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Oscillations of Rapidly Rotating Stars

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Abstract. We present numerical simulations of gravito-inertial waves propagating in radiative zones of rapidly rotating stars. A first model, using the Boussinesq approximation, allows us to study the oscillations of a quasi-incompressible stratified fluid embedded in a rapidly rotating sphere or spherical shell. In a second step, we investigate the case of a γ Doradus-type star using the anelastic approximation. Some fascinating features of rapidly rotating fluids, such as wave attractors, appear in both cases.

1. The Boussinesq Model

In this configuration, the Brunt–Väisälä frequency is simply proportional to the radial distance. Many mathematical results are known (Friedlander & Siegmann 1982) concerning the shape of critical surfaces and characteristics of the governing mixed-type operator. We confirm all these results by calculating the orbits of characteristics which propagate in the hyperbolic domain. In particular, we find that characteristics can be focused along attractors leading to associated singular velocity fields (Dintrans, Rieutord, & Valdettaro 1999).

2. The Anelastic Model

We study, using the anelastic approximation, the low-frequency oscillations of a typical γ Doradus star. Hence, we show that dealing with rotation by the means of a second-order perturbative theory is not correct for rotation periods less than 3 days. Using the same geometric formalism as above (i.e. calculations of orbits of characteristics) allows us to compute the frequencies of oscillations in the rapid rotation régime (rotation periods $\sim$ 1 day). We find again that wave attractors are a common feature of rapidly rotating fluids and conclude that they are promising features for the transport of angular momentum and chemicals in the radiative zone of rotating stars (Dintrans & Rieutord 1999).

References

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