Spontaneous Droplet Jump with Electro-bouncing

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We investigate the dynamics of water droplet jumps from superhydrophobic surfaces in the presence of an electric field during a step reduction in gravity level. In the brief free-fall environment of a drop tower, when a strong non-homogeneous electric field (with a measured strength between 0.39 and 2.36 kV/cm) is imposed, body forces acting on the jumped droplets are primarily supplied by polarization stress and Coulombic attraction instead of gravity. The droplet charge, measured to be on the order of $2.3 \cdot (10^{-11})$ C, originates by electro-osmosis of charged species at the (PTFE coated) hydrophobic surface interface. This electric body force leads to a droplet bouncing behavior similar to well-known phenomena in 1-g, though occurring for larger drops ∼0.1 mL for a given range of impact Weber numbers, $\mathbf{We} < 20$. In 1-g, for $\mathbf{We} > 0.4$, impact recoil behavior on a super-hydrophobic surface is normally dominated by damping from contact line hysteresis and by air-layer interactions. However, in the strong electric field, the droplet bounce dynamics additionally include electrohydrodynamic effects on wettability and Cassie-Wenzel transition. This is qualitatively discussed in terms of coefficients of restitution and trends in contact time.

1. Introduction

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