The onset of fragmentation in binary liquid drop collisions

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Abstract

Binary collisions of liquid drops have been of scientific interest since many decades, starting with investigations in meteorology to explain rates of rainfall accelerated by drop collisions and merging. Subsequent investigations of binary drop collisions treated primarily drops consisting of the same liquid. It has been only since a few years that interest in collisions of drops of different (in part immiscible) liquids has arisen [1]-[4]. The application behind these processes may be the encapsulation of, e.g., an aqueous liquid inside an oil shell. The latter could carry a dissolved oligomer which could be polymerized by UV light to solidify the surface layer. For the mentioned applications, the stability of the collision complex formed by the binary drop collisions plays a major role. Encapsulation, for example, requires the formation of an oil layer on the surface of an aqueous drop, and, therefore, the stability of the collision complex in a sense that at least a part of the oil remains on the aqueous drop after the end of the deformation and break-up processes induced by the collision. It is thus of natural interest to look at the conditions for the onset of fragmentation in binary liquid drop collisions (Fig. 1). We present experiments on collisions of glycerol-water and silicon oil drops of equal sizes, varying the relative impact velocity and the impact parameter. The drops are produced by controlled Rayleigh-Plateau-type break-up of laminar liquid jets. The trajectories of the drops are controlled accurately by placement of the drop generators on high-precision traverses. All measurements (drop size, velocity, impact parameter, geometrical properties of the drops after the collision) are based on image processing. The images are taken with a high-resolution video camera under flash-light illumination [4]. From the experiments we deduce the energy budget of the drops for two phases after the collision: a first phase from the instant of drop contact to the state of maximum deformation, where the collision complex assumes the shape of a disk with a rim at its edge, and a second phase of relaxation of the disk into an approximately cylindrical shape with an aspect ratio measured on the images. The results show that a considerable part of the initial drop energy is invested in the rim formation and dissipated there, so that only a small part of it remains available in the relaxation phase. The Rayleigh criterion turns out suitable for characterizing the stability of the relaxed cylindrical state.

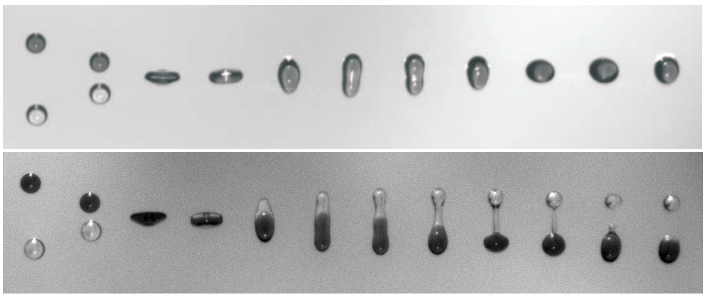

Figure 1. Top: Full encapsulation of a 50 % glycerol solution drop by SO M20 at relative velocity $U = 3.88$ m/s. Bottom: Crossing separation of a 50 % glycerol solution drop with SO M5 at U = 3.97 m/s.

References

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