How to make a splash: a multi-scale framework for understanding high speed drop impact

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ABSTRACT:

The rich structures arising from the impingement dynamics of water drops onto solid substrates at high velocities will be discussed over a range of length- and timescales. Current methodologies in the aircraft industry for estimating water collection are based on particle trajectory calculations and empirical extensions thereof in order to approximate the complex fluid-structure interactions. The presented approach incorporates the detailed fluid dynamical processes often ignored in this setting, such as the drop interaction with the surrounding air flow, drop deformation, rupture and coalescence, as well as the motion of the ejected microdrops in the system. One-to-one comparisons are performed with experimental data available in the pre-impact stage, while the early stages of the impact itself are validated using an extension of the asymptotic analysis machinery provided by Wagner theory. The main body of results is created using parameters relevant to flight conditions with droplet sizes in the range of tens to several hundreds of microns impacting at speeds of up to 100 m/s.