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Dynamics of a fluid inside a precessing cylinder ROMAIN LAGRANGE, IFP, PATRICE MEUNIER, CHRISTOPHE ELOY, IRPHE, FRANCOIS NADAL, CEA, CNRS/CEA COLLABORATION — The instability of a fluid inside a precessing cylinder is studied theoretically and experimentally. This study is motivated by aeronautics and geophysics applications. Precessional motion forces hydrodynamics waves called Kelvin modes whose structure and amplitude are predicted by a linear inviscid theory. When a forced Kelvin mode is resonant, a viscous and weakly nonlinear theory has been developed to predict its saturated amplitude. We show that this amplitude scales as $Re^{1/2}$ for low Reynolds numbers and as $\theta^{1/3}$ (where θ is the precessing angle) for high Reynolds numbers. These scalings are confirmed by PIV measurements. For Reynolds numbers sufficiently large, this forced flow becomes unstable. A linear stability analysis based on a triadic resonance between a forced Kelvin mode and two free modes has been carried out. The precessing angle for which the flow becomes unstable is predicted and compared successfully to experimental measurements. A weakly nonlinear theory was developed and allowed to show that the bifurcation of the instability of precession is subcritical. It also showed that, depending on the Reynolds number, the unstable flow can be steady or intermittent. Finally, this weakly nonlinear theory allowed to predict, with a good agreement with experiments, the mean flow in the cylinder; even if it is turbulent.

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