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EFFECT OF GRAVITY ON INTERFACIAL INSTABILITY IN MISCIBLE LIQUIDS INDUCED BY VIBRATIONS

Abstract

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The stability of the system under periodic vibrations with the direction along the interface has attracted large research interest in different problems studied under microgravity and normal gravity conditions. Liquid-liquid interfaces may become unstable if a shear stress is applied and a well-known example is the Kelvin-Helmholtz instability. Our recent experiments [1 , 2] demonstrated that an interfacial instability may occur between two miscible liquids of similar (but non-identical) viscosities and densities under horizontal periodic excitations. In a gravity field, a spatially periodic saw-tooth frozen structure is generated on the interface under horizontal vibrations somewhat similar to immiscible liquids. Under the low gravity conditions of a parabolic flight, the crests widen and the final and long-lived pattern consists of a series of vertical columns of alternating liquids. The target of present study is to identify the influence of gravity on instability of the interface between two miscible liquids and to examine the evolution of the interfacial wave shape for parameter ranges that are out of reach experimentally, i.e., when gravity changes within the range from zero up to the Earth's gravity. This study is related to space experiment VIPIL (Vibrational Phenomena in Liquids) which is planned to be performed on ISS.

We present results of parabolic flight and numerical simulations in the geometry which corresponds to the experimental cell for the nonlinear evolution of waves at the interface between two miscible liquids subjected to horizontal oscillations at different gravity levels (see Fig.1). A detailed comparison between simulations and recent experimental observations in normal and low gravity showed an excellent agreement. The obtained results delineate parameter space where gravity affects differently interfacial instability. Based on qualitative observation of a large number of snapshot sequences and an extensive quantitative analysis, three distinctive regimes of instability were identified depending on the gravity level.

[1] Y. Gaponenko, M. Torregrosa, V. Yasnou, A. Mialdun and V. Shevtsova, Interfacial patter selection in miscible liquids under vibration, Soft Matter 11, 8221 (2015).

[2] Y. Gaponenko, M. Torregrosa, V. Yasnou, A. Mialdun and V. Shevtsova, Dynamics of the interface between miscible liquids subjected to horizontal vibration, J. Fluid Mech. 784, 342-372 (2015).