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New Method to Calculate Electrical Forces Acting on a Sphere in an Electrorheological Fluid[1] KWANGMOO KIM, DAVID STROUD, The Ohio State University, XIANGTING LI, DAVID BERGMAN, Tel Aviv University — We describe a method to calculate the electrical force acting on a sphere in a suspension of dielectric spheres in a host with a different dielectric constant, under the assumption that a spatially uniform electric field is applied. The method uses a spectral representation for the total electrostatic energy of the composite. The force is expressed as a certain gradient of this energy, which can be expressed in a closed analytic form rather than evaluated as a numerical derivative. The method is applicable even when both the spheres and the host have frequency-dependent dielectric functions and nonzero conductivities, provided the system is in the quasistatic regime. In principle, it includes all multipolar contributions to the force, and it can be used to calculate multi-body as well as pairwise forces. We also present several numerical examples, including host fluids with finite conductivities. The force between spheres approaches the dipole-dipole limit, as expected, at large separations, but departs drastically from that limit when the spheres are nearly in contact. The force may also change sign as a function of frequency when the host is a slightly conducting fluid.

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