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The relation between the rotational and inertial modes of a triaxial planet

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Inertial modes are natural oscillations in the fluid parts of planets which are caused by the restoring action of the Coriolis force. The relation between these modes, as they appear in the liquid core of planets, and the well-known rotational modes – the Free (Inner) Core Nutation (FCN & FICN) and the Chandler and Inner Core Wobble (CW & IW) – is not well understood, with the FCN often being mistakenly identified to the simplest inertial mode, the Spin-Over (SO). In this work, we clarify this relation using a new formalism to compute the rotational modes of a two-layer triaxial planet with a rigid mantle and an inviscid fluid core to all order in the eccentricity. We confirm the validity of our model through comparison with the results from direct numerical integration of the equations of motion. Using this technique, we demonstrate how the SO is the only inertial mode affecting the rotation of the planet and we show how this mode identifies with the FCN only in the limit of vanishing eccentricity.