Abstract Submitted
for the DFD16 Meeting of
The American Physical Society

The spontaneous puncture of thick liquid films BAPTISTE NEL, EMMANUEL VILLERMAUX, Aix Marseille Université, CNRS, Centrale Marseille, IRPHE UMR 7342, 13384 Marseille, France — We call thick those films for which the disjoining pressure is ineffective. Water films with thickness h in the 1-10 μm range are thick, but it is also known that, paradoxically, they nucleate holes spontaneously. We have uncovered a mechanism solving the paradox. Most natural films are dirty to some extent, and we show that if a spot of dissolved substance lowers locally the surface tension of the liquid, the corresponding Marangoni stress may lead to a self-sustained instability triggering film rupture. When deposited with size a, the spot dissipates by molecular diffusion (coefficient D) along the film in a time a^2/D. Before doing so, the surface tension gradient $\Delta\sigma/a$ between the spot center (tension $\sigma - \Delta\sigma$) and the rest of the film (tension σ) induces an inhomogeneous outward interstitial flow which digs the spot, and reinforces the tension gradient. Hence the instability, which occurs within a timescale $\tau \sim \sqrt{\rho a^2 h/\Delta\sigma}$, with ρ the liquid density. When the Pclet number $Pe = a^2/D\tau$ is small, diffusion regularizes the film, which remains flat: clean films dont break, while for $Pe > 1$, the film punctures. This new scenario will be illustrated by several experiments.

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Date submitted: 27 Jul 2016 Electronic form version 1.4