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Rigid and Soft Wetting at Nanoscale

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Wetting phenomena at macro- and microscale have been studied intensively, and significant advancement in the understanding of both statics and dynamics of wetting has been achieved. That resulted in well-established ways to define contact angles and to predict the evolution of the liquid systems. However, due to the current state of imaging techniques, many questions about wetting at the nanoscale and its (dis)similarity to microscaled wetting are left to be unraveled theoretically.
In the present work, we study nanoscaled liquid droplets and rivulets on rigid and soft surfaces. We show that the equilibrium contact angles at the nanoscale depend drastically on the droplet size as well as on the way in which they are defined. Remarkably, the dependencies of the equilibrium contact angle on the droplet height collapse when plotted dimensionless with respect to the range of the surface force action. When the nanodroplet spreads over a wetting film, neither Cox-Voinov nor Tanner laws are valid anymore. Besides, the existence of the wetting film allows capillary ripples to emerge at the advancing front. In contrast to the microscale picture, the ripples are affected by the surface forces and can be fully suppressed by them. Soft substrates respond to the traction exerted by the droplet by forming a wetting ridge. That suppresses the development of the ripples. The wetting ridge height is shown to evolve non-monotonically.
Another focus of the present work is imbibition into corner geometries. It is well known that at macro- and microscale a rivulet must propagate indefinitely along the corner when the sum of half-opening angle of a corner and a contact angle is smaller than ninety degrees. The situation, however, changes when the surface forces are taken into account. Counterintuitively, they stop the rivulet rendering its steady-state even when the condition on spreading described above is fulfilled. We analyze how the corner opening angle, the corner size, and the surface forces influence the static shape of the rivulet. We additionally consider the case when the walls of the corner is soft and, hence, can be deformed by the liquid.

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