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Data: 24 febbraio 2015
Aula: U2-02
Ora: 14.30-15.30

Off-equilibrium surface tension between miscible fluids

Surface tension is the tendency of a liquid to minimize its interface with another substance. Surface tension literally shapes the world around us: soap bubbles and liquid drops, insects striding on a water pond, and water transport in plants are but a few phenomena where surface tension plays a key role.

Does a surface tension exist between two *miscible* fluids? While the interface between two such fluids inevitably fades out as the liquids mix due to diffusion, physicist and mathematician D. Korteweg proposed more than a century ago that an effective, off-equilibrium surface tension rules the behavior of the interface on time scales shorter than mixing. A direct proof of Korteweg's ideas, however, was still lacking.

Here, we report on experiments probing the interface between two miscible fluids, an aqueous suspension of submicron colloidal particles and water. The suspension is confined between two plates and water is injected through a small hole in the top plate. As water is pushed through the more viscous colloidal suspension, the interface between the two fluids is destabilized, forming distinctive patterns similar to those observed for immiscible fluids. We show that the interface shape is ruled by an off-equilibrium surface tension and validate quantitatively Korteweg's predictions. These findings open the way to a better understanding of a wealth of phenomena, from crystal nucleation and growth to shaping and forming in material science.