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Induced motion of a sphere due to a flexible elastic sheet BHARGAV RALLABANDI, Princeton University, NAOMI OPPENHEIMER, Flatiron Institute, Simons Foundation, THOMAS SALEZ, University of Bordeaux, HOWARD A. STONE, Princeton University — A sphere translating parallel to a rigid wall in Stokes flow experiences an increased drag but no normal force. In contrast, a sphere translating along the surface of a soft elastic substrate experiences an induced normal force due to the coupling between hydrodynamic stresses and elastic deformation. Here, we use theory and experiments to show that an analogous effect occurs for a particle moving near a flexible elastic membrane with bending and stretching resistances. Applying the Lorentz reciprocal theorem in the lubrication limit, we find that the induced force on the particle is repulsive, scaling with the square of its translational speed and inversely with the bending modulus and tension of the membrane. The theoretical predictions are validated by experiments of a sphere driven by gravity down a vertically suspended elastic sheet, where we observe a spontaneous motion of the sphere away from the sheet. The general theoretical approach and the specific results are pertinent to the dynamics of objects near biological membranes and other deformable interfaces.

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