Transient grating formation in colloidal suspensions subjected to biaxial magnetic fields

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Magnetorheological (MR) suspensions consist of magnetically soft particles suspended in a nonmagnetic fluid. These fluids are useful in electromechanical devices as damping fluids with field controllable rheology, but can also be considered a model system for the study of structure formation and dynamics in dipolar suspensions with tunable particle interactions. We have recently reported studies of the dynamics of MR suspensions in rotating fields[1–4]. Upon applying a low frequency rotating field ($f < 10$ Hz) to a dilute suspension ($\phi < 2\%$), particle chains quickly form and rotate with the field like propellers, causing significant chain-chain interference, that is, aggregating and fragmenting until a steady state is attained[2].

Our interest is in the high frequency regime ($f > 200$ Hz). Halsey et al.[5] reported on the formation of two-dimensional aggregates in high frequency electric fields, and Martin et al.[6,7] used high frequency magnetic fields to create sheet-like, layered particle composites with enhanced magnetic properties.

We report on two dimensional light scattering experiments to study the evolution of the field-induced structures in low concentrated soft magnetic particle suspensions ($0.1\% < \phi < 5\%$) subject to high frequency biaxial magnetic fields. Diffraction patterns produced in the direction orthogonal to the plane of the field have been measured. We find that from the moment the magnetic field was applied, strong light scattering lobes appeared at a finite scattering wave vector q orthogonal to the field lines. As time goes far, these lobes became brighter and moved to $q = 0$ indicating the formation of sheets. In each sheet of particles the light is completely absorbed so we consider these structures as absorption gratings. We have studied the dependence of the diffraction peaks on the degree of periodicity of the absorption lines and the width of the absorption lines relative to the transparent lines.

As an example, in Fig. 1 we plotted the scattering pattern obtained when applying an eight shaped magnetic field in the plane XY with amplitude $B_{rms} = 150$ G on a suspension of magnetizable particles at $\phi = 5.22$ %. The lobes appear at scattering vectors orthogonal to the field lines, indicating the presence o unstable concentration fluctuation orthogonal to the magnetic field.

The experimental results have been qualitatively compare with simulations for the case of higher volume fraction $\phi = 5.22$ % showing good agreement.

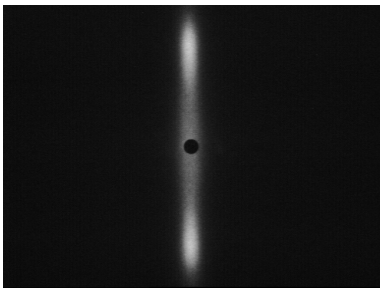

FIG. 1. Scattering pattern obtained when applying an eight shaped magnetic field in the plane XY with amplitude $B_{rms} = 150$ G on a suspension of magnetizable particles at $\phi = 5.22$ %.

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