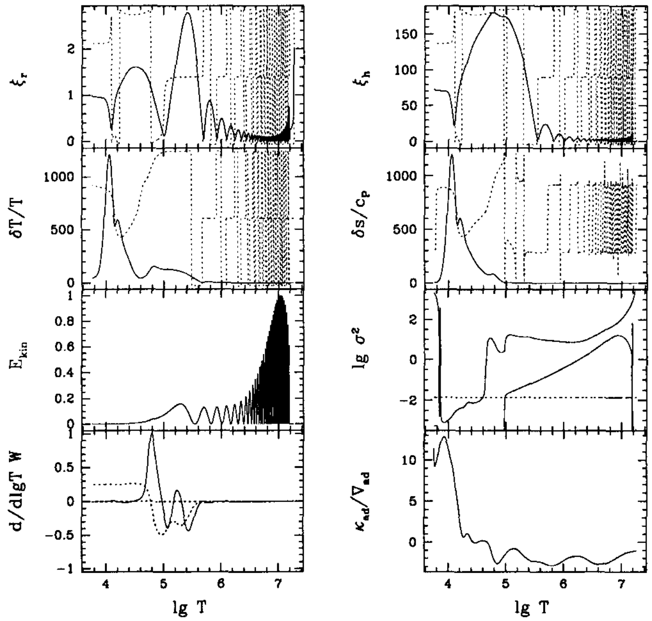

Figure 1. Eigenfunctions (complex amplitude and phase), kinetic energy, propagation diagram and work integrals of the unstable mode g_{36} ($\Pi = 2080\,\mathrm{min}$, $\ell = 1$) in our $1.5\,\mathrm{M}_\odot$ zero-age main-sequence model.

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References

Gautschy, A., Glatzel, W. 1990, MNRAS, 245, 154

Gautschy, A. 1996, private communication

Löffler, W. 1999, PhD Thesis, Universitt Basel

Löffler, W. 2000, in ASP Conf. Ser., Vol. 203, The impact of Large-Scale Surveys on Pulsating Star Research, eds. L. Szabados & D. Kurtz, (San Francisco: ASP), 447

Muller, D. E. 1956, MTAC, 10, 208

Pamyatnykh, A.A. 2000, in ASP Conf. Ser., Vol. 210, Delta Scuti and Related Stars, eds. M. Breger & M. Montgomery, (San Francisco: ASP), 215

Two happy women (Anja Andersen and Suzanne Höfner) returning home by train after the conference.