Graduate Student Research Seminar

Spring 2024

Oscillations of a sessile drop driven by oblique substrate vibrations

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3:00 pm (EST) – 132 Fluor Daniel Building

Abstract

Surface waves are formed on the surface of a sessile drop with pinned contact line when subjected to mechanical vibration, which are characterized by the mode number pair (l, m). Prior experiments by Chang *et al.* 2015, *JFM*, have shown that when the vibration is plane-normal (vertically oriented) the wave dynamics can be complex, with zonal modes $(m = 0)$ responding harmonically and non-zonal modes $(m \neq 0)$ subharmonically. Particularly important are the (1,1) rocking mode and (2,0) pumping mode, as these motions are associated with the dominant horizontal and vertical center-of-mass motions, respectively, and often associated with climbing drops. We report on experiments of oblique substrate vibrations focusing on the dynamic response of the rocking mode, which can either i) respond harmonically at its resonance frequency f_r or ii) respond subharmonically and mix with the harmonic pumping mode at $f_p = 2f_r$. We measure the instability tongues in the driving acceleration-frequency space and show how the dominant dynamic response depends upon the orientation of the mechanical vibration. To better understand these experimental observations, we develop a theoretical model by detuning the driving acceleration, which results in an inhomogeneous Mathieu equation governing the drop oscillations. We use a perturbation method to compute the stability tongues showing qualitative agreement with both prior and current experimental results.

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