Phase Transition of a Meniscus in a Capillary under the Influence of Gravity

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Phase transitions of inhomogeneous fluids such as wetting and capillary-condensation that occur when a fluid is confined near a substrate or in parallel-plate geometries have received enormous attention over the last few decades. In most theoretical studies of these transitions the influence of a gravitational field is either considered secondary or, more often, completely neglected. However, it is clear that gravity plays a central role in many practical situations and, in combination with the confinement, induces further interfacial behaviour. Consider, for example, a large volume of a non-volatile liquid in a tall vertical capillary-slit or cylindrical pore which is capped at its bottom. What happens to the liquid when the capillary is slowly turned to the horizontal? Common experience tells us that the liquid will escape from the open end if the capillary is wide, as when water drains from a tipped glass, but will remain trapped if it is sufficiently narrow such as a drinking straw. It is somewhat surprising to find that this rather basic aspect of capillarity has not been investigated in depth. We show here some theoretical and experimental results of this phenomenon, and point out that this common phenomena is analogous to an interfacial unbinding phase transition involving the meniscus shape and reveals an unexpected connection between capillary-condensation and the theory of wetting transitions[1].

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