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DYNAMICS OF JANUS MAGNETIC PARTICLES UNDER THE INFLUENCE OF AN EXTERNALLY APPLIED MAGNETIC FIELD

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Janus particles, named after the Roman god Janus, are anisotropic particles with asymmetry and directionality in a single particle [1, 2]. These particles exhibit more complex self-assembly structures than those obtained from isotropic particles, enabling them to overcome limits that would otherwise constrain isotropic particles. Most research on the magnetic interaction and self-assembly of Janus particles relies on experimentation.

In this study, dynamics of circular Janus magnetic particles suspended in a Newtonian fluid is studied under the influence of a uniform magnetic field. The particles are equally compartmentalized into paramagnetic and non-magnetic sides (see Fig. 1). The fluid is assumed to be incompressible and Newtonian. Since we are concerned with a microfluidic application, we neglect the inertia of both fluid and particles, solving the Stokes equations. To tackle the magnetic particulate flow problem, a previously developed direct numerical scheme [3, 4] is enhanced to take into account the magnetic anisotropy of the particles.

First, the newly developed scheme is validated using a single-particle problem by comparing results obtained from a reference boundary-fitted mesh to those obtained from regular meshes. Contrary to isotropic paramagnetic particles, even a single Janus particle can rotate in the presence of a magnetic field due to the magnetic torque created by the magnetic anisotropy of the particle [5]. Then, we extended our interest to a two-particle problem. It is found that, depending on the initial angle between the field and the line-of-centers of the particles, the interaction between the particles is either attractive or repulsive. Detailed particle motions and the final conformations of the particles are also influenced by the initial orientations of the particles. In a multi-particle problem (see Fig. 2), straight and staggered chains observed in an experimental study [1] can be re-

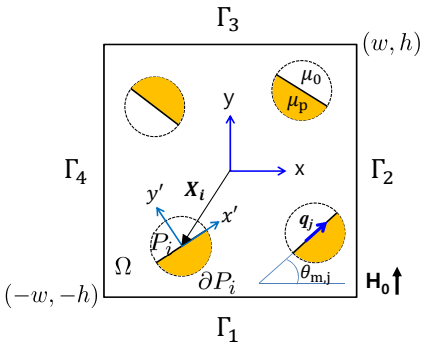

Figure 1: Janus particles suspended in a liquid-filled chamber under the influence of a uniform magnetic field $\boldsymbol{H}_0$. In each particle, the shaded area is the magnetic side.

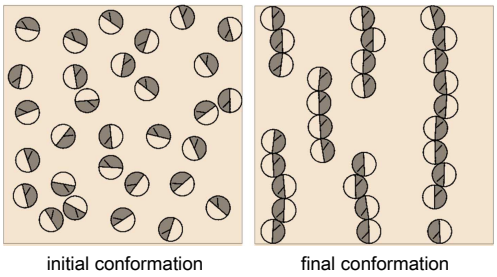

Figure 2: Chain conformations obtained from numerical simulation. Initially, 30 particles are suspended in the chamber. In this problem, an externally applied uniform magnetic field is directed vertically.

produced by numerical simulation. Finally, the dynamics of two particles in the presence of both continuous shearing and a uniform field are studied. Particle motions are highly influenced by the inter-particle distance and a dimensionless number called the Mason number (the ratio of viscous force to magnetic force).

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