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Droplets spreading under contact-line friction

This talk is concerned with the spreading of a liquid droplet on a plane solid surface in the regime of lubrication approximation. The focus is on effective conditions which relate the speed of the contact line (where liquid, solid and vapor meet) to the microscopic contact angle. One such condition has been recently proposed by Weiqing Ren and Weinan E [Phys. Fluids 19 (2007), 022101]: it includes into the model the effect of frictional forces which arise at the contact line from unbalanced components of the Young's stress, leading to an additional dissipation term in the energy balance. For speed-dependent contact angle conditions of rather general form, a matched asymptotic study is worked out, relating the macroscopic contact angle to the speed of the contact line. Here, well-posedness for a class of traveling-wave solutions, which does not seem to have been observed so far, is proved and used. For the specific model of Ren and E, ODE arguments are then applied to infer the intermediate scaling laws and their timescales of validity: in complete wetting, they depend crucially on the relative strength of surface friction (at the liquid-solid interface) versus contact-line friction; in partial wetting, they also depend on the magnitude of the static contact-angle.
The results have been obtained jointly with Lorenzo Giacomelli (Sapienza University of Rome).