Eight Lectures on the Cohesion and Fragmentation of Liquids

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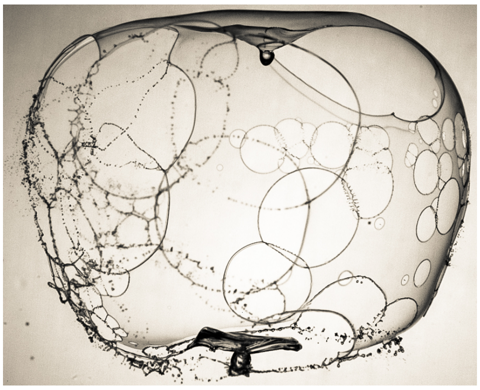
Capillarity is the familiar manifestation of the cohesion of liquids. Since Laplace (1805), we know that intense attractive forces between the molecules *bridge the small with the large* as they shape liquid/vapor interfaces at the macroscopic scale through the concept of surface tension (menisci, drops, bubbles, puddles, liquid rise in tubes, etc...).

These lectures will concentrate on situations where liquids 'disgregate', following the neologism of R. Clausius (1862), meaning that they fragment by the action of deformations stresses whose intensity competes with that of cohesion forces. Various examples, including explosions, blow-ups, hard and soft impacts, and shears applied to liquid jets, sheets and drops will be reviewed. They concern applications ranging from liquid propulsion, agricultural spraying, to the formation of spume over the ocean, raindrops, and human exhalations by violent respiratory events.



A liquid shell violently expanded by an exothermic chemical reaction.

In spite of their diversity, the various modes of fragments production share an ultimate common phenomenology, suggesting that the final stable droplets size distribution can be interpreted from elementary principles. The outline of the lectures will be†:

1. General overview. Origin and concept of surface tension. Founding idea and derivation of Laplace (1805).
2. Static equilibria, shape of liquid volumes at rest. Capillary length, classical solutions, menisci, bubbles, lying drops and puddles, films. Surface energy, variational calculus.
3. Dynamic equilibria, Savart's (1833) sheets and bells, holes, film edge recession, paradox, Taylor-Culick formulae.
4. Capillarity can be stabilizing: Capillary waves, Kelvin-Helmholtz and Rayleigh-Taylor instabilities. Impulsive acceleration. Case of a finite liquid layer thickness.
5. Capillarity can be destabilizing: The particular case of the cylindrical geometry, result of Plateau (1839).
6. Jets, threads, ligaments and the formation of drops (Rayleigh 1878, Weber 1931). Breakup and ultimate singularity. Viscous corrections, transients, time-varying substrates.
7. The post Plateau-Rayleigh erra: Paradigm of the corrugated ligament, inverse cascade of aggregations, fractional convolutions, Gamma distributions, fragments sizes, generalizations and analogies.
8. Miscellaneous: Mechanisms for the formation of 'fines', direct cascades. Energetics of fragmentation, misconceptions, analogies and differences with solid fragmentation.

†Relevant texts are: ROWLINSON, J. S., *Cohesion*, Cambridge University Press (2002), VILLERMAUX, E. Fragmentation. *Annu. Rev. Fluid Mech.* **39**, 419–446 (2007), and EGGERS, J. AND VILLERMAUX, E. Physics of Liquid Jets. *Rep. Prog. Physics* **71**, 036601 (2008).