Kelvin-Helmholtz instability in viscous two-layer oscillatory flow

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ABSTRACT

Superposed liquid layers in horizontal oscillatory motion can develop waves on their immiscible interface due to an instability. The investigation of this instability is of importance because it is responsible for wave formation in different practical problems, e.g., frozen waves observed in liquid layers in a container vibrated horizontally, waves found in a cylindrical tank spun up alternatively. Although the first stability analysis in inviscid approximation dates around half a century ago[1], it is very recently that viscous flows have been considered in stability analyses[2,3]. The viscous theories predict successfully critical parameter behavior that had not been explained by the inviscid theories.

We will present our linear stability analysis based on the Floquet theory. The analysis shows the instability threshold in relative velocity between the two layers and the most instable mode are frequency dependent. It also shows significant influence of the viscosity contrast at the interface on the stability. We will address the mechanism behind the instability by identifying the velocity- and shear-induced components in the disturbance growth rate. They interchange dominance depending on the frequency and the viscosity contrast. The theoretical predictions are compared favorably with our experiments as well as experiments in the literature.

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