Restitution coefficients of drops bouncing on a vibrating surface

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Drops exhibit fascinating rebound behavior when interacting with superhydrophilic solid surfaces, such as atomically smooth mica sheets [1]. Experimental observations show that drop bouncing occurs without the drop ever touching the solid and there is a nanometer-scale film of air that separates the liquid and solid. At touchdown, the drop experiences both primary and secondary reaction forces, strongly influencing its deformation and subsequent jump-off mechanism [2]. In the case of a vibrating stage, the drop can either remain in a 'bound' state, that will eventually lead to contact, or enter a sustained 'bouncing' state triggering harmonic oscillations. We investigate the bouncing and period-doubling thresholds up until chaos for varying accelerations γ/g, with γ the peak stage acceleration, and vibration numbers $2\pi f/\sqrt{\sigma/\rho R^3}$ corresponding to the ratio between the forcing frequency and the characteristic drop oscillation frequency. We use the free software basilisk [3] to solve the two-phase Navier-Stokes equations in an axisymmetric formulation by the Volume-Of-Fluid method on quadtree adaptive meshes. The numerical results demonstrate a remarkable agreement with experimental observations, facilitating a comprehensive exploration of the system's dynamics and allowing us to extend the regime diagram of previous work on a similar setup [4]. Extracting the coefficient of restitution C_R and the characteristic 'contact-time' τ_C, we are able to cast a simplified nonlinear spring model that accurately predicts the drop center oscillation for any given set of parameters. The exact nonlinearities pertaining to this reduced-order model are compared to those deduced from the application of a state-of-the-art data-driven learned model.

Références

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