84

Deformation and breakup of sessile and pendant magnetic fluid droplets on a magnetized sphere

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Droplet manipulation is a rapidly developing, interdisciplinary field in microfluidics. Droplets of magnetic fluid can be used in biomedical and chemical applications, e.g., to create soft microrobots and actuators. The magnetic forces, in combination with the force of surface tension, allow for the magnetic droplet to be manipulated via control of the external magnetic field. Substrate curvature affects the shape, stability, and apparent contact angle of sessile and pendant drops. Droplets of non-magnetic fluids on curved surfaces have been studied quite well, including the wetting of a droplet on a sphere [1]. In this study, the equilibrium of sessile and pendant magnetic fluid droplets on a magnetized sphere (see Figure) is analyzed as a function of the magnetic field intensity and drop volume experimentally, as well as using analytical and numerical calculations.

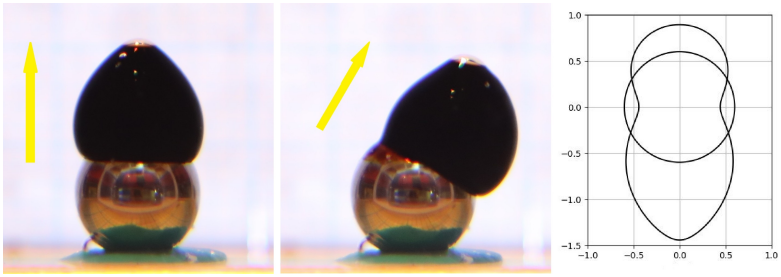

Figure 1: Profiles of magnetic fluid droplets on a magnetized sphere: experiment (vertical, tilted field) and calculations (example).

The uniform tilted magnetic field distorted by a magnetized sphere offers wireless and programmable manipulation. A magnetic fluid droplet takes its equilibrium position depending on the balance between magnetic forces, surface tension, and gravity. We develop a three-dimensional model to predict the deformation of the droplet under uniform magnetic fields of different directions and magnitudes. This research examines both the shape control of immobile droplets and the position control of shifting droplets. It is shown that for a fixed field strength there is a maximum volume of sessile and pendant droplets that can be held on a sphere. Finally, the problem of two competing "partially engulfing" (an axisymmetric drop sitting on the sphere) and "completely engulfing" (a drop completely covering the sphere) morphologies [1] is studied in the case of a magnetized sphere and a spherical magnet. Thus, in this work, it is demonstrated that under a magnetic field, various operations can be performed on magnetic fluid droplets on a magnetized sphere, such as deformation, displacement, splitting, and merging.

The study was conducted under the state assignment of Lomonosov Moscow State University.

References

[1] H. B. Eral, G. Manukyan, and J. M. Oh, *Wetting of a Drop on a Sphere*, Langmuir, 27: 5340–5346 (2011).

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