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Microscale hydrodynamics computer simulations of magnetic suspension

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The equations governing the motion of N magnetic particles suspended in a viscous fluid at low Reynolds number and finite Stokes numbers are solved numerically for different Péclet numbers. The simulations include all dipole-dipole magnetic interactions for force and torque and the pair wise hydrodynamic interactions. An external applied magnetic field and near field interactions represented by contact and repulsion forces are also considered. The initial particle distribution is an ergodic ensemble in which each member consists of N mutually impenetrable sphere whose centers are randomly distributed in a prismatic cell of volume V with wall boundaries. The stability of the proposed numerical method and its convergence in calculating some relevant macroscopic properties of the magnetic the suspension are carefully examined. The simulations are used to investigate structure transition from an isotropic random distribution to other structures in the presence of an external magnetic field. It is seen dimmers and short chains formation in the suspension space at low volume fraction. When the volume fractions is increased long chains and thin strip-like anisotropic structure may be observed along magnetic field direction. The numerical method is also applied to calculate the suspension magnetization, and accurate results are obtained for different particle volume fraction φ with a maximum number of particles in the numerical cell equal to 1500. In the limit of low Péclet number, the numerical simulations reproduce values of the average suspension magnetization as a function of particle volume fraction in excellent agreement with asymptotic calculation O(φ3). In addition, we show numerical results for higher Péclet numbers, corresponding to the regime in which the theoretical predictions failure.

Biography

Francisco Ricardo Cunha received the diploma in Mechanical Engineering from the Department of Mechanical Engineering, University of Brasília, Brazil, in 1986. In 1989, he received a M.S. degree in Mechanical Science from the University of Brasília, Brazil. Then at the Department of Applied Mathematics and Theoretical Physics of University of Cambridge, UK, he was conferred, in 1995, a Ph.D. degree in Fluid Mechanics of Hydrodynamic Dispersion in Suspension Flows. He did a Postdoctoral work at Yale University, where he was also a visiting Associate Professor of the Chemical Engineering Department. He joined the University of Brasília in 1995, and is currently Professor of Fluid Mechanics and Applied Mathematics and a Researcher of the National Council for Scientific and Technological Development – CNPq – Brazil. Prof. Cunha's current research interests are in Microhydrodynamics, Micro-Mechanics, Rheology of Complex Fluids and Hydrodynamic of Magnetic Fluids.

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