CONTROLLED SHAPING OF SESSILE MAGNETIC DROPLETS

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Controlled shaping of droplets is used in digital microfluidics to manipulate droplets for mixing and sensing [1]. Droplets can be shaped through the application of electromagnetic fields, which exert a force on ions or electric and magnetic dipoles in the droplet. This force can be calculated using the electromagnetic stress tensor, which is a powerful tool derived from first principles of electromagnetism and thermodynamics [2]. The electromagnetic stress tensor in vacuum has been applied to a limited set of well-defined problems such as electrowetting, a technique where surface energies of the substrate are electrostatically modified [3].

Electric actuation techniques are well-studied and widely adopted [1]. In contrast, relatively little work exists on magnetic actuation techniques, such as the actuation of paramagnetic salt solutions, which has been demonstrated on superhydrophobic surfaces [4]. Since magnetic actuation techniques require the presence of magnetic dipoles, they open a range of new possibilities for sensing and measurement applications.

Here, we explicitly apply the electromagnetic stress tensor to a sessile droplet in a homogeneous magnetic field and derive a relationship for the change in droplet shape as a function of applied magnetic field. We validate this relationship experimentally, by measuring the change in shape of a paramagnetic sessile droplet in a magnetic field and showcase its potential by demonstrating lateral movement and mixing of paramagnetic droplets [5]. Our results demonstrate the controlled shaping and manipulating of magnetic droplets while highlighting the fundamental physics involved in these interactions.

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