LadHyX Seminar – March 9, 10:45 – LadHyX library

From bouncing to making a splash: computational modelling of impact across scales

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The canonical framework of drop impact provides excellent opportunities to co-develop experimental, analytical and computational techniques in a rich multi-scale context. The talk will represent a journey across parameter space, as we address beautiful phenomena such as bouncing, coalescence and splashing, with a particular focus on scientific computing aspects and associated numerical methods.

To begin with, consider millimetric drops impacting a deep bath of the same fluid that are generated using a custom syringe pump connected to a vertically-oriented needle. Measurements of the droplet trajectory are compared directly to the predictions of a quasi-potential model, as well as fully resolved unsteady Navier-Stokes direct numerical simulations (DNS). Both theoretical techniques resolve the time-dependent bath interface shape, droplet trajectory, and droplet deformation. In the quasi-potential model, the droplet and bath shape are decomposed using orthogonal function decompositions leading to a set of coupled damped linear oscillator equations solved using an implicit numerical method. The underdamped dynamics of the drop are directly coupled to the response of the bath through a single-point kinematic match condition, which we demonstrate to be an effective and efficient technique. The hybrid methodology has allowed us to unify and resolve interesting outstanding questions on the rebound dynamics of the multi-fluid system (Alventosa, Cimpeanu and Harris, JFM 957, 2023).

We then shift gears towards the much more violent regime of high-speed impact resulting in splashing, where a combination of matched asymptotic expansions grounded in Wagner theory and DNS allow us to produce theoretical predictions for the location and velocity of the ejected liquid jet, as well as its thickness (Cimpeanu and Moore, JFM 856, 2019). While the early-time analytical methodology neglects effects such as surface tension or viscosity (focusing on inertia instead), generalisations of the technique (Moore et al., JFM 882, 2020) and 3D extensions will also be presented and validated against an associated computational framework.

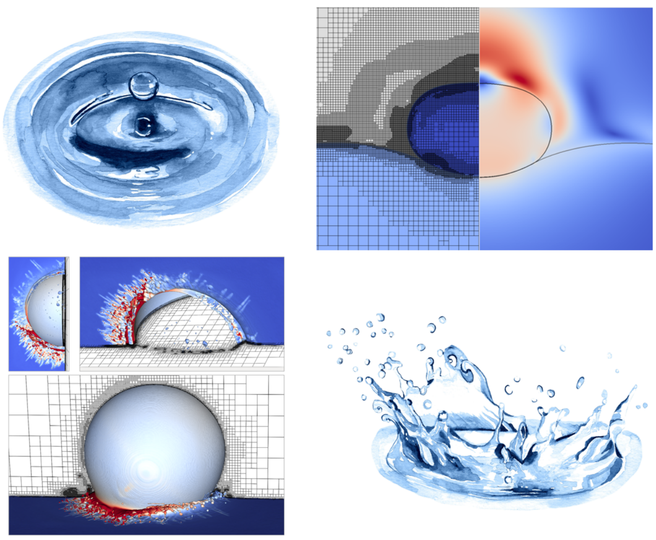

Figure 1: Watercolor visualisations and direct numerical simulation snapshots of bouncing (top) and splashing (bottom) following drop impact onto a liquid pool.