Shape of the cavity formed by an oblique capillary jet

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When a liquid enters another liquid with enough velocity, air can be entrained. This phenomenon is widely studied, as it is found in multiple practical situations [1], from waves breaking in the ocean to the pouring of a beer in a pint.

Here, we study the case of an oblique capillary jet of water with or without surfactants entering a bath of the same liquid. Most of the literature indeed focuses on the vertical case, which appears to be very different concerning the air entrainment process. This behavior also differs from the case where an inclined jet impacts a thin soap film [2].

We show that when the jet impacts the bath, a stationary cavity and meniscus are formed. When the speed of the jet increases, an instability appears, which can grow enough to pinch bubbles at the tip of the cavity. The size and shape of the cavity is then primordial to understand air entrainment in this situation.

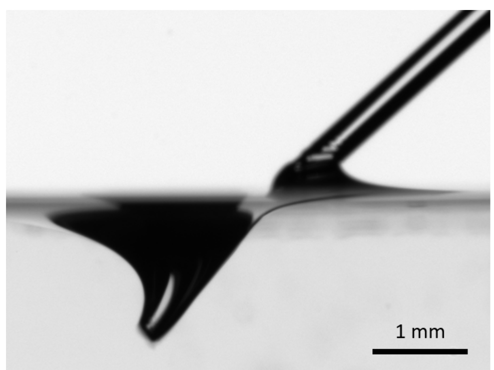

Figure 1. Image of a jet of radius 190 μm entering a bath of water at 2.1 m.s^{-1}.

We find that the shape of the cavity and the meniscus can partly be described by an hydrostatic balance between gravity and Laplace pressure at the interface. We observe that the size of the cavity is weakly dependent on the speed of the jet, but very sensitive to the angle between the jet and the bath. Adding surfactants to the solution will change the size of the cavity. The smallest cavity is observed for a minute amount of surfactant. The cavity then grows with the concentration of surfactant, but remains smaller than in the case of pure water.

References

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