Abstract Submitted
for the DFD16 Meeting of
The American Physical Society

Singular effective slip length for longitudinal flow over a dense bubble mattress ORY SCHNITZER, Department of Mathematics, Imperial College London — We derive accurate asymptotic expansions in the small-solid-fraction limit $\epsilon \ll 1$ for the effective slip length characterising unidirectional liquid flow over a 'bubble mattress' — a periodically grooved surface, with trapped bubbles protruding between solid ridges. The slip length diverges in this limit: inversely with $\sqrt{\epsilon}$ for contact angles θ near $\pi/2$, and logarithmically for $0 \leq \theta < \pi/2$. The analysis of the velocity field entails matching 'inner' expansions valid close to the solid segments with 'outer' expansions valid on the scale of the periodicity, where the protruding bubbles appear to touch. For θ close to $\pi/2$, the inner-region geometry is narrow and the analysis there resembles lubrication theory; for smaller contact angles the inner region is resolved using a Schwarz-Christoffel mapping. In both cases the outer problem is solved using a mapping from a degenerate curvilinear triangle to an auxiliary half plane. The asymptotic analysis explicitly illustrates the logarithmic-to-algebraic transition, and yields a uniformly valid approximation for the slip length for arbitrary contact angles $0 \leq \theta \leq \pi/2$. We demonstrate good agreement with a numerical solution (courtesy of Ms Elena Luca).

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Date submitted: 26 Jul 2016 Electronic form version 1.4