Interacting magnetic nanoparticles of three dimensional magnetic vortex in geometrically different configurations

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1. Introduction

Magnetic nanostructures such as patterned thin films and nanoparticles of different shapes are promising as bio applications and information-storage and -processing technologies [1-5]. Self-assembly of isolated or aggregated magnetic nanoparticles, one of the bottom-up approaches to making novel metastructures, requires controllability. Notwithstanding the recent insights into such self-assembly mechanisms, the formation of spherical-shape nanoparticles of a very specific spin configuration known as a three-dimensional (3D) vortex remains elusive. In the present study, we clarified the magnetic interaction of the permalloy (Py) nanoparticles of 3D vortices in the forms of isolated-single and aggregated-double, -triple, and -quadruple spheres of different geometrical configurations.

2. Experimental method

In our approach, Spherical permalloy 100nm nanoparticles have been prepared by the process known as polyol method. We performed TEM, SEM observation. We then carried out micromagnetic simulation to focus on the interaction between magnetic nanoparticles of the ensemble of intermediate assemblies in terms of the magnetic interaction energy. We used micromagnetic code FEMME (version 5.0.8) [11] to determine the equilibrium magnetic configuration and energy of assemblies. The Landau-Lifshitz-Gilbert equation was solved to calculate the magnetizations of individual nodes (mesh size 5nm) at zero temperature. The 3D nanoparticle sizes introduced for the simulations are deduced from the SEM images with the assumption that the permalloy nanoparticles are perfectly spherical spheres with diameter of 100nm.

3. Result and Conclusion

Using TEM and SEM, we found self-assembled building-block structures, secondary particles, consisting of between one and four primary nanoparticles in geometrically different configurations. With the help of micromagnetic simulations, we revealed spin configurations both in each secondary particle and in the respective interacting primary particles. We determined the stability or instability of the geometrical configurations of those Py nanoparticle assemblies in terms of the exchange and dipolar interacting energies. Our results indicate that there is a controllable means of assembling complex geometrical configurations of the nanoparticles of unique

3D-vortex spin configuration.

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4. Reference

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