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The influence of mass imperfections on the evolution of standing waves in slowly rotating spherical bodies

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Abstract

Standing waves can exist as stable vibrating patterns in perfect structures such as spherical bodies, and inertial rotation of the body causes precession (Bryan's effect). However, an imperfection such as light mass anisotropy destroys the standing waves. In this paper, an imperfection is introduced in the form of light mass anisotropy for a vibrating, slowly rotating spherical body. Assuming this light mass imperfection throughout this paper, the effects of slow rotation and light isotropic viscous damping are considered in a system of variables consisting of the amplitudes of principal and quadrature vibrating patterns, the angle of the rotation of the vibrating pattern (called the *precession angle*) and the phase shift of the vibrating pattern. We demonstrate how a combination of both qualitative and quantitative analysis (using, inter alia, the method of averaging) predicts that the inertial angular rate does not influence changes with time in the amplitudes of the principal and quadrature vibrations or the phase shift. The light mass imperfection causes changes with time which appear to be of a damped oscillatory nature for both the quadrature component as well as the principal component. The precession angular rate appears to depend on the inertial angular rate as well as the quadrature component of the vibration but is not influenced by the damping factor. It is not directly proportional to the inertial angular rate as is the case for a perfect isotropically damped structure. If the quadrature component is not suppressed, then a “capture effect” appears to occur, namely that the precession angle will not grow at a constant rate but is “captured” and shows periodic behaviour. It is evident that the damping factor does not influence changes with time in the phase shift and that the mass imperfection substantially influences these changes. The phase shift appears to be negative, strictly decreasing and unbounded