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The nanoscale instability driving Leidenfrost film collapse TOM Y. ZHAO, NEELESH A. PATANKAR, Northwestern University — Above a critical temperature known as the Leidenfrost point (LFP), a heated surface can suspend a liquid droplet above a film of its own vapor. Here, we identify the vapor film instability for small length scales that ultimately sets the collapse condition at the LFP. From a linear stability analysis, it is shown that the main film stabilizing mechanisms are the liquid-vapor surface tension, viscous transport of vapor mass, and evaporation at the liquid-vapor interface. Meanwhile, van der Waals interaction between the bulk liquid and the solid substrate across the vapor phase drives film collapse. This physical insight into vapor film dynamics allows us to derive an ab-initio, mathematical expression for the Leidenfrost point of a fluid. The expression captures the experimental data on the LFP for different fluids under various surface wettabilities and ambient pressures. For fluids that wet the surface (small intrinsic contact angle), the expression can be simplified to a single, dimensionless number that encapsulates the nanoscale instability governing the LFP.

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