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Global symmetry relations in linear and viscoplastic mobility problems KEN KAMRIN, MIT, JOE GODDARD[1], UC San Diego — The mobility tensor of a textured surface is a homogenized effective boundary condition that describes the effective slip of a fluid adjacent to the surface in terms of an applied shear traction far above the surface. In the Newtonian fluid case, perturbation analysis yields a mobility tensor formula, which suggests that regardless of the surface texture (i.e. nonuniform hydrophobicity distribution and/or height fluctuations) the mobility tensor is always symmetric. This conjecture is verified using a Lorentz reciprocity argument. It motivates the question of whether such symmetries would arise for nonlinear constitutive relations and boundary conditions, where the mobility tensor is not a constant but a function of the applied stress. We show that in the case of a strongly dissipative nonlinear constitutive relation — one whose strain-rate relates to the stress solely through a scalar Edelen potential — and strongly dissipative surface boundary conditions — one whose hydrophobic character is described by a potential relating slip to traction — the mobility function of the surface also maintains tensorial symmetry. By extension, the same variational arguments can be applied in problems such as the permeability tensor for viscoplastic flow through porous media, and we find that similar symmetries arise. These findings could be used to simplify the characterization of viscoplastic drag in various anisotropic media.

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