Nonnormal-nonlinear feedback between counter propagating Rossby waves in shear flows

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ABSTRACT

The counter propagating Rossby wave (CRW) concept rationalize the essence of both normal and nonnormal linearized dynamics of plane parallel shear flows. Here we present a wave-wave nonlinear formulation of CRWs and exemplify it on a simple setup of a 2D inviscid single shear layer. This basic state supports the existence of two CRWs, for each wavenumber, on the two sides of the shear layer. We focus on the triad interaction mechanism and identify that the nonlinear wavenumber doubling seeds new perturbations where the two CRWs are always in anti- phase. This configuration is favor for nonmodal growth; hence a positive nonnormal-nonlinear feedback is in the heart of the CRW interaction. When the doubled wavenumber CRWs affect backward the initial ones, the four CRWs system may achieve a new saturated steady state with final CRWs' phases and amplitudes that can be predicted from analyzing the fixed points of the system. We discuss several examples, showing how decaying linear solutions experience nonlinear-nonnormal amplification and finally saturate with finite amplitudes.