Optically observed magnetic instabilities in thin ferrofluid layers

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Colloidal solutions of magnetic nanoparticles – ferrofluids – are systems capable of unique pattern forming behavior. In the present work attention is paid to some notable effects in the Forced Rayleigh Scattering experiments with an applied magnetic field, $\nabla T \parallel H$. In the work we consider an idea that the experimentally observed effects are caused by a microconvection [1, 2].

The experiment was carried out with the continuous laser forced scattering setup in combined scattering mode. The ferrofluid layer is put between the poles of electromagnet parallelly to the ground. The temperature grating is applied from above so that magnetic field is perpendicular to temperature grating. All reading optics are adjusted to see particle concentration distribution in the sample. Our ferrofluid contains Fe_2CoO_4 particles, the mean magnetic diameter of which 8…10 nm.

Ferrofluid layers with different thickness (10μm, 100μm) were initially exposed to the temperature grating and due to the Soret effect a concentration grating is induced (Fig. 1., left). After applying external magnetic field with different values, the concentration grating loses contrast and is interrupted (Fig. 1., right).

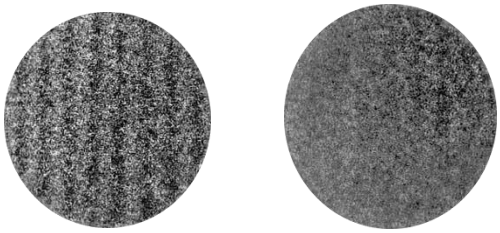

Fig.1. Phase separation patterns: left – optical illumination without external magnetic field, right – optical illumination with external magnetic field 60mT. Both images are photo retouched equally.

References

[1] M. Igonin. On the microconvective instability of an inhomogeneous magnetic fluid in a Hele-Shaw cell. Magnetohydrodynamics, vol. 40 (2004), no. 1, pp. 53–64.

[2] A. Cebers, M. Igonin. Convective instability of magnetic colloid and forced Rayleigh scattering experiments. Magnetohydrodynamics, vol. 38 (2002), pp. 265–270.