SCALING LAWS FOR DROPLETS SPREADING UNDER CONTACT-LINE FRICTION *

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Abstract. This manuscript is concerned with the spreading of a liquid droplet on a plane solid surface. 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 at the contact line, which arise from unbalanced components of the Young's stress. In lubrication approximation, the spreading of thin droplets may be modeled by a class of free boundary problems for fourth order nonlinear degenerate parabolic equations. For speed-dependent contact angle conditions of rather general form, a matched asymptotic study of these problems is worked out, relating the macroscopic contact angle to the speed of the contact line. 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.

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