Liquid Hertz impact

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The interaction between a drop of liquid and a rigid substrate upon collision depends on many physical factors, including the drop surface tension, γ; inertial properties (characterized by the drop density, ρ); external force fields (for example, gravity); and the wetting properties of the surface. Impact parameters such as the drop size (characterized by the drop's equivalent radius, R) and the impact velocity, v_0, govern the transition between different impact regimes. The Weber number, $\mathrm{We} = \rho R v_0^2/\gamma$, which represents the ratio of inertial to surface tension forces, naturally arises in the impact problem and serves as the key dimensionless group.

Recently, Gabbard *et al.* [1] reviewed the state of the art in analytical modeling of drops impacting non-wetting substrates at low Weber numbers. Within the landscape of mathematical models, two are particularly prominent: the model by Chevy *et al.* [2] and that of Moláček and Bush [3]. The present study further develops the first approach by relaxing its assumption of small drop deformations. Specifically, we construct a quasi-static model for the normal impact of a viscous drop on a non-wetting substrate. The axisymmetric deformation of a sessile drop is described analytically using new asymptotically exact approximations to solutions of the Young–Laplace equation. Viscous dissipation is accounted for in linearized form through a damping coefficient inversely proportional to the relaxation time of small-amplitude oscillations of a viscous sessile drop. This formulation enables evaluation of the key characteristics of Hertz-type impact at low Weber numbers, including the drop spreading factor, restitution coefficient, and characteristic time scale. Comparison with experimental data demonstrates that the model reliably captures the essential features of slow, viscously-damped liquid-drop impacts on non-wetting surfaces.

References

[1] C.T. Gabbard, E.A. Agüero, R. Cimpeanu, K. Kuehr, E. Silver, J.-W. Barotta, C.A. Galeano-Rios, and D.M. Harris, Drop rebound at low Weber number, *J. Fluid Mech.*, 1019:A25, 2025.

[2] F. Chevy, A. Chepelianskii, D. Quéré, and E. Raphaël, Liquid Hertz contact: softness of weakly deformed drops on non-wetting substrates, *Europhys. Lett.*, 100:54002, 2012.

[3] J. Moláček and J.M. Bush, A quasi-static model of drop impact, *Phys. Fluids*, 24:127103, 2012.