A Diffuse Interface Model for Two-Phase Ferrofluid Flows

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ABSTRACT

A ferrofluid is a liquid which becomes strongly magnetized in the presence of applied magnetic fields. It is a colloid made of nanoscale monodomain ferromagnetic particles suspended in a carrier fluid. These particles are suspended by Brownian motion and will not precipitate nor clump under normal conditions. Ferrofluids are dielectric and paramagnetic.

There are two well established PDE models used as a mathematical description for the behavior of ferrofluids: the Rosensweig [1] and Shliomis [2] models. These deal with one-phase flows, which is the case of many technological applications. However, some applications arise naturally in the form of a two-phase flow: one of the phases has magnetic properties while the other one does not (magnetic manipulation of microchannel flows, microvalves, magnetically guided transport, etc.).

We develop a model describing the behavior of two-phase ferrofluid flows using phase field techniques and present an energy-stable numerical scheme for it. For a simplified version of this model and the corresponding numerical scheme we prove, in addition to stability, convergence and, as a consequence, existence of solutions. With a series of numerical experiments we illustrate the potential of these simple models and their ability to capture basic phenomenological features of ferrofluids such as the Rosensweig instability.

REFERENCES

[1] R.E. Rosensweig, *Ferrohydrodynamics*, Dover Publications, 1997.

[2] M.I. Shliomis, “Ferrohydrodynamics: Retrospective and issues. In Sefan Odenbach, editor, *Ferrofluids: Magnetically controllable fluids and their applications*”, Lecture Notes in Physics, pages 85-111. Springer 2002.