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Contact Angle Dynamics of Droplets Impacting on Flat Substrates

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An experimental study is presented on contact angle dynamics of water droplets striking orthogonally smooth surfaces with widely disparate wetting characteristics (wetting to non-wetting). Fundamental information related to the relation between apparent (macroscopic) contact angle θ and contact line speed V_{CL} is presented. The impact conditions correspond to $Re = O(100) - O(1000)$, $We = O(10)$, $Ca = O(0.001) - O(0.01)$, $Oh = O(0.001)$ and $Bo = O(0.1)$. In this parameter regime, inertial, viscous, and capillary phenomena act simultaneously to influence contact line motion and arrest. The combined molecular-hydrodynamic theory of contact line speed dependence of the contact angle was found to fit the experimental θ vs. V_{CL} data yielding physically reasonable molecular-kinetic parameters for wetting and partially wetting surfaces. Impact on non-wetting surfaces is followed by rebound, and reveals that both advancing and receding contact angles do not change with contact line speed. The combined molecular-hydrodynamic theory could not predict the experimental data for non-wetting surfaces. Contact angle hysteresis was detected on each surface, however it was found to be minimum on the non-wetting surface. Moreover, impact with lower initial velocity on the non-wetting surface showed more elastic rebound than impact with higher initial velocity. It is concluded that droplet impact at moderately high Weber numbers on surfaces of varying wetting characteristics does not support a simple relation between apparent contact angle and contact-line velocity.

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