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Harvesting liquid from unsaturated vapor nanoflows induced by capillary condensation OLIVIER VINCENT, BASTIEN MARGUET, ABRAHAM STROOCK, Cornell University — A vapor, even subsaturated, can spontaneously form liquid in nanoscale spaces. This process, known as capillary condensation, plays a fundamental role in various contexts, such as the formation of clouds or the dynamics of hydrocarbons in the geological subsurface. However, large uncertainties remain on the thermodynamics and fluid mechanics of the phenomenon, due to experimental challenges as well as outstanding questions about the validity of macroscale physics at the nanometer scale. We studied experimentally the spatio-temporal dynamics of water condensation in a model nanoporous medium (pore radius $\sim$ 2 nm), taking advantage of the color change of the material upon hydration. We found that at low relative humidities ($<$ 60%RH), capillary condensation progressed in a diffusive fashion, while it occurred through a well-defined capillary-viscous imbibition front at $>$ 60%RH, driven by a balance between the pore capillary pressure and the condensation stress given by Kelvin equation. Further analyzing the imbibition dynamics as a function of saturation allowed us to extract detailed information about the physics of nano-confined fluids. Our results suggest excellent extension of macroscale fluid dynamics and thermodynamics even in pores $\sim$ 10 molecules in diameter.

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