Nonmonotonic Response of Drop Impacting on Liquid Film: Mechanism and Scaling

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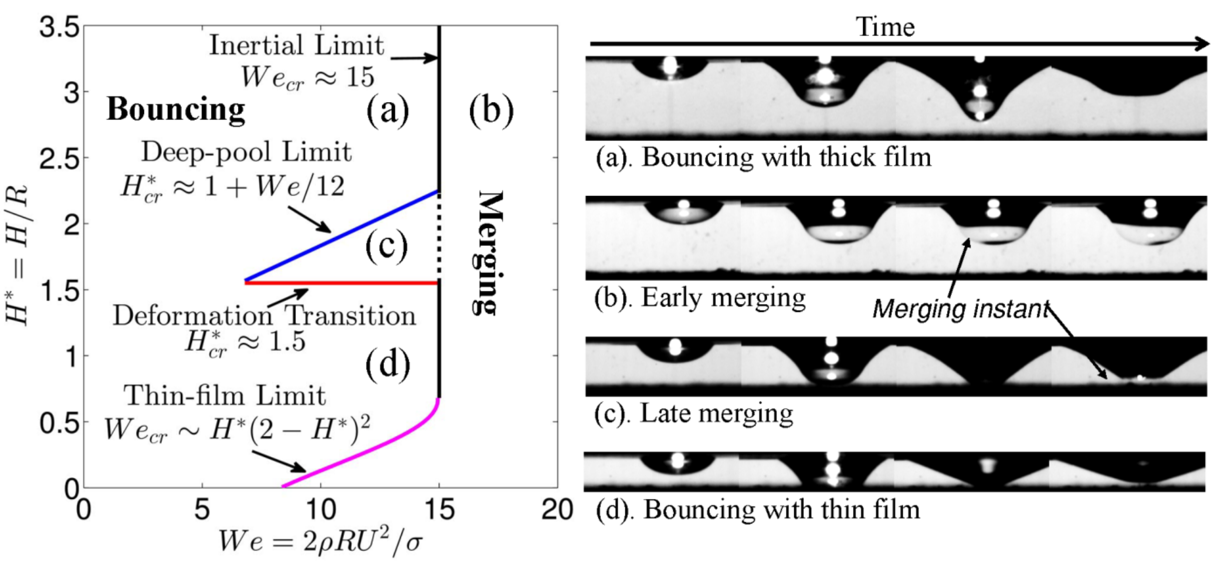
Drop impacting a liquid film with finite thickness is omnipresent in nature and plays a critical role in numerous industrial processes such as controlling the quality of ink-jet printing through spreading and mixing of the inks, the microstructure of thermal coating through bonding of drops of ceramic material on the base material, soot and pollutant formation through vaporization and subsequent burning of liquid fuel spray deposited on wetted engine surfaces, and the transport of the saline content through impacting rain drops on ocean surface. The impact can result in either bouncing or merging, which are mainly controlled by the impact inertia of the drop and film thickness. Although it is known that impacts with inertia beyond a critical value on a thick film promotes merging through the breakage of the interfacial gas layer, here we demonstrate that for impact inertia less than that critical value, increasing film thickness leads to a nonmonotonic transition from merging to bouncing to merging and finally to bouncing again. This behavior is mapped in the *H*-We* space, where *H** is the liquid thickness normalized by the drop radius, and *We* the drop Weber number and the transition boundaries are shown in the left figure below. For the first time, two different merging mechanisms are identified and the scaling laws of the nonmonotonic transitions are developed as indicated in the left figure. These results provide important insights into the role of the film thickness on the impact dynamics, which is critical for optimizing operating conditions for spray or ink-jet systems among others.



X. Tang, A. Saha, C. K. Law, C. Sun, "Nonmonotonic response of drop impacting on liquid film: mechanism and scaling", *Soft Matter,* 2016, **12**, 4521

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