Probing magnetic fields in stars: A 2D oscillation framework including rotation and magnetism

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Abstract

Understanding the role of internal magnetic fields in stars remains a major stumbling block for the description of angular momentum transport and stellar evolution. In this work, we present a new implementation of the 2D oscillation code ACOR, which incorporates the effects of both stellar rotation and magnetic fields. The code has been rendered modular, allowing to specify the set of equations to solve and the hypotheses through a symbolic calculus approach. The full set of adiabatic, non-radial pulsation equations is solved using a spectral approach in the angular direction and high-order finite differences in the radial direction. As a first step, we focus on a simplified case in which the magnetic field is purely toroidal, axisymmetric, and aligned with the star's rotation axis. The numerical results are validated against first-order perturbative predictions in the weak-field regime and compared to the magnetic Traditional Approximation of Rotation (TAR) for stronger magnetic fields. We show that internal magnetic fields leave signatures in the period spacing of g-modes. These features could provide a promising seismic diagnostic to probe deep stellar magnetism. Future work will aim to extend this framework to more realistic magnetic field topologies and a broader range of pulsating stars, including red giants.