Can we detect deep axisymmetric toroidal magnetic fields in stars?

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One of the major discoveries of asteroseismology is the signature of a strong extraction of angular momentum (AM) in the radiative zones of stars in the whole Hertzsprung-Russell diagram, leading to weak core-to-the surface rotation contrasts. Despite all the efforts made to elaborate a consistent AM transport model this remain one of the major unsolved questions of modern stellar astrophysics.

A possible key ingredient to figure out this puzzle is magnetic field with its various topologies. Among them, strong axisymmetric toroidal fields, which are subject to the so-called Tayler MHD instability, could play a major role. They could trigger a dynamo action in radiative layers while the resulting magnetic torque allows an efficient transport of AM.
But is it possible to detect signatures of these deep toroidal magnetic fields?

The only way to answer this question is asteroseismology and the best laboratories of study are intermediate-mass and massive stars. Since most of these are rapid rotators during their main-sequence, we have to study stellar pulsations propagating in stably stratified, rotating, and strongly magnetised radiative zones.

For that, we generalise the traditional approximation of rotation, which provides in its classic version a flexible treatment of the adiabatic propagation of gravito-inertial modes, by taking simultaneously general axisymmetric differential rotation and toroidal magnetic fields into account.
Using this new non-perturbative formalism, we derive the asymptotic properties of magneto-gravito-inertial modes and we explore the different possible field configurations. We found that the magnetic effects should be detectable for equatorial fields using high-precision asteroseismic data.