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Unified thickness profile of radially expanding sheets in the air

YONGJI WANG, LYDIA BOUROUIBA, The Fluid Dynamics of Disease Transmission Laboratory, Massachusetts Institute of Technology — The impact of a drop on a small solid surface or an edge results in a sheet expansion in the air. The sheet can then fragment into droplets. Understanding the dynamics of expansion and fragmentation in the air is important for a range of applications, including the transport of pathogen-bearing droplets created from contaminated leaves or surfaces. Here, we revisit the axisymmetric case of a radially expanding sheet formed from the impact of a drop on a small target of comparable size to that of the drop. We show that the temporal and spatial evolution of the sheet thickness profile is governed by a self-similar solution derived from first principles. The derived profile allows to collapse on a single curve the direct experimental measurements of sheet thickness profile for impacts on targets reported in the literature to date. A unified functional form governing the sheet thickness profile is proposed and reconciles the two conflicting theoretical profiles proposed in the literature thus-far. Finally, we show that the surface-to-drop size ratio plays an important role in affecting the thickness profile of the sheet in the air and rationalize the effects involved. Our findings allow to unify the thickness profile of unsteady expanding sheets in the air.

Lydia Bourouiba
The Fluid Dynamics of Disease Transmission Laboratory, Massachusetts Institute of Technology

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