Research

Mechanics Seminar

Newtonian and non-Newtonian Thin Films

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07 April 2021

Time: 16:00

Microsoft Teams - https://tinyurl.com/48fqbv82

Abstract.

Thin viscous films are important features of coating and lubrication flows. Here, we study the thin film flow of Newtonian and yield stress (viscoplastic) fluids in the context of droplet spreading. For the Newtonian part of the talk, we will present experiments based on digital holographic microscopy, measuring with nanoscale resolution the morphology of capillary ripples ahead of a viscous drop spreading on a prewetted surface. Our experiments reveal that upon increasing the spreading velocity, the amplitude of the ripples first increases and subsequently decreases. Above a critical spreading velocity, the ripples even disappear completely, and this transition is accompanied by a divergence of the ripple wavelength. These observations are explained quantitatively using linear wave analysis, beyond the usual lubrication approximation, illustrating that new phenomena arise when the capillary number becomes of the order of unity. For the non-Newtonian part of the talk, we will study the same problem but with a yield stress fluid. We show that the droplet converges to a final equilibrium shape once the driving stresses inside the droplet fall below the yield stress. Scaling laws are presented for the final radius and complemented with an asymptotic analysis for shallow droplets. Moreover, numerical simulations using the volume-of-fluid method and a regularized constitutive law, and experiments with an aqueous solution of Carbopol, are presented.

References:

[1] Maziyar Jalaal, Carola Seyfert, and Jacco H Snoeijer. Capillary ripples in thin viscous films. Journal of Fluid Mechanics, 880, 430–440, 2019.

[2] Maziyar Jalaal, Boris Stoeber, and Neil Balmforth. Spreading of viscoplastic droplets. Journal of Fluid Mechanics, 914, 2021.