DY 33 Ferrofluids and Liquid Crystals

Zeit: Montag 14:00–16:15 Raum: TU H2032

DY 33.1 Mo 14:00 TU H2032

Band structure of surface waves on periodic fluid ridges resulting from the Rosensweig instability — •Rene Friedrichs — ABB AG, Corporate Research Center Germany, Wallstadter Str. 59, 68526 Ladenburg

Parallel fluid ridges can be generated on the free surface of a magnetic fluid by means of a tilted magnetic field [1]. Though the surface deformations resulting from this so called "Rosensweig instability" are static, surface waves can propagate on the periodic deformations since the developed structures remain liquid.

Based on a weakly nonlinear analysis of the static ridge pattern [2], we derive a closed equation for the dynamics of the free fluid surface. We calculate the dispersion relation of the surface waves in dependence on the amplitude of the periodic fluid ridges. The resulting band structure of the surface waves can be controlled easily by the external magnetic field. This is in contrast to other hydrodynamic systems such as waves on a fluid with periodic surface tension [3] or over a periodic bottom [4].

[1] Y. D. Barkov and V. G. Bashtovoi, Magnetohydrodynamics 13, 497 (1977)

[2] R. Friedrichs and A. Engel, Europhys. Lett. 63 (6), 826 (2003)

[3] T. Chou, J. Fluid Mech. 369, 333 (1998)

[4] M. Torres, et al., Phys. Rev. E 63, 011204 (2000)

DY 33.2 Mo 14:15 TU H2032

Comparing measurements of the growth rate of the Rosensweig instability with theoretical predictions — •Holger Knieling, Reinhard Richter, and Ingo Rehberg — Universität Bayreuth, Lehrstuhl Experimentalphysik V, 95440 Bayreuth

The surface of magnetic fluids subjected to a normal magnetic field is becoming unstable when a certain threshold of the magnetic induction is surpassed and the initially flat surface exhibits a stationary array of peaks (Rosensweig or normal field instability). Up to now there exists only a theoretical prediction of the behaviour of the growth rate of this surface instability [1]. Therefore we have performed time resolved measurements of the amplitude and their relaxation with the help of a linear array of 32 Hall sensors which are placed directly under the ferrofluid. Sensors situated under a ridge (trough) detect higher (lower) values of the local magnetic induction, respectively. By calibrating the magnetic signal with normed reliefs of the ferrofluid surface the height of the liquid surface can be measured as well. With a time resolution of the sensors of about a half millisecond the maximal growth rate of the modes of the Rosensweig instability can be measured and are compared with the theoretical predictions.

[1] A. Lange, Europhys. Lett., 55 (3), 327-333 (2001)

DY 33.3 Mo 14:30 TU H2032

Ferrofluid controlled by ac-fields — •Robert Krauss, Reinhard Richter, and Ingo Rehberg — Experimentalphysik V, Universität Bayreuth

Considering the effect of pumping ferrofluid by a rotating field [1] and its theoretical description, led us to the conclusion that the mechanism should work in the same manner with ferrofluid droplets. Thus we arranged an experimental setup where magnetic liquid droplets swimming on the surface of another non-permeable liquid move linearly in a rotating field. The velocity of the droplets is changed depending on the applied ac-field strength and frequency as well as the size of the droplets (making a size seperation possible). With some modifications to the field geometry the droplets can be forced to make any 2-dimensional movement on the surface plane.

[1] R. Krauss et al., *Fluid pumped by magnetic stress*, Appl. Phys. Lett. accepted

DY 33.4 Mo 14:45 TU H2032

Influence of a magnetic field on the Soret effect in ferrofluids — •Thomas Voelker and Stefan Odenbach — ZARM, University of Bremen

Investigations were made to determine the influence of a magnetic field on the Soret coefficient of magnetic particles in a ferrofluid. This so called magnetic Soret effect was theoretically predicted to be two to three orders of magnitude smaller than the conventional Soret effect. In contrast, former experiments have qualitatively shown that the magnetic Soret effect is much higher than the theoretical predictions. However in those experiments the influence of buoyancy and magnetically driven convection disturbed the measurement significantly. Thus it is still an open question how strong the magnetic Soret effect can be. Therefore an experimental setup was developed which minimizes parasitic effects, simplifying the analysis of the experimental results. These results provide quantitative measures of the magnetic field dependence of the Soret effect in suspensions of magnetic nanoparticles. It is shown, that the magnetic Soret effect can even be higher than the conventional one and that its strength as well as its direction depend on the magnetic field strength and its relative alignment to the temperature gradient in the fluid.

DY 33.5 Mo 15:00 TU H2032

Rosensweig instability and hysteretic behaviour of an inverse ferrofluid — •Christian Gollwitzer[1], Reinhard Richter[1], Ruben Saldivar-Guerrero[2], and Ingo Rehberg[1] — [1]Experimentalphysik V, Universität Bayreuth, D-95440 Bayreuth — [2]Centro de Investigación en Química aplicada, 25100 Saltillo, Coahuila México

An inverse ferrofluid is a suspension of non-magnetic particles in a conventional ferrofluid, and has been first investigated by Skjeltorp[1]. The particles can be treated as magnetic "holes", the magnetic moments of which point into the opposite direction of the external magnetic field. The Rosensweig instability of an inverse ferrofluid is investigated and compared to the pattern formation of the base fluid. Due to chain formation and magneto-visco-elastic effects[2] the qualitative behaviour changes drastically, in that hysteresis is introduced, which is not present in the base fluid. By the use of X-rays, complete surface profiles can be recorded[3] and phase separation of the inverse ferrofluid in gravitational and magnetic gradient fields are observed. In combination with the Rosensweig instability this gives rise to a memory effect.

References:

[1]A.T. Skjeltorp, *Phys. Rev. Lett.* **1983** *51,* 2306

[2] R. Saldivar: Magneto-rheological study of inverse ferrofluids with polystyrene particles of different size, *to be submitted*

[3]R. Richter, J. Bläsing: Measuring surface deformations in magnetic fluids by radioscopy. *Rev. Sci. Instrum.* **72**, 1729-1733

DY 33.6 Mo 15:15 TU H2032

Small angle neutron scattering study of the magnetoviscous effect in ferrofluids — •Loredana Mirela Pop[1], Stefan Odenbach[1], and Albrecht Wiedenmann[2] — [1]ZARM, University of Bremen — [2]HMI Berlin

The increase of the viscosity of ferrofluids, by means of moderate magnetic fields, the so called magnetoviscous effect, can be used for different technological applications like, for example, in active dampers. However, due to a strong shear thinning in commercially available ferrofluids, the viscosity changes diminish for technical useful shear rates to values that are not suitable for applications. Thus, an optimisation by development of new types of ferrofluids exhibiting stronger changes of the viscosity with the magnetic field and a higher shear stability of the effects is required. Therefore, a better understanding of the microscopic mechanisms of the magnetoviscous effect is essential. The results of the investigation of the microstructure of ferrofluids using small angle neutron scattering as well as of the corresponding rheological investigations will be presented. In addition, the comparison between experimental results and theoretical approaches will provide the information that is necessary for a detailed understanding of the magnetoviscous effects allowing the synthesis of suited ferrofluids for innovative applications in the future.

DY 33.7 Mo 15:30 TU H2032

Two-dimensional solitons on the surface of magnetic liquids — •Reinhard Richter[1] and Igor Barashenkov[2] — [1]Experimentalphysik V, Universität Bayreuth, D-95440 Bayreuth, Germany — [2]University of Cape Town, Rondebosch 7700, South Africa

We report the observation of a stable soliton-like structure on the surface of a ferrofluid in the hysteretic regime of the Rosensweig instability. Unlike other pattern-forming systems with localized 2D structures [1], magnetic fluids are characterized by energy conservation; hence their mechanism of soliton stabilization is different from the previously discussed gain/loss balance mechanism. The radioscopic measurements of

the soliton's surface profile suggest that locking on the underlying *periodic* structure is instrumental in its stabilization [2].

[1] see e.g., P.B. Umbanhowar et al., Nature (London) **382** (1996) 793.
[2] R. Richter, I. Barashenkov, submitted to Phys. Rev. Lett. (2004)

DY 33.8 Mo 15:45 TU H2032

Ramanspektroskopie an ionisch-stabilisierten Ferrofluiden im äußeren Magnetfeld — •Dirk Heinrich[1], Alejandro Goñi[2] und Christian Thomsen[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, Hadenbergstrasse 36, 10623 Berlin,Deutschland — [2]Institut de Ciencia de Materials de Barcelona, Consejo Superior de Investigaciones Cientificas, Campus de la UAB, E-08193 Bellaterra, Spanien

Wir untersuchten die Cluster-Bildung magnetischer Nanoteilchen in Ionischen Ferrofluiden unter dem Einfluss von äußeren Magnetfeldern mit Hilfe von Ramanspektoskopie. Ein besonders Augenmerk lag dabei auf der Temperaturabhängigkeit der Bildungs- bzw. der Zerstörungsdynamik der sich unter den Einfluss des Feldes gebildeten Strukturen und deren Nachweis uns mittels Änderungen in der Ramanintensität der Streckschwingung der OH-Gruppen im Wasser (Trägermedium) gelungen ist. Dabei wird explizit den Effekt ausgenutzt, dass das Raman-Streuvolumen von der Stärke der Mie-Lichtstreuung im Kolloid und dies wiederum von Dichte und Größe der Magnetischen Partikeln bzw. Clustern abhängt. Bei den Experimenten zeigte sich, dass in ionischen Ferrofluiden die Änderungen in der Ramanintensitäten, die mit der Bildung bzw. Zerstörung der Cluster verknüpft sind, typische Zeitkonstanten in Bereich von Sekunden bis einige Minuten aufweisen. Die Dynamik wird mit zunehmender Temperatur schneller, wobei interessanterweise das Zeitverhalten sich bei ca. Zimmertemperatur abrupt ändert.

DY 33.9 Mo 16:00 TU H2032

Influence of Small Admixtures on Termal Director Fluctuations in Filled Flexoelectric Nematic Liquid Crystals — •Anna Berezovskaya — Univ. Kiev, UA–01033 Kiev, Ukraine

Thermal director fluctuation correlations were calculated in the case of flexoelectric liquid crystals (LC) without admixtures, when the effect of flexopolarisation appeared because of thermal director fluctuations [1].

In paper [2] it was shown that the interaction between the liquid crystal director and colloidal particle surface in filled liquid crystals leads to the screening of the thermally induced director fluctuation correlations.

Both these results will be linked together to consider the flexoelectric liquid crystal matrix filled with small spherical silica particles.These solid particles produce static LC director inhomogeneities around inclusions. Flexopolarisation appeared not only because of thermal director fluctuations but due to the static fluctuations too.

[1] P.G. de Gennes and J.Prost, The Physics of Liquid Crystals, Clarendon Press, Oxford, 1993
[2] O. Vasilyev, I. Pinkevich, T. Sluckin, Correlations of Thermal Director Fluctuations in Filled Liquid Crystals, Mol. Cryst. Liq. Cryst (preprint)

Török:
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