FORSCHERGRUPPE 608
DEUTSCHE FORSCHUNGSGEMEINSCHAFT

13th Fall Seminar on Nonlinear Dynamics 2008

28 September – 01 October 2008 at the University of Bayreuth (Germany)

13^{th} Fall Seminar

on Nonlinear Dynamics

University of Bayreuth

28 September – 01 October 2008

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Program

Sunday, 28 September 2008

19:00	Tavern Oskar, Welcome	

Monday, 29 September 2008

08:55 – 09:00		**Welcome**
09:00 – 09:40	V. Steinberg	**Dynamics of a Single Vesicle in Various Flows**
09:40 – 10:00	C. Heußinger	**Filaments and Grains: Some Analogies Concerning Elastic and Rheological Properties**
10:00 – 10:20	A. Fortini	**Crystallization and Gelation in Colloid-Polymer Mixtures**
10:20 – 10:40	R. Spatschek	**Density Functional Theory of Forces Between Crystal-Melt Interfaces**
10:40 – 11:10	COFFEE BREAK AND POSTERS	
11:10 – 11:50	F. Sagués	**The Vulnerability of Mixed Mode Bifurcations by Noise**
11:50 – 12:10	H. Pleiner	**Amplitude Equation for Instabilities Driven at Deformable Surfaces - Rosensweig Instability**
12:10 – 12:30	F. Großmann	**Equilibrium Shapes of Gilbert – Taylor Cones**
12:30 – 14:30	LUNCH	
14:30 – 15:10	U. Ebert	**The Multiscale Dynamics of Lightning**
15:10 – 15:30	A. Buka	**Transition from Longitudinal to Transversal Patterns in an Anisotropic System**
15:30 – 15:50	R. Stannarius	**Time Reversal of Parametric Excitation and the Stability of Dynamical Systems**
15:50 – 16:20	COFFEE BREAK AND POSTERS	
16:20 – 17:00	S. Kempf	**Dynamics of Saturn's Diffuse E-Ring**
17.00 – 18.30	SHORT POSTER PRESENTATION	
18:30		**DINNER AND POSTERS**

Tuesday, 30 September 2008

09:00 – 09:40	I. M. Sokolov	**Scaling in Rupture of Polymer Chains**
09:40 – 10:00	I. Kulic	**Fluctuation Driven Transport in Biological Systems**
10:00 – 10:20	F. Ziebert	**Cytoskeletal Filaments and Molecular Motors: Rheology and Alignment**
10:20 – 10:40	F. Höfling	**Anisotropic Diffusion of Strongly Hindered Rods**
10:40 – 11:10	COFFEE BREAK AND POSTERS	
11:10 – 11:50	E. Moses	**From Percolation to Logical Devices with Living Neural Networks**
11:50 – 12:30	R. Dimova	**Membrane Fusions:** **Time Scales and Applications**
12:30 – 14:15	LUNCH AND POSTERS	
14:15 – 14:55	C. Misbah	**Micro and Macrodynamics of Vesicles and Red Blood Cells Under Flow**
14:55 – 15:15	P. Tierno	**Magnetically Driven Colloidal Microswimmers**
15:15 – 15:30	COFFEE BREAK AND POSTERS	
15:30 – 15:50	J. Nase	**Pattern Formation During Deformation of a Confined Viscoelastic Layer: From a Viscous Liquid to a Soft Elastic Solid**
15:50 – 16:10	G. Seiden	**Pattern Forming System in the Presence of Different Symmetry-Breaking Mechanisms**
16:10 – 16:30	M. Schröter	**The Granular Phase Diagram**
16:30 – 17.30	COFFEE BREAK AND POSTERS	
17:30 – 18:30	I. Aronson	***3rd Lorenz Kramer Memorial Lecture*** **Magnetic Snakes: Self-Propelled, Self-Assembled, … and Furious**
19:00 – 22:00	Conference Dinner in Theta	

Wednesday, 01 October 2008

09:00 – 09:40	A. Peeters	**Momentum Transport in Fusion Devices due to Small Scale Turbulence**
09:40 – 10:00	M. Evonuk	**Zonal Flow in Rotating Giant Planets: The Effect of Density-Stratification**
10:00 – 10:20	T. Börzsönyi	**Predicting Important Properties of Grain Avalanches – Shape Matters**
10:20 – 10:40	B. Rumpf	**Quasisolitonic Turbulence**
10:40 – 11:10	COFFEE BREAK AND POSTERS	
11:10 – 11:50	N. Gov	**Dynamic Instability in an Expanding Cell Culture**
11:50 – 12:10	P. Seitz	**Dissipative Structure Formation in Surfactant Films**
12:10 – 12:30	M. Tribelsky	**Soft-Mode Turbulence and Symmetry**
12:30 – 12:40		**Final Discussion**
12:40 – 14:30	LUNCH	

End of the seminar and departure

Lorenz-Kramer Memorial Lecture

3rd Lorenz Kramer Memorial Lecture

Magnetic Snakes: Self-Propelled, Self-Assembled , ... and Furious

Igor Aronson

Argonne National Laboratory, USA

Fundamental mechanisms governing locomotion at macro- and micro-scale have been attracting enormous attention in the physics community. The interest is driven by the need of understanding how the biological organisms propel themselves in various environments and by the growing demand for design of artificial structures capable of performing useful functions at the microscale, including targeted cargo delivery and stirring in microfluidic devices. I will discuss a new type of self-assembled magnetically actuated surface swimmers: magnetic snakes. The snakes self-assemble from a dispersion of magnetic microparticles suspended on the liquid-air interface and subjected to an alternating magnetic field. The self-propulsion mechanism is related to a spontaneous symmetry breaking instability of the self-generated surface flows, ubiquitous in pattern-forming systems like Rayleigh-Bénard convection or Faraday crispations. The self-assembled snakes often exhibit behavior normally thought to be characteristic of true biological objects, such as "hunting" and "chemotaxis".

General tools of nonlinear dynamics yield fundamental insights into mechanisms of snake's self-assembly and locomotion.

Talks

(in alphabetical order)

Predicting Important Properties of Grain Avalanches - Shape Matters

Tamás Börzsönyi[1,2], Robert E. Ecke[2]

[1]Research Institute for Solid State Physics and Optics, P.O. Box 49, H-1525 Budapest, Hungary
[2]Condensed Matter and Thermal Physics & Center for Nonlinear Studies, Los Alamos National Lab, New Mexico 87545, USA

We show that the properties of avalanches in a gravitationally-forced granular layer on a rough inclined plane - a model system for rock avalanches on a hillside - depend dramatically but in a predictable manner on the shape (angularity) of the grains. Measuring major characteristics of avalanches as the the typical height, the ratio of the particle and front velocities and the growth rate of avalanche speed with increasing avalanche size we find that they correlate well with the most basic property of the material - the angle of repose. For rough non-spherical grains (i.e. materials with a high angle of repose), avalanches are faster, bigger and overturning in the sense that individual particles have downslope speeds that exceed the front speed as compared with avalanches of rather spherical particles that are quantitatively slower, smaller and where particles always travel slower than the front speed.

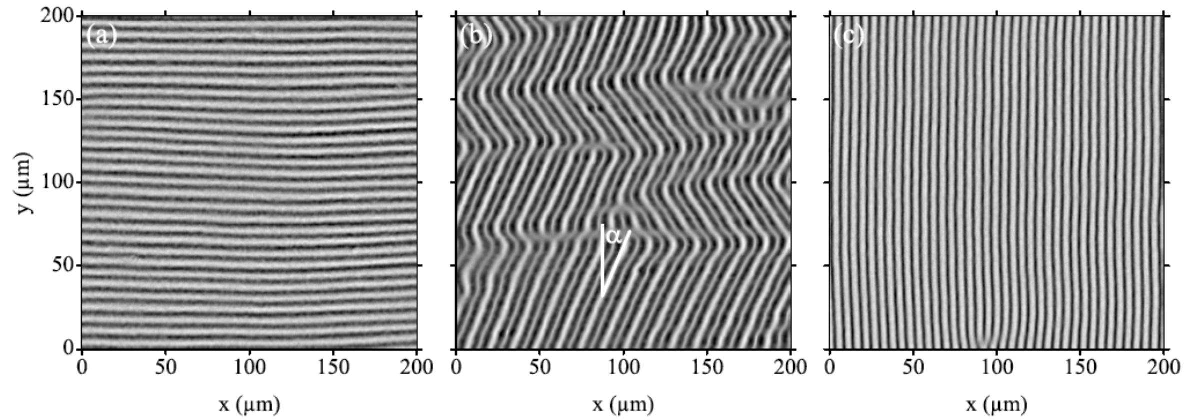
Transition From Longitudinal to Transversal Patterns in an Anisotropic System

M. May†, W. Schöpf†, I. Rehberg†, A. Krekhov†, A. Buka‡

† *Universität Bayreuth, D-95440 Bayreuth, Germany*

‡ *Research Institute for Solid State Physics and Optics of the Hungarian Academy of Sciences, H-1525 Budapest, Hungary*

Periodic stripe patterns which form when an electric field is applied to a thin nematic liquid crystal layer with a very low conductivity are discussed. In this case, the dielectric electroconvection mode persists down to very low frequencies of the driving voltage. A Lifschitz point, i.e. a transition from normal to oblique rolls, is detected in the dielectric regime. A crossover from electroconvection to flexoelectric domains occurs for extremely low frequencies of about 0.1 Hz. The crossover scenario yields pattern morphologies characteristic for both mechanisms, i.e. electroconvection and flexoelectric domains, which appear consecutively within one period of the driving voltage. A theoretical description of the onset characteristics of dielectric convection, which is based on an extended model including flexoelectricity, is also presented.



Snapshots of (a) Flexoelectric domains at dc voltage (b) Oblique dielectric convection rolls at f = 4 Hz and (c) Normal dielectric convection rolls at f = 150 Hz.

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Fusion of Model Lipid Membranes: Timescales and Applications

Rumiana Dimova

Max Planck Institute of Colloids and Interfaces, Science Park Golm, 14424 Potsdam, Germany

Membrane fusion is a vital process as it is involved in many cellular functions and stages of cell life like import of foodstuffs and export of waste, signaling between nerve cells, fertilization, and virus infection. In both, life sciences and bioengineering, controlled membrane fusion has many potential applications, such as drug delivery and gene transfer, chemical microreactors, or synthesis of nanomaterials. Fusion dynamics is intriguing but microscopy observations with time resolution higher than several milliseconds have not been achieved until recently. Using micromanipulation of giant unilamellar vesicles as model membranes one can directly observe membrane fusion. We induce the fusion of giant lipid vesicles in a controlled manner and monitor the fusion dynamics with a temporal resolution of 50 microseconds; see Proc. Natl. Acad. Sci. USA. 103, 15841–15846 (2006). Two different approaches of inducing directed fusion are used. In the first one, we employ synthetic fusogenic molecules incorporated in the membranes. In the second approach we use electrofusion. Some aspects on the response of lipid membranes to electric fields will be presented. For both fusion protocols, the opening of the fusion necks is very fast, with an average expansion velocity of centimeters per second. This velocity indicates that the initial formation of a single fusion neck can be completed in a few hundred nanoseconds.

The Multiscale Dynamics of Lightning

Ute Ebert

Centrum Wiskunde & Informatica (CWI) Amsterdam and TU Eindhoven, The Netherlands

A thundercloud separates electric charges and generates strong electric fields. However, these fields are not strong enough to generate a conducting plasma in the atmosphere. How can the cloud discharge through lightning strokes nevertheless? It discharges either internally or to other clouds or to the ground or to the ionosphere. Do high energetic cosmic particles play a role in this process? How does lightning generate terrestrial gamma-ray flashes?

Answers to these questions have to take the nonlinear dynamics of the discharge into account that evolves on a wide range of length and time scales. I will review our present experimental access and theoretical understanding.

For scientific articles and popular presentations, please refer to http://homepages.cwi.nl/~ebert

Zonal Flow in Rotating Giant Planets: The Effect of Density-Stratification

Martha Evonuk

Theoretische Physik I, Universität Bayreuth, 95440 Bayreuth, Germany

Two and three-dimensional simulations of thermal convection in giant planets demonstrate a strong interaction between rotation and fluid flow through a density profile. Compressional torque generates vorticity when the Coriolis force acts on fluid parcels expanding or contracting as they move through a planet's background density profile. While the compressional torque mechanism has been neglected in the majority of giant planet simulations, the convergence of this non-linear Reynolds stress maintains a pattern of differential rotation independent of the vortex-stretching mechanism. Both compressional torque and vortex-stretching may play a role in maintaining the observed zonal features on the giant planets, however in highly turbulent environments, where density varies greatly with radius, it is likely that compressional torque plays an increasingly dominant role.

Crystallization and Gelation in Colloid-Polymer Mixtures

Andrea Fortini

Theoretical Physics II, University of Bayreuth, 95440 Bayreuth, Germany

We systematically study the relationship between equilibrium and non-equilibrium phase diagrams of a system of short-ranged attractive colloids. Using Monte Carlo and Brownian dynamics simulations we find a window of enhanced crystallization that is limited at high interaction strength by a slowing down of the dynamics and at low interaction strength by the high nucleation barrier. We find that the crystallization is enhanced by the metastable gas-liquid binodal by means of a two-stage crystallization process. First, the formation of a dense liquid is observed and second the crystal nucleates within the dense fluid. In addition, we find at low colloid packing fractions a fluid of clusters, and at higher colloid packing fractions a percolating network due to an arrested gas-liquid phase separation that we identify with gelation. We find that this arrest is due to crystallization at low interaction energy and a slowing down of the dynamics at high interaction strength causes it. Likewise, we observe that the clusters, which are formed at low colloid packing fractions, are crystalline at low interaction energy, but glassy at high interaction energy. The clusters coalesce upon encounter.

Dynamic Instability in an Expanding Cell Culture

Nir Gov

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Multi-cellular migration is of great significance in many biological processes, such as wound-healing, morphogenesis and embryogenesis. We present here a physical model for the dynamics of such cell migration during the wound healing response. Recent experiments demonstrate that an initially uniform cell-culture monolayer expands in a non-uniform manner, developing finger-like shapes, composed of columns of cells that move collectively. We propose a physical model to explain this phenomenon, based on the notion of dynamic instability, similar to the classic instability of fluids and crystal growth of solids. In this model we treat the outer contour of the cell culture as a continuous membrane, with the usual curvature and surface-tension elasticity. The internal motility of the cells provides the driving force for the outwards normal motion of the contour. We find in this model a dynamic instability which we then compare to the dynamic patterns observed in the wound healing experiments. Our model may be relevant for describing other phenomena involving large-scale motions of cell cultures, where there is spontaneous pattern formation.

Equilibrium Shapes of Gilbert - Taylor Cones

Florian Großmann, Bruno Eckhardt

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Excerting a liquid droplet hanging from a nozzle to an electric field results in an accumulation of charge carriers inside the droplet. The charge causes additional Maxwell stress at the fluid interface and results in a deformation of the droplet. If the electrical field is large enough, the fluid develops a conical singularity, which is already known since Gilbert [1]. In 1964 Taylor [2] explained his very well designed experiments theoretically via the balance between Laplace's pressure and Maxwell's pressure and derived the Gilbert - Taylor cone opening angle of 49.3 degrees.

Numerical simulations of a droplet within an ideal plate capacitor are presented considering the fluid interface in mechanical and electrical equilibrium from first principles. The adiabatic charging reveals the continuous deformation of the droplet as a function of the applied electrical field. The resulting Gilbert - Taylor cone angle is found to be approximately 38 degrees, which matches recent challenging experiments quite well [3,4].

Study of the local electrical Weber number reveals insights into the mechanism responsible for jet emission from the apex of the Gilbert-Taylor cone.

[1] Sir William Gilbert, "De magnete", Dover, (1958), originally published (1600).

[2] Sir Geoffrey Taylor, Proc. R. Soc A. 280, 383, (1964)

[3] A. L. Yarin, J. Appl. Phys. 90, 4836, (2001).

[4] E. Giglio, B. Gervais, J. Rangama, B. Manil, B. A. Huber, PR E 77, 036319, (2008).

Filaments and Grains: Some Analogies Concerning Elastic and Rheological Properties

Claus Heußinger

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Biological networks of stiff filamentous polymers and anorganic systems of colloidal or granular hard spheres do not seem to share many common features. Nevertheless, there is an interesting duality between their mechanical properties on the single particle level. Stiff polymers are "stiff" only in extension, while they show only little resistance to bending deformations, which are oriented transversly to their contour. On the other hand, "hard" spheres are nearly incompressible, but easily roll around each other.

We discuss how this scale-separation between a soft (axial) and a stiff (transverse) deformation mode allows a detailed understanding of elastic and rheological properties in both systems. An illustrative example is given by the (un)jamming transition, during which the hard-sphere system system loses its mechanical stability. Recently, this has attracted much interest, as nontrivial scaling properties emerge upon approaching the critical point from above [1]. Quite analogously, stiff polymer networks also show anomalous scaling behavior but now below their "jamming" point [2].

As in the critical phenomena of thermal systems, a growing length-scale is at the origin of these phenomena. We demonstrate that the filament-length as a structural parameter provides a natural candidate for this length-scale in the case of the polymer network. In contrast, the granular system shows no structural signature of the nearby critical point, which makes this issue more subtle. To clarify this aspect we present new results obtained from quasistatic shear simulations of a frictionless granular material close to its jamming point.

References

[1] C. O'Hern et al., PRE 68, 011306 (2003)

[2] C. Heussinger and E. Frey, PRL 97, 105501 (2006)

Anisotropic Diffusion of Strongly Hindered Rods

Tobias Munk, Felix Höfling, Erwin Frey, and Thomas Franosch

Arnold Sommerfeld Center for Theoretical Physics (ASC) and Center for NanoScience (CeNS), Fakultät für Physik, Ludwig-Maximilians-Universität München, Theresienstraße 37, 80333 München, Germany

Slender rods in concentrated suspensions constitute strongly interacting systems with rich dynamics: transport slows down drastically and the anisotropy of the motion becomes arbitrarily large [1,2]. We have developed a mesoscopic description of the anisotropic dynamics down to the length scale of the interparticle distance. Our theory is based on the exact solution of the Smoluchowski-Perrin equation; it is in quantitative agreement with extensive Brownian dynamics simulations in the dense regime. The analysis is based on a two-dimensional model, but its generalization to three-dimensional suspensions is straightforward. In particular, we show that the confined motion within an effective tube is characterized by a power law decay of the intermediate scattering function, $F(k,t) \sim t^{-1/2}$.

A surprising enhancement of translational diffusion is revealed by molecular dynamics simulations for ballistic thin rods or needles, i.e., when momentum conservation holds [3]. The diffusion coefficient diverges according to a power law in the density with an approximate exponent of $\zeta = 0.8$. This observation is connected with a new divergent time scale, reflected in a zigzag motion of the needle, a two-step decay of the velocity-autocorrelation function, and a negative plateau in the non-Gaussian parameter. Finally, we provide a heuristic scaling argument for the new exponent ζ.

[1] F. Höfling, T. Munk, E. Frey & T. Franosch, Phys. Rev. E **77,** 060904(R) (2008).

[2] T. Munk, F. Höfling, E. Frey & T. Franosch, arXiv:0808.0450, submitted to Phys. Rev. Lett.

[3] F. Höfling, E. Frey & T. Franosch, arXiv:0806.1138, to appear in Phys. Rev. Lett.

Dynamics of Saturn's diffuse E Ring

Sascha Kempf

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Saturn's diffuse E ring - the largest planetary ring of the solar system - is composed of approximately micron-sized ice grains. In a plasma-rich environment such as that around Saturn, grains of this size are subject to both gravitational and non-gravitational perturbations. These perturbing forces alter the behaviour of individual grains, and thereby affect the ring's macroscopic properties as it extent and the ring particle size distribution.

The icy ring moon Enceladus was proposed early as the dominant source of ring particles since the edge-on brightness profile peaks near the moon's mean orbital distance. Perhaps the most striking finding is the unusual blue colour of the E ring, implying a narrow grain size range centered between 0.3 μm and 3 μm. The narrow size distribution was difficult to explain because the assumed dust production mechanism replenish the ring with particles of a broad size distribution. Finally, Horányi et al. (1992) introduced a model, where charged ring particles are subject to perturbations by the planet's oblate gravity field, electromagnetic forces, and solar radiation pressure. They found that the first two perturbing forces cause the particle's orbits to precess in opposite directions. For approximately 1 μm particles the two processes nearly cancel each other causing the orbit's pericentre of those grains to stay locked with respect to the position of the Sun, which in turn leads to a swift growth of the orbit's eccentricities due to the solar radiation pressure. This model explains at least qualitatively the narrow size distribution even if particles of a broad size distribution are injected into the ring.

Unfortunately, nature did not choose the Horányi-mechanism to create and maintain the E ring. In fact, the data returned by the Cassini spaceraft forced us to revise our picture of the ring dynamics drastically. Since Cassini is equipped with a dust detector it became possible for the first time to investigate the evolution of the ring ring particle ensemble in detail. The perhaps most important finding was the discovery of the active cryo-volcanism on the ring moon Enceladus. On the one hand side explains the southpole source the narrow ring particle size distribution. On the other hand demonstrates this discovery how limited our knowledge of the geophysics of Enceladus actually is.

Fluctuation Driven Transport in Biological Systems

I. M. Kulic

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Non-equilibrium fluctuations can drive enhanced diffusive and directed transportin a variety of physical systems. We explore two generic biophysical systems occurring in nature (on very different length- and timescales) that have recently been shown to exploit active non-equilibrium fluctuations for transport and propulsion. In particular we demonstrate that in living cells molecular motor generated non-equilibrium noise within the cytoskeleton network leads to efficient active mixing of organelles – a novel type of intracellular transport called "microtubule-hitchhiking".

Micro and Macro Dynamics of Vesicle and Erythrocyte Suspensions

Chaouqi Misbah

LSP, CNRS (UMR5588) and Université J. Fourier, BP 87 - 38402 Grenoble Cedex, France

This talk is dedicated to the dynamics and rheology of vesicles (a simple model for red blood cells) under flow. Vesicles and red blood cells under flow exhibit several interesting dynamics: tank-treading, tumbling, vacillating-breathing (or swinging), and so on. These dynamics have a direct impact on rheology, as will be discussed both from the theoretical and experimental point of views. We also present features like transverse migration in a Poiseuille flow, co-existence of different types of modes induced by non-equlibrium conditions, like a parachute and bullet-like mode. Experimental and numerical results regarding the law of transverse migration of vesicles in a microfluidic channel are also presented.

References

1) Chaouqi Misbah, *Vacillating Breathing and Tumbling of Vesicles under Shear Flow* Phys. Rev. Lett. **96**, 028104 (2006).
2) Gerrit Danker and Chaouqi Misbah, *Rheology of a dilute suspension of vesicles*, Phys. Rev. Lett. **98**, 088104 (2007).
3) G. Danker, T. Biben, T. Podgosrki, C. Verdier, and C. Misbah, *Dynamics and rheology of a dilute suspension of vesicles: Higher-order theory* , Phys. Rev. E **76,** 041905 (2007).
4) B. Kaoui, G.H. Ristow, I. Cantat, C. Misbah, and W. Zimmermann Lateral migration of a two-dimensional vesicle in unbounded Poiseuille flow Phys. Rev. E **77,** 021903 (2008).
5) V. Vitkova, M.A. Mader, B. Polack; C. Misbah T. Podgorski, *Micro-macro link in rheology of erythrocyte and vesicle suspensions*, Biophys. J. Lett. , **95**, L33-L35(2008).

From Percolation to Logical Devices with Living Neural Networks

Elisha Moses

Physics of Complex Systems, Weizmann Institute of Science, P. O. Box 26, Rehovot 76100, Israel

We review a number of recent developments that have allowed us to study properties of living neural networks that are inaccessible to standard electrophysiological approaches. Linear '1D' networks have been used to study information transport and have enabled for the first time the magnetic excitation of cultured central nervous system neurons.

Engineering hybrid 1D-2D systems in a variety of geometries has enabled the creation of neuronal logic devices. In 2D, the use of percolation and graph theory has opened a new vista on the connectivity in the culture. We find that the role of the integration in the 'integrate and fire' neuron is crucial for creation of logic functions, and the need for input from many neurons to overcome a threshold for activation is a basis for multiplexing and redundancy in reliable computation.

Pattern Formation During Deformation of a Confined Viscoelastic Layer: From a Viscous Liquid to a Soft Elastic Solid

Julia Nase°, Anke Lindner°, Costantino Creton*

° PMMH – ESPCI, 10, rue Vauquelin, 75231 Paris Cedex 05, France
** PPMD – ESPCI, 10 rue Vauquelin, 75231 Paris Cedex 05, France*

We study pattern formation during tensile deformation of confined viscoelastic layers. The use of a model system (PDMS with different degrees of crosslinking) allows us to go continuously from a viscous liquid to an elastic solid. We observe two distinct regimes of fingering instabilities: a regime called "elastic” with interfacial crack propagation where the fingering wavelength only scales with the film thickness, and a bulk regime called "viscoelastic” where the fingering instability shows a *Saffman-Taylor*-like behaviour. We find good quantitative agreement with theory in both cases and present a reduced parameter describing the transition between the two regimes and allowing to predict the observed patterns over the whole range of viscoelastic properties.

Momentum Transport in Fusion Devices due to Small Scale Turbulence

A. G. Peeters

University of Warwick, Physics Department, CV4 7AL Coventry, United Kingdom

The presentation will start with a brief introduction into the characteristics of the turbulent dynamics in a fusion device. The quasi two dimensional nature, the reason behind the occurrence of small scales, as well as the basic dynamics of the instabilities is reviewed. It will furthermore be shown that the turbulence, which is driven by the free energy of the density and temperature gradients, generates fluctuating large wavelength flow velocities which have a stabilizing effect, and control the level of turbulence.

The numerical tool used for the study of the turbulent dynamics will be very briefly introduced.

The talk then discusses the consistent development of the theory including, besides the fluctuating flow velocities, also a stationary rotation, as indeed is present in many experiments. The influence of such a rotation is investigated, and shown to lead to a transport of momentum up the gradient. The result of this pinch velocity is a peaked rotation profile which, like the fluctuating velocities, has a stabilizing influence on the turbulence. The physical reason behind the momentum pinch will be shown to be due to a coupling of the momentum balance to the density and temperature perturbations, as well as due to an acceleration of the particles in the fluctuating electro-static potential. Both these effects are directly related to the Coriolis force obtained in the co-moving frame. Implications for current and future experiments will be briefly reviewed.

Amplitude Equation for the Rosensweig Instability

S. Bohlius,[1] H. R. Brand,[2] H. Pleiner[1]

[1] *Max Planck Institute for Polymer Research, Mainz, Germany*
[2] *Theoretical Physics, University of Bayreuth, Germany*

The derivation of amplitude equations from basic hydro-, magneto-, or electrodynamic equations requires the knowledge of the set of adjoint linear eigenvectors. This poses a particular problem for the case of a free and deformable surface, where the adjoint boundary conditions are generally non-trivial. In addition, when the driving force acts on the system via the deformable surface, not only Fredholm's alternative in the bulk, but also the proper boundary conditions are required to get amplitude equations. This is explained and demonstrated for the normal field (or Rosensweig) instability in ferrofluids as well as in ferrogels. An important aspect of the problem is its intrinsic dynamic nature, although at the end the instability is stationary.

We have succeeded in deriving from the basic hydrodynamic and magnetic equations and boundary conditions an amplitude and envelope equation for the Rosensweig instability. Starting from the linear solution, a systematic expansion of those nonlinear equations and boundary conditions in terms of the distance from the threshold is the standard procedure of a weakly nonlinear analysis. To adapt this method to the Rosensweig instability, the adjoint linear eigenvectors in the presence of a deformable surface are needed to satisfy Fredholm's theorem. This has been achieved recently [1] and is useful for other instability problems involving deformable surfaces, like the Marangoni instability. This enabled us to perform the usual expansion procedure for the full dynamic problem up to third order, which in the limit of vanishing frequency gives the desired amplitude and envelope equation for the stationary instability. The resulting amplitude equation contains cubic and quadratic nonlinearities as well as first and (in the gel case) second order time derivatives [2]. Spatial variations of the amplitudes cannot by obtained by Newell's method.

A comparison will be made to corresponding results obtained by the so-called energy method [3], which is approximative and not systematic.

[1] S. Bohlius, H.R. Brand, and H. Pleiner, "Solution of the adjoint problem for instabilities with a deformable surface: Rosensweig and Marangoni instability", *Phys. Fluids* **19** (2007) 094103.
[2] A. Gailitis, "Formation of the hexagonal pattern on the surface of a ferromagnetic fluid in an applied magnetic field", *J. Fluid Mech.* **82** (1977) 401; S. Bohlius, H. Pleiner, and H.R. Brand, "Pattern formation in ferrogels: Analysis of the Rosenweig instability using the energy method", *J. Phys.: Condens. Matter* **18** (2006) S2671.
[3] S. Bohlius, H.R. Brand, and H. Pleiner, "The amplitude equation for the Rosensweig instability", *Prog. Theor. Phys. Suppl*. (2008); to be published.

Quasisolitonic Turbulence

Benno Rumpf

Technische Universität Chemnitz, Chemnitz, Germany

Quasisolitons in nonintegrable dynamical systems are solitary waves that decay as they emit radiation. Such waves emerge for example in the turbulent Majda-McLaughlin-Tabak equation: Narrow soliton-like waves coexist with disordered turbulent waves. In my talk, I discuss whether the quasisolitons cause the non-Kolmogorov type of spectrum of this system.

Vulnerability of a Mixed Mode Bifurcation to Noise

F. Sagués

Departament de Química Física, Universitat de Barcelona, Diagonal 647, 08028 Barcelona, Spain

This presentation will be divided in two parts. In the first one we will present experimental evidence of the existence of mixed Turing-Hopf modes in a two-dimensional chemical system. To be precise we will refer to the photosensitive chlorine dioxide-iodine-malonic acid reaction (CDIMA). Using external constant background illumination intensity, standing spots oscillating in amplitude and with hexagonal ordering will be reported. Numerical simulations using the Lengyel-Epstein (LE) model for the CDIMA reaction will be also provided confirming the experimental observations [1].

In the second part, the influence of superimposed parametric noise on the vicinity but past a mixed Turing/Hopf bifurcation will be discussed. A noise-driven attenuation of oscillations will be reported. Numerical, LE-based, simulations confirm these results, and farther away from the Turing/Hopf codimension-two point permit to unveil a dominant effect of Turing patterns over oscillatory modes, a phenomenon which is mediated by noise of intermediate intensity and small correlation length [2].

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The Granular Phase Diagram

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Granular media like sand, snow or soil can behave like solids or liquids: the beach sand you just walked on will rinse through your fingers the next moment. However, due to the macroscopic nature of the individual grains this phase transition is not controlled by temperature but rather by the combination of volume fraction, pressure and shear stress. Here we will present experiments measuring the yield stress of granular samples with well controlled voluming fractions (ranging from 0.57 to 0.63) and pressure. The so determined phase diagram exhibits the onset of dilatancy as its most prominent feature. It will be a benchmark for the different attempts to develop a statistical mechanics for static granular media.

Pattern Forming System in the Presence of Different Symmetry-Breaking Mechanisms

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We report experiments on spatially forced inclined layer convection (ILC), where the combined effect of the intrinsic symmetry breaking due to a gravity-induced shear flow and a spatially periodic 1D forcing is studied. We observed pattern selection processes resulting in stabilization of spatiotemporal chaos and the emergence of novel two-dimensional states. Phase diagrams depicting the different observed states for typical forcing scenarios are presented. Convection in the weakly nonlinear regime is compared with theory and a good agreement is found.

Dissipative Structure Formation in Surfactant Films

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Spreading of binary mixtures of lipid / lipopolymer on aqueous subphase and subsequent Langmuir-Blodgett transfer onto a solid substrate results in a stripe-like structure due to the demixing of lipid and lipopolymer. However, no demixing is observed at the air / water interface. Thus structure formation takes place in the meniscus region. To further explore the origins and dynamics of the dissipative structure formation we study the meniscus during transfer using imaging ellipsometry and fluorescence microscopy. The dependency on transfer speed and subphase viscosity has been investigated quantitatively. The lateral and vertical profiles near the three-phase contact line in time as well as the dynamics of demixing provide a quantitative experimental basis for a future theoretical description.

Scaling in Rupture of Polymer Chains

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We discuss different experimental situations pertinent to the rupture of polymer chains leading to different regimes of such rupture. We moreover concentrate on a situation when the chain is pulled at one end at a constant loading rate. Compared to a single bond breaking situation (corresponding to the thermal excitation of the system over a time-dependent barrier), the existence of the chain introduces two new aspects into the rupture dynamics: the nonmarkovian aspect in the barrier crossing and the slow-down of the force propagation to the breakable bond.

We investigate the relative impact of both these processes and show the second one to be the most important at moderate loading rates. In this case the most probable rupture force is found to decrease with the number of bonds N as const-$\ln(N)^{(3/2)}$ and finally to approach a saturation value independent on N for a given loading rate. All our analytical findings are confirmed by extensive numerical simulations.

Density Functional Theory of Forces Between Crystal-Melt Interfaces

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Many materials appear naturally as polycrystals, with major implications for their properties. The formation of interfaces and grain boundaries is therefore of significant scientific and technological interest, and understanding the interactions between adjacent solid-melt interfaces therefore essential. Among a variety of forces that can contribute here, only little is known about those, which originate from the interaction of the periodic lattice structures between neighboring crystals; especially in metals they play the dominant role. I will demonstrate a new microscopic concept to explain these *structural forces*, which depend on lattice structure and grain misorientation, and are intimately related to elastic deformations and the emergence of dislocation. They can be attractive or repulsive, are significantly shorter ranged than previously anticipated, and their strength depends on the roughness of the interfaces. In particular, we predict grain boundary premelting of iron.

The arising theory has interesting links to pattern formation in Bénard convection and many other processes in nonlinear dynamics.

Time Reversal of Parametric Excitation and the Stability of Dynamical Systems

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A variety of dynamical systems, e.g. the parametrically excited pendulum, Faraday waves, or electro-hydrodynamic convection in liquid crystals, are usually driven by time-periodic excitation. In other well-known pattern forming systems, like e.g. Rayleigh-Benard convection or Taylor-Couette flow, a constant driving parameter is commonly used, but studies with periodically varying parameters have been reported for these systems, too. Often, simple harmonic parameter variation is employed, which is symmetric under time reversal. For the case of periodic waveforms that are not time-reversal symmetric (for example the superposition of phase-shifted harmonic functions with integer frequency ratio), we raise the question which consequences a time-reversal of the driving function may have.

In general, such time-reversal will lead to different solutions of the relevant differential equations, and to different stability thresholds. Interestingly, there are some remarkable exceptions. Two systems are discussed, viz. nematic electro-hydrodynamic convection (EHC) and a particular version of the parametric pendulum, where time-reversal of the parametric excitation leaves the stability (and pattern selection in EHC) unchanged, although it changes the trajectories of the dynamic variables within each period of excitation. We compare this scenario with the Faraday instability.

Dynamics of a Single Vesicle in Various Flows

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Dynamics of deformable mesoscopic objects under hydrodynamic stresses determine rheology of many complex fluids, such as emulsions, suspensions of droplets or bubbles, solutions of vesicles, blood, biological fluids, etc. From a theoretical point of view this non-equilibrium problem is rather challenging due to the coupling between the object deformations and the flow, where the object shape is not given *a priori* but determined by interplay between flow, bending energy, and various physical constraints. A vesicle is an example of such deformable objects.

Dynamics of a single vesicle in shear and elongation flows is investigated experimentally. In a shear flow study of influence of thermal noise and a viscosity contrast on dynamics of vesicle in tank-treading motion reveals rather good agreement with theory. The surprisingly good agreement of the transition curve from tank-treading-to-tumbling regime with numerical simulations in 2D was found. A new type of unsteady motion at a large degree of vesicle deformability, called trembling, was discovered and described as follows: a vesicle trembles around the flow direction, while the vesicle shape strongly oscillates.

The relaxation dynamics of vesicles subjected to a time-dependent elongation flow was studied. We observed and characterized a new instability, which results in the formation of higher order modes of the vesicle shape (wrinkles), after a switch in the direction of the velocity gradient. This surprising generation of membrane wrinkles can be explained by the appearance of a negative surface tension during the vesicle compression, which tunes itself to alternating stress. In a stationary elongation flow at sufficiently strong extensional rates an analog of coil-stretch transition well-known in dynamics of polymer molecules was discovered for a single vesicle. Its connection to the pearling instability was also established.

Recent results on phase diagram of vesicle different dynamical states in various flows are also discussed.

Magnetically Driven Colloidal Microswimmers

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To achieve permanent propulsion of submerged objects in viscous fluids is an elusive but challenging goal that may foster the present development of microfluidics and biotechnology. Here we show that anisotropic paramagnetic colloidal particles dispersed in water and floating above a flat plate can be endowed with controlled propulsion when subjected to a horizontal precessing magnetic field. During cycling motion, stronger viscous friction at the bounding plane, as compared to fluid resistance in the bulk, creates an asymmetry in dissipation that rectifies rotation into a net translation of the suspended objects. This simple mechanism also permits reinterpreting Purcell's scallop theorem of impeded swimming from reciprocal periodic motion. We combine a report of experimental observations with a theoretical analysis that fully characterizes the swimming velocity in terms of the relative strength and frequency of the actuating magnetic field.

Soft-Mode Turbulence and Symmetry

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Soft-mode turbulence (SMT) is an unusual type of spatiotemporal chaos at onset analogous to the second order phase transitions in equilibrium systems. On one hand it exhibits typical features of developed turbulence, such as the Kolmogorov cascades, decay of correlations, etc. On the other hand it is characterized by critical slowing down and divergence of the correlation length at the onset, typical to the second order phase transitions. In the present contribution deep connection between SMT and the problem symmetry (including effects of weakly broken symmetry) is revealed. The symmetry violation may result in suppression of SMT so that instead spatially periodic patterns arise. The simplest 1D model describing the effects of weakly broken symmetry is introduced and analyzed. It is shown that the problem exhibits rather unusual scaling properties, so that different domains in the parameter space obey different types of scaling.

Cytoskeletal Filaments and Molecular Motors: Rheology and Alignment

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I discuss collective dynamics of cytoskeletal filaments interacting via molecular motors.

First, I show how the rheology of such a system can be studied by means of Brownian dynamics simulations of a two-dimensional toy model. An effective temperature is determined to quantify the nonequilibrium situation and correlation functions are studied.

Second, I focus on the alignment of two filaments by multiple motors that can be described by a micromechanical model. The timescale of alignment is predicted and is in good agreement with in vitro experiments.

Posters

(in alphabetical order)

Laser-Induced Soap Bubble Formation from a Langmuir Monolayer

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Monolayer collapse is an instability occurring upon compression of a Langmuir monolayer beyond its collapse pressure. Heating of the water/air surface with a focussed IR-laser locally reduces this collapse pressure and induces a transition from a two dimensional film toward three dimensional soap bubbles. The soap bubbles trapped in the laser may coalesce and contain domains of different density. First experiments with such bubbles are presented.

Dumbbell Diffusion and Transport in a Spatially Periodic Potential

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The transport of colloidal particles through external fields is of interest for many technological applications such as particle sorting. However most previous cases have only investigated spherical colloids. We study theoretically the deterministic and stochastic motion of a dumbbell, which consists of two connected beads, in a spatially periodic potential.

It turns out that the hydrodynamic interactions between the two beads and the competition between the two involved length scales, namely the wavelength of the potential and the size of the dumbbell, are the origin of interesting effects like the enhancement of the diffusion constant in a certain parameter range.

If the dumbbell is pulled by a uniform flow through the potential, one finds a crossover between two regimes of motion, which also depends on the length scales, and one observes a resonance-like modulation of the deflection angle of the dumbbell.

Viscous Fingering in Granular Materials in a Vertical Hele-Shaw Cell

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We present an experimental characterization of viscous fingering in a vertically aligned Hele-Shaw cell. Air was pressed into the dry granular material at the bottom of the cell through a single hole and the development of the propagating fingers was analyzed with the help of fast video recording. The behaviour of the system was analyzed as a function of the applied air pressure, the grain size and the grain shape by using spherical glass beads or sorted sand particles. We find that the fingers have a characteristic width w which is independent of the grain size and scales as $w \sim v^{1.5}$ where v is the velocity of the tip.

Interaction between Rotating Anisotropic Paramagnetic Doublets at Oil-Water Interface and in the Bulk

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Optical microscopy is employed for studying hydrodynamic interactions between rotating anisotropic paramagnetic doublets in the bulk and at the oil-water interface. Anisotropic rotors are formed by linking two paramagnetic colloidal particles with two complementary sequences of single stranded DNA. An external precessing magnetic field induces rotation of the doublet.

Physical Description of the Endosomes Dynamics

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The endocytic machinery of eukaryotic cells comprises a myriad of membranes bound compartments among which several populations of endosomes of different chemical composition, feature and function. Endosomes are highly dynamical objects that frequently fuse, divide and mature. All together they ensure the sorting and targeting to its proper destination of the material endocytosed by the cell. Our project aims to:

(i) characterize quantitatively the populations of endosomes by using fluorescence microscopy and images analysis tools [1]

(ii) make the link between the statistical properties of the population and the dynamics of the individual endosomes by building a generic physical model for the collective dynamics of a large ensemble of endosomes.

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The Effect of Insulating Lids on the Dynamics and Stirring Properties in Rayleigh-Bénard Convective Systems

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Rayleigh-Bénard convection is a commonly studied process in non-linear physics. One important application is its analogy to convective motions in the Earth's mantle, which are thought to be the driving forces of plate tectonics.

There are two different types of plates on Earth. Oceanic plates are recycled into the mantle and are characterized by a relatively strong heat flux, while continents are more insulating, lighter, and unsubductable.

The dichotomy between continents and oceans is likely to have a first order influence on mantle motions, thus on the efficiency of convective stirring over billions of years. Understanding these processes is essential to interpret surface geophysical and geochemical data on Earth, such as the observed isotopic heterogeneities in basalts samples compositions.

In this contribution, the influence of insulating lids (i.e. continents), on the dynamics of the convective system is presented. In particular, we quantify the convective stirring efficiency as a function of the Rayleigh number and the size of the insulating lid. We model numerically convection at infinite Prandtl number in a 2D isoviscous, incompressible fluid on a rectangular grid (aspect ratio 1:4).

In addition, we account for the differences between oceanic and continental plates by imposing heterogeneous surface boundary conditions.

Oceanic plates are described by Dirichlet boundary conditions ($T=0$) while the insulating character of the continents is modeled by imposing Neumann boundary conditions ($\partial T/\partial z=0$).

We use Lagrangian tracers that are passively advected by the flow, to quantify the stirring efficiency. This allows one to determine various stirring diagnostics such as mixing time, Lyapunov exponents distribution and mean tracer age.

Electroconvection in a Sheared Nematic Liquid Crystal

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We have studied the influence of an electric field and a steady circular shear on a homeotropically aligned nematic liquid crystal, Phase 5 (Merck). In the absence of shear the usual electric field induced scenarios could be detected: a Freedericksz transition at the threshold voltage $U = U_F$, followed by the onset of electroconvection (EC) at a frequency dependent $U_c > U_F$; both with underlying random spatial variations of the local director as expected from the degeneracy of the homeotropic alignment.

The circular shear introduces a preference for tangential alignment, removes the threshold and reduces the voltage needed for a given deformation. In the EC regime shear removes the disorder of the stripe pattern. Besides it affects the EC threshold: at high frequencies U_c grows with increasing shear rate S ; however, at low frequencies $U_c(S)$ was found to be non-monotonic exhibiting a minimum at medium shear rates.

The influence of the shear on the subsequent (homogeneous then patterned) director distortions is strongly reminiscent of the effect of a magnetic field applied normal to the electric one [1].

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Flexoelectricity and Competing Time Scales in Electroconvection

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An electric field induced pattern forming instability - electroconvection (EC) – has been studied under the less explored condition of comparable timescales of the director relaxation and the period $1/f$ of the driving ac voltage in various nematic liquid crystals.

In compounds exhibiting standard EC (Phase 5, 5A, 4 and MBBA) measurements indicated a novel behaviour in the frequency dependence of the EC threshold voltages U_c: for the conductive regime $U_c(f)$ bends down considerably, while for the dielectric regime it bends up strongly with the decrease of the driving frequency f [1]. We show by numerical simulations that the standard model of EC – where flexoelectricity is neglected - does not account for this phenomenon. Inclusion of the flexoelectric effect into the theoretical description [2], however, leads to a quantitative match for the conductive regime even at low f, while for the dielectric regime a qualitative agreement can be achieved [1].

A compound (**8/7**) which exhibits standard as well as non-standard EC [3] depending on the temperature has also been tested, and the novel low f behaviour of $U_c(f)$ could also been detected. It was found that the frequency dependence of U_c for the non-standard EC strongly resembles that of the standard dielectric regime.

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Travelling-Stripe Forcing of a Shallow Layer of Magnetic Liquid

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Transport of a ferrofluid has been achieved by rotating [2], but also by travelling magnetic fields [3,4]. As described in [5] the surface of a magnetic liquid shows quite a number of phenomena in the vicinity of the Rosensweig instability [6,7]. We found, that forcing by an undercritical spatiotemporally modulated magnetic induction does not just cause surface-waves to travel along the fluid surface, but also shows a transport of the liquid. For high subcritical magnetic fields the increase of the forcing frequency can lead the fluid to form rosensweig cusps in different patterns. A further increase of the magnetic field strength up to the subsequent overcritical regime changes the spectrum of surface patterns, and therefore also the effect of locomotion.

In order to measure the transport and the surface patterns of the ferrofluid we capture the surface profile of the fluid by means of X-ray imaging [8]. The results are discussed in terms of [9].

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The Rosensweig Instability with a Ferrogel

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Ferrogels are an interesting new class of [1], which are able to change their shape and exert forces in response to external magnetic fields [2]. Large deformations could be achieved by gradient magnetic fields [3]. The deformation in homogeneous magnetic fields has not been studied to the same extent [4, 5].

A homogeneous magnetic field evokes an instability on the surface of a layer of ferrofluid, which should also be possible in ferrogels. From a linear stability analysis [6], the critical magnetization is given by

$$M_c^2 = \frac{2}{\mu_0}\frac{1+\mu}{\mu}(\sqrt{\rho g \sigma} + G)$$

where G is the shear modulus. The critical field is shifted to higher values due to the elastic forces compared to a ferrofluid. The critical wavenumber is predicted to remain the same.

We use a thermoreversible ferrogel [7] and expose it to a homogeneous magnetic field. By controlling the temperature we can easily change the elastic modulus over several orders of magnitude. The surface topography of the ferrogel is then recorded using an X-ray technique [8] Additionally, the instability is driven by a static field plus a sinusoidal modulation. We measure the amplitude of the modulated surface deflection as well as the mean height of the pattern and compare it with the theory.

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Barchan Dunes in two Dimensions: Experimental Tests for Minimal Models

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A well defined two-dimensional single barchan dune under the force of a shearing water flow is investigated experimentally. From an initially prepared triangular heap a rapid relaxation to a steady-state solution is observed with constant mass, shape, and velocity. This attractor exhibits all characteristic features of barchan dunes found in nature, namely a gently inclined windward side, crest, brink, and steep lee face. The relaxation time towards the steady state increases with mass. For small dunes we find significant deviations from a fixed height-length aspect ratio. As predicted by recent theoretical models, the migration velocity scales reciprocal to the length of the dune.

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Does the Oscillation of a Sphere Affect its Coefficient of Restitution?

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The sound emitted by a sphere hitting a rigid surface can be recorded by a computer. The coefficient of restitution as a function of the impact velocity can then be obtained using the time instants of three successive impacts at a time.
After gathering several hundred thousand datapoints at varying impact velocities, the plotted data reveals steps in $\varepsilon(v)$. These steps can be explained by eigen frequencies of the bouncing sphere in the range of $f \sim 10^6$ 1/sec and a contact time sphere↔surface of about 30 μs which is in agreement with theoretical results.

Brownian Ratchet Effect in a Ferrofluid Sample

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We investigate experimentally a suggested Brownian ratchet system from Engel et al. [1,2]. This ratchet system is based on a magnetic fluid witch contains nm sized magnetic particles in a thermal bath of carrier fluid. An external static and perpendicular oscillatory magnetic field acting on the particles. The temporal shape of the oscillatory field defines the ratchet in the system. Depending on the parameter of the *non-rotating* field, we measured an induced macroscopic torque on a spherical ferrofluid sample in a torsional pendulum. A quantitative com-parison of measured torques and predictions from the microscopic model are given.

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Mimetic Intruders in a Two Dimensional System of Vertically Excited Granulate

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An initially close packed granular bed of hard spheres is confined by two glass plates with a separation only slightly larger than the particle diameter. In this experiment one or more intruders are inserted and the container is exposed to sinusoidal oscillations. When a critical value of the forcing strength is reached, the granular bed begins to fluidize[1] and segregation as well as intruder-intruder interaction can be observed. While common experiments[2] to study these effects use large disks as intruders this approach utilizes intruders composed of the same beads as the granulate.

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Pattern Formation in Langmuir-Blodgett Transfer Systems

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Self-organized regular patterns have been observed in experiments [1] when phospholipid monolayers were transferred onto solid substrates via Langmuir-Blodgett technique. The patterns consist of broad areas of lipid in the liquid-expanded phase divided by equidistant groove-like liquid-condensed areas.

We present a theoretical investigation of the mechanism behind these phenomena. In our approach two coupled equations, one for the surfactant and one for the subphase, serve as a theoretical model of the experimental setup. The observed pattern formation occurs, when the monolayer on the subphase is close to the so-called main transition, the phase transition between the liquid-expanded and the liquid-condensed phase. We expect this transition to play a key role in the process of pattern formation. Within our framework, a transition of the surfactant phase directly affects the fluid by a change of surface tension. The interplay of surface thermodynamics and film evolution then builds up oscillations which finally lead to the observed structure. Linear stability analysis is applied in order to trace the instabilities behind the pattern formation.

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Complex Nonlinear Phenomena Above the Optically Induced Fréedericksz Transition for Different Geometries

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It is known that the nematic is an anisotropic uniaxial medium with the optical axis parallel to the local molecular distribution described by the director **n**. When the light propagates through the nematic, its electric field exerts a torque on the molecules that can induce collective molecular reorientation. In some cases the initial distribution of the director becomes unstable when the intensity of light reaches a certain critical value. This is the so-called Optically Induced Fréedericksz Transition. We study complex nonlinear phenomena above the primary transition for different geometries which ranges from simple stationary director reorientation, through relatively simple director precession and nutation, to low-dimensional chaos and spatio-temporal pattern formation.

Onset of Sand Ripple Formation in Weakly Turbulent Flow

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One of the most fascinating examples of pattern formation in nature are the dunes and ripples formed in sand, caused either by wind or by shear flows in water. Laboratory studies have focused mainly on the surface profile of the granular layer, describing the ripples and their instability in terms of global parameters. Here, we present an experimental study of ripple generation in an annular channel at rather low Reynolds numbers in weakly turbulent flow. We characterize the fluid velocity field at the onset of ripple generation by utilizing a laser doppler velocimeter. These experimental studies show that the local rapid increase of velocity fluctuations close to the sandy bottom initiate the motion of particles and thus will finally lead to the formation of ripple patterns with finite amplitude.

Granular Transport Hysteresis

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Since the pioneering works of R.A Bagnold, a grown interest in the physics of granular movement evolved. Initial granular movement of a sandbed starts, when the windspeed over the bed surpasses a critical threshold speed. With further increase of flow the amount of dislodged and transported grains also increases. However, threshold speed and windspeed versus sandflow are not constant but can be varied through control parameters - especially the humidity of the fluid. Using a closed-circuit wind tunnel and at a set humidity we were already able to produce hysteresis to inverse hysteresis effects in the sandflow. However, this has only been a proof of concept for the measurments. Consequently, the exact and systematic measurment of the found effects by modifying the control parameters has still do be done.

Solid-Fluid Transition of a Thin Granular Layer with Various Air Pressure

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In this experiment the air pressure can be varied in a system, in which the effect of solid to fluid transition appears. Glas beads are transported in a circular conveyor by sinusodial motion in vertical and horizontal direction, also the frequency and the amplitude of the motion can be modified. The purpose is to see the influence of air pressure, especially low air pressure.

Ising and Bloch Fronts in Lattices of Coupled Forced Oscillators

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We study the dynamics of Ising and Bloch fronts in parametrically forced oscillating lattices. Using as a prototypical example the discrete Ginzburg-Landau equation, we show that much information about front bifurcations can be extracted by projecting onto a cylindrical phase space. Starting from a normal form that describes the nonequilibrium Ising-Bloch bifurcation in the continuum and using symmetry arguments, we derive a simple dynamical system that captures the dynamics of fronts in the lattice [1]. We can expect our approach to be extended to other pattern-forming problems on lattices.

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Asymptotic Continuous-Time Random Walk Models for Deterministic Diffusion

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Since the introduction of the continuous-time random walk (CTRW) by Montroll and Weiss [J. Math. Phys. 6, 167 (1965)], its concept has been successfully applied to model sub- and superdiffusive processes. Some recent examples are: blinking quantum dots [Chem. Phys. 284, 181 (2002)], human travel [Nature 439, 462 (2006)] and economics [Physica A 362, 225 (2008)].

On the other hand, for sufficiently mixing deterministic dynamics, Beck and Roepstorff [Physica A145, 1 (1987)] have shown, that the integrated dynamics converges to a Brownian motion in the long time limit. For slowly mixing systems, this in no longer the case. Here, we concentrate on the case that the mixing is so slow that the ergodic measure is not normalizeable which also appear as the measures with weakly broken ergodicity [J. Phys. I 2, 1705 (1992), Europhys. Lett. 74, 15 (2006)]. The method of inducing used in mathematics to handle these measures [Aaronson 1997] suggests that CTRWs emerge as the stochastic description of these dynamics.

For this, we extend the description of a CTRW by Fogedby [Phys. Rev. E 50, 1657 (1994)] with two independent stochastic differential equations by setting up a general description of a (possibly) space-time coupled version of a CTRW with continuous "operational time". We identify the self-affine ones which emerge as long time limits. The method allows to give an interpretation of a result obtained by Becker-Kern, Meerschaert and Scheffler [Ann. Prob. 32, 730 (2004)]. The components of such CTRWs are identified from the probabilistic behavior of the deterministic maps. This setup is exemplified analytically and numerically in a Manneville-Pomeau like setting. Depending on the ranges of the parameter we obtain sub- and superdiffusion.

Glass Spheres Driven by Horizontal Swirling With One Fixed Intruder

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In this experiment a dish filled with glass spheres is shaken horizontally, so every point on that dish moves on a circle path. In the centre of this dish a intruder is fixed, so the balls can poke with two walls, the wall at the border of the dish and the surface of the intruder in the center. During the experiment, the driving frequency and amplitude are fixed, but the size of the intruder and the count of balls are diversified.

Why does a Ferrofluidic Pendulum FLIP at a Critical Driving Frequency

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Recently a new type of torsional pendulum was proposed [1] which we realize by suspending a DISC SHAPED container in a Helmholtz pair of coils driven by an alternating sinusoidal current. The container is suspended with its long axis in line with the fiber. In contrast to a spherical pendulum [2, 3] the orientation of the disc is sensitive both to the field direction and the field frequency: As sketched in Fig. 1 it should expose its edge to the field vector of low oscillating field and its broad side to the field vector of high frequency.

Unfortunately, this reorientation (FLIP) does not occur for available ferrofluids because of their polydispersity. But with help of an additional constant magnetic field $B_{\rm help}$, which is orientated perpendicular to the oscillating one, the FLIP of the pendulum can be observed. Figure 2 displays the pendulum frequency $f_{\rm P}$ versus the driving frequency f . The flip occurs at $f_{\rm P}$ = 0Hz. The mechanism for the flip is intrinsically connected with the frequency dependence of the generalized ac-susceptibility $\chi'_{\|}(f)$ for a field parallel, and $\chi'_{\perp}(f)$ for a field orthogonal to the symmetry axis of the filled pendulum. The solid line in Fig. 2 gives our theoretical estimate for the pendulum frequency according

$$\hat{f_P}^2 = B_0 V \frac{\chi'_{\perp}(f) - \left(\chi'_{\|}(f) + h(\gamma)\right)}{4\pi\,\mu_0 J} + f^2_{\rm mech}.$$

Here B_0 denotes the amplitude of the oscillating field, V the volume of the disc-shaped body, J the moment of inertia of the pendulum and $f_{\rm mech}$ its frequency without any magnetic field.

Moreover we use the abbreviation

$$h(\gamma) = \frac{\gamma}{\mu_0} V \left(\chi'_{\perp}(0) - \chi'_{\|}(0)\right), \quad \gamma = 2B^2_{\rm help}/B^2_0.$$

We have measured the variation of f_P for different values of B_{help}, and find again a convincing agreement with the model. The observed effect is a physical mechanism in principal which should occur not only for oblate magnetizable bodies like the disc, but also for prolate bodies, like rods. Moreover it should be observed in electrical polarized matter, too.

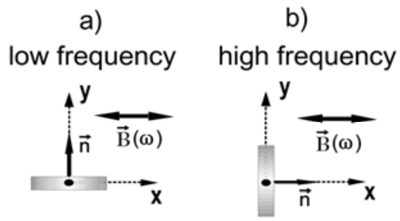

Figure 1: The two different orientations of the pendulum for low and high driving frequencies.

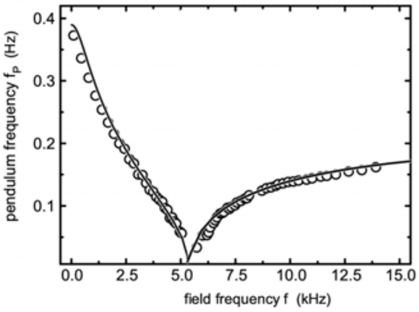

Figure 2: Pendulum frequency versus driving frequency for a constant driving amplitude. The flip occurs for $f_P = 0$ *at* $f \approx 5.2$ *kHz. From [4].*

Acknowledgments

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Anomalous Diffusion in Inhomogeneous Mobility Landscapes

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We theoretically investigate the Brownian motion of particles in inhomogeneous mobility landscapes, a situation which may occur in binary fluid mixtures close to the critical point [1].

As a model for the Brownian motion we introduce a Langevin Equation (LE) with spatially varying mobility at a constant temperature. In addition a generalized Fokker Planck Equation (FPE) for the space and time dependent probability density is derived by eliminating the momentum variable in the phase space of the LE for a position-dependent friction, following Ref. [2].

The analysis of both approaches (LE and FPE) reveals a subdiffusive behavior near a minimum of the mobility and a superdiffusive behavior near a maximum. Furthermore we find a particle drift spatially limited to regions of huge mobility gradients in the vicinity of absolute mobility minima [3].

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Mechanosensitive Pattern Formation in Active Biogels

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We report on mechanosensitive pattern formation in a cytoskeletal solution composed of filaments (like actin, microtubules), motors and crosslinks. One part of the filaments is supposed to be crosslinked to a (visco-)elastic solid-like network or gel, while filaments that are not part of the gel are mobile.

Due to the nonequilibrium action of the molecular motors, which is driven by ATP hydrolysis, the system undergoes various instabilities like the long range clustering of filaments to form propagating pulses or stationary periodic patterns. [1]

Furthermore it is shown that the pattern forming process is mechanosensitve to external forces and to the state of the elastic background formed by the network/gel. By stretching and compression of the network, patterns can be induced or suppressed into the system. In turn, a reorganisation of the filaments leads to a stiffening of the whole system. [2]

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Pattern formation in active cytoskeletal networks,
New J. Phys. **10** 035002 (2008)

[2] V. Schaller, R. Peter, F. Ziebert and W. Zimmermann;
Mechanosensitive patterns in cytoskeletal systems,
in preparation

Interfaces in Driven Ising Models: Shear Enhances Confinement

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We use a phase-separated driven two-dimensional Ising lattice gas to study fluid interfaces exposed to shear flow parallel to the interface [1]. The interface is stabilized by two parallel walls with opposing surface fields and a driving field parallel to the walls is applied which (i) either acts locally at the walls or (ii) varies linearly with distance across the strip. Using computer simulations with Kawasaki dynamics, we find that the system reaches a steady state in which the magnetisation profile is the same as that in equilibrium, but with a rescaled length implying a reduction of the interfacial width. An analogous effect was recently observed in sheared phase-separated colloidal dispersions. Pair correlation functions along the interface decay more rapidly with distance under drive than in equilibrium and for cases of weak drive can be rescaled to the equilibrium result.

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Hydrodynamic Attraction and Repulsion Between Rotated Asymmetric Dumbbells

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Two asymmetric and hydrodynamically interacting dumbbells are rotated in a solvent. We show that they may either attract or repell each other depending on the asymmetries of the dumbbells and on the different torques acting on them. We present phase diagrams of this novel dynamical effect, which is induced via hydrodynamic interaction.

Soret Driven Pattern Formation in a PDMS/PEMS Polymer Blend

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Utilizing the Soret effect, we have investigated pattern formation in the critical polymer blend PDMS/PEMS (poly(dimethylsiloxane)/poly(ethylmethylsiloxane)) close to the critical temperature T_C. Due to the divergence of the Soret coefficient at T_C, moderate temperature gradients induce composition modulations of large amplitudes which persist for long time-scales (minutes). The new approach to investigate their 3D-structure uses Differential Interference Contrast (DIC) due to its better axial resolution compared to phase contrast techniques. Furthermore, we have investigated local perturbations consisting of light absorbing gold nano-particles. When exposed to laser radiation they modify their local environment which in turn influences their dynamic behaviour.

Membrane Flow Patterns in Giant Vesicles Induced by Inhomogeneous Alternating Electric Fields

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Electric fields are widely applied for particle and fluid manipulation in numerous micro-scale systems, e.g. for moving, trapping or sorting cells; pumping and directing fluid flows, etc. Recently, a new class of electrically induced fluid flows has been demonstrated in the vicinity of electro-neutral, polarizable objects. These flows are driven by the displacement of the field-induced surface charges arising from the lateral components of the electric field. Such flows have been observed at various liquid and solid interfaces (drops, rigid particles, stripes, edges) but, to the best of our knowledge, no experimental or theoretical studies on lipid membranes have been reported previously. We use giant vesicles, which allow us to directly observe the electric field effects on membranes by optical microscopy. These vesicles are not only bio-mimetic model for the cell membrane but also have many potential biotechnological applications, e.g. as drug-delivery system, micro-reactors, etc. Their lipid membranes are incompressible fluids, which develop tension under forcing. Under homogeneous AC fields, membrane flow within the vesicle is not expected because the lateral electric stress is counterbalanced by the resulting axially symmetric gradient in the membrane tension. However, in most chambers and conditions used for electric manipulation, vesicles, cells or other particles experience inhomogeneous fields, due to screening by neighbors, sedimentation, chamber geometry, etc. Here, we show for the first time that even weakly inhomogeneous AC fields may induce a pronounced membrane flow in giant vesicles. The flow is visualized by fluorescently labeled lipid domains. The flow pattern differs substantially from any pattern that has been reported previously. The influence of the field parameters and media properties will be discussed and a mechanism based on finite element calculations will be proposed. The AC-field induced membrane flow should be useful for applications in microfluidic technologies, for lipid mixing, trapping and displacement, as will be demonstrated. We believe also that this method for visualization of the lipid displacement by intramembrane domains will be helpful for studies on membrane behavior in vesicles subjected to shear flows or mechanical stresses.

Defect Structure and Evolution in Thin Block Copolymer Films

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With in-situ scanning force microscopy we study defect dynamics in thin films of a cylinder forming polystyrene-*block*-bolybutadiene (SB) diblock copolymer melt. High temporal resolution of scanning allows for observation of elementary dynamic processes of structural rearrangements with the time scales ranging from seconds to hours. We reveal defects' annihilation pathways via interfacial undulations and formation of transient phases, such as spheres, perforated lamella and lamella. The temporal phase transitions to non-bulk structures are reproduced in simulations that are based on the dynamic self-consistent mean field theory. The role of the observed structural evolution in the overall phase behavior in SB thin films is discussed.

Periodic Patterns in a Spatio-Temporal Forced Cahn-Hilliard Model

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Motivated by recent experiments on polymer blends with a large Soret effect [1,2] we have studied phase separation in the presence of an inhomogeneous temperature field. Within the framework of a suitably generalized Cahn-Hilliard model [3,4] we have investigated the effects of an additive spatio-temporal forcing $a\cos[q(x-vt)]$ on phase separation, which corresponds to a spatio-temporal temperature modulation in optical grating experiments [1,2].

It has been found that for a stationary forcing ($v=0$) phase separation is locked beyond a critical forcing amplitude $a_0(q)$ to periodic patterns of wavenumber $Q=q$ (harmonic solutions). This critical amplitude is increased at increasing the pulling velocity v. The bifurcation diagram, existence range, as well as the dynamics of phase separation influenced by the forcing have been studied.

We have also investigated the existence and stability of subharmonic periodic patterns of wavenumber $Q=q/m$ (m ≥ 2) and their spatio-temporal behaviour for the cases $v=0$ and $v\neq 0$. We found that the smallest critical forcing amplitude for the stabilization of a periodic solution with a given wavenumber Q corresponds to the harmonic modulation.

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Hexagon – Square Transition of the Rosensweig Instability in the Presence of a Magnetic Ramp

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The Rosensweig instability has been predicted[1] and found experimentally[2] to show a transition from a hexagonal arrangement of the peaks to a square one. In a recent experiment we unveiled that this transition does show an inverse hysteretic character (proteresis)[3]. In our contribution, we reinvestigate this transition in a container with a larger aspect ratio and under the influence of a magnetic ramp to minimize the influence of the boundary.

The experimental setup consists of a flat aluminium container (a pella pan which is shown in the picture) with a diameter of about 40 cm positioned in the center of a Helmholtz pair of coils. The magnetic field exceeds the critical value in a circular area with a diameter of about 24 cm. To analyze the surface structure of the fluid we use the attenuation of X-rays[4].

Starting at subcritical values we increase the induction B quasi adiabatically, and observe the well known subcritical transition to a hexagonal pattern. Increasing B further we measure a transition to squares. From the radioscopic pictures we extract several parameters which can discriminate between the two different patterns like the peak to peak distance or the angular correlation function $\boldsymbol{Q}$ from the real space. From the Fourier space we can extract the angular correlation $\mathbf{P}_\alpha$ and the wavelength of the pattern. Especially the selection of the wave number by variation of the induction brings interesting results.

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Convection in Colloidal Thermosensitive Suspensions

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Microgel suspensions consist of core-shell nanoparticles (Fig. 1) which change their size with the temperature and as a result the viscosity of the suspension. Temperature gradients in the suspension induce a gradient of the colloid concentration. This extremely modifies the nonlinear properties of the thermal convection compared to a simple fluid or a binary-fluid mixture. We now investigate the consequences of these effects on the onset and the nonlinear behavior of the thermal convection.

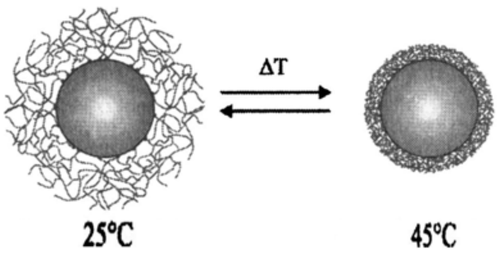

Fig. 1 Schematic drawing of the core-shell nanoparticles (PS-PNIPA) [1]. The PNIPA-network swell at lower and shrink at higher temperatures.

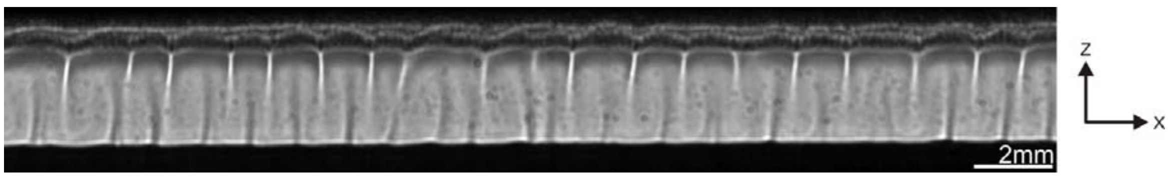

Fig. 2 Shadowgraph image of the thermal convection of a microgel suspension in a Hele-Shaw-Cell. The applied temperature difference in z-direction is $\Delta T=10K$.

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Polymer Solutions in Co-Rotating Couette Cylinders

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We investigate the behaviour of dilute polymer solutions in a Taylor-Couette cell with independently rotatable cylinders. The focus of our interest lies on the examination of the elongation of the solved polymers and their response on the imposed flow. Our measurements show that we are able to detect these counteracting forces and to relate them to the polymer relaxation time of the respective solution. In addition we give a summary of a mathematical discussion of possible laminar flow states in a Taylor-Couette system including a pure elongational flow. The final argumentation is pointing to the usefulness of this flow state to our investigations.

Brownian Fluctuation in Shear Flow

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We investigate the hydrodynamic interaction of Brownian particles in shear flow. We use optical tweezers to localize the particles in a harmonic potential and to detect the position of the particles as a function of time. Two particles in the range of micrometers are separated in a distance of the diameter range. The positions are measured with a camera or with PSD's. In the direction of direct linking, the particle fluctuations are anti-correlated for times in the range of milliseconds. Fluctuations in orthogonal directions are uncorrelated. In shear flow, these orthogonal movements of the beads should be coupled because of the linear shear flow.

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