ABSTRACT

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DYNAMIC DEWETTING: A WORKING MODEL OF THE DYNAMIC CONTACT LINE

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ABSTRACT:
Huh and Scriven (1971) published a landmark paper on the hydrodynamics of wetting/dewetting phenomena based on solutions of the bi-harmonic equation of flow to describe velocity profiles near the moving contact line. Experimental results (Savelski et al, 1995, Fuentes and Cerro, 2005) showed large discrepancies between theory and data. This marked discrepancy between apparently sound theoretical derivations and experiments configure a hydrodynamic paradox that went unexplained for two decades. The source of discrepancy can be traced to the effect of molecular forces -disjoining pressure- the dominant effect in the molecular region close to the moving contact line. These molecular forces were not included in Huh and Scriven (1971) analysis.
The flow near a moving contact line can be divided in two separate regions with an intermediate transition region between the two. In the macroscopic region, for distances up to 10^{-3} m from the contact line, the pressure field is determined by gravity and viscous forces. In the molecular region, for distances up to 10^{-8} m, the pressure is determined by molecular forces and is described by the generic name of disjoining pressure. In the intermediate region, the flow field is a combination of the macroscopic and molecular contributions but quickly turns into the macroscopic solution for distances of the order of 2×10^{-8} m.
In our presentation we show analytical results of the bi-harmonic equation for the macroscopic and molecular regions and how can these solutions are matched to create a solution valid for the entire flow field. The resulting flow profiles show some interesting features. First, there is a split-streamline inside the flow field such that both the solid surface and the free interface move towards the contact line. This is the main result consistent with experimental observations. Second, there is slip on the solid surface within the molecular region. The presence of slip removes the singularity on the force field, one of the main objections to the theoretical results. Third, relative interface velocities and inclination of the split streamline show agreement with existing experimental results.

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