

Dynamics of droplet–film collision

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(Received 8 September 2006 and in revised form 14 March 2007)

The head-on collision of a droplet onto a liquid layer of the same material, backed by a solid surface, was experimentally and computationally investigated, with emphasis on the transition from bouncing of the droplet to its absorption by the film for given droplet Weber number, We , and the film thickness scaled by the droplet radius, H_f . Experimental results show that while absorption is favoured with increasing We , there exists a range around $H_f \approx 1$ over which this tendency is moderated. This local moderation in turn corresponds to a regime, $11 \lesssim We \lesssim 14$, over which increasing H_f from a small value leads to a triple reversal behaviour of absorption, bouncing, absorption again, and bouncing again. The collision dynamics including evolution of the surface contours of the droplet and film, as well as the energy budgets, were then simulated by using a front-tracking technique. For collisions leading to absorption and partial absorption, for which part of the absorbed droplet is subsequently ejected from the film, rupture and hence merging of the interfaces were manually imposed at an instant that leads to agreement between the subsequent calculated and experimental images. The simulation satisfactorily identified the different factors influencing the observed non-monotonic response of the collision event.

1. Introduction

The collision dynamics of droplets on liquid and solid surfaces is of relevance to a variety of natural phenomena and technological applications such as spray combustion in liquid-fueled combustors, ink-jet printing, raindrop interaction with ocean and soil surfaces, insecticide spraying, meteorite impaction, spray painting and coating, etc. Earlier studies were primarily concerned with water in air (Jayaratne & Mason 1964; Stow & Hadfield 1981) because of the prevalence of water and its relevance to meteorological implications. Results showed that, depending on such parameters as the impact inertia, surface tension, and impact angle, collision can result in bouncing, absorption by the liquid layer, and splashing (Rein 1993; Stanton & Rutland 1998). The controlling dynamic parameter is the collision Weber number, defined as $We = 2\rho_l V_0^2 R/\sigma$, where R is the droplet radius, V_0 the impact velocity, and ρ_l and σ the density and surface tension of the liquid, respectively. Studies involving head-on collisions (Harlow & Shannon 1967; Rodriguez & Mesler 1985) were mostly concerned with the transition between absorption and splashing that occurs at high We . Bouncing was observed at lower values of We (Ching, Golay & Johnson 1984), although its characteristics, including the transition to merging, have not been sufficiently studied.

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