

Physical mechanism of centrifugal-gravity wave resonant instability in azimuthally symmetric swirling flow

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Abstract:

We present an explicit analysis of wave-resonant instability of swirling flows inside fast rotating cylindrical containers. The linear dynamics are decomposed into the interaction between the horizontal inner centrifugal edge waves and the outer vertical gravity waves with the aim of understanding the dynamics of the centrifugal waves. We show how the far field velocity induced respectively by the centrifugal and the gravity waves affect each other's propagation rates and amplitude growth. We follow this with an analysis of the instability in terms of a four- wave interaction, two centrifugal and two gravity ones, and explain why the resonant instability can be obtained only between a pair of two counterpropagating waves, one centrifugal and one gravity. Furthermore, a near resonant regime which does not yield instability is shown to result from a phase-locking configuration between a pair of a counterpropagating centrifugal wave and a propropagating gravity one, where the interaction affects the waves' propagation rates but not the amplitude growth.