Droplet Dynamics Under Applied Airflow: A Mathematical Investigation

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ABSTRACT

The application of airflow sweeps across a droplet-laden surface is commonplace in printing and coating processes. The droplet under an airflow can exhibit complex behaviors that arise from the coupling of surface tension, inertia of the external flow, and contact-line dynamics. Our experiments revealed that a millimetric partially wetting water droplet under an impinging jet can oscillate in place, split, or de-pin away from the jet, depending on the magnitude and position of the jet. To rationalize these observations, we develop a theoretical model that incorporates the external pressure induced by the airflow and the capillary pressure of the droplet. The resulting mathematical formulation allows us to perform numerical simulations, which reproduce the main experimental behaviors and provide insight into the mechanisms governing the observed dynamics.