# ABSTRACTS FROM
# THE 2ND INTERNATIONAL WORKSHOP ON

# *COMPLEX PHYSICAL PHENOMENA IN MATERIALS*

**Hotel Armação, Porto de Galinhas - PE, Brazil**
**January 31- February 3, 2012**

EDITED BY

Jon Otto Fossum and Giovani L. Vasconcelos

**The scope of the workshop include a variety of topics such as:**
Complex fluids and complex systems - soft matter pheonomena - microfluidics - granular systems - adhesion - sorption - selfassembly in colloids - flow phenomena - complextity and magnetism

**Invited speakers:**
J. Albino Aguiar (UFPE, Recife, Brazil)
Ernesto Altshuler (Univ. Havana / CAS - Oslo, Norway)
José Andrade Jr. (UFC, Fortaleza, Brazil)
Françoise Brochard-Wyart (Institute Curie, Paris, France)
Marcio Carvalho (Pontificia Universidade Catolica do Rio de Janeiro, Brazil)
Paul Dommersnes (Univ. Paris 7 / CAS - Oslo, Norway)
Mario Engelsberg (UFPE, Recife, Brazil)
Antonio M. Figueiredo Neto (USP, São Paulo, Brazil)
André Galembeck (CETENE/UFPE, Recife, Brazil)
Wilson Grava (CENPES, Petrobras, Rio de Janeiro, Brazil)
Hans Herrmann (ETH Zurich, Switzerland)
Yves Meheust (Univ. Rennes 1, Geosciences, France)
Mark Mineev-Weinstein (NMC, Los Alamos, USA)
Fernando Oliveira (UnB, Brasilia, Brazil)
Wilson Ortiz (UFScar, São Carlos, SP, Brazil)
Roger Pynn (Univ. Indiana, USA)
Sergio Rezende (UFPE, Recife, Brazil)
Dan Rothman (MIT, Cambridge, MA, USA)
Adriaan Schakel (UFPE, Recife, Brazil)
Arne Skjeltorp (IFE, Kjeller / CAS . Oslo, Norway)
Jørn Inge Vestgården (Univ. Oslo, Norway)

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Abstracts from
2nd International Workshop on

# Complex Physical Phenomena in Materials

Hotel Armação, Porto de Galinhas - PE, Brazil,
January 31- February 3, 2012

Edited by
Jon Otto Fossum and Giovani L. Vasconcelos

Webedition



Giovani L. Vasconcelos

Jon Otto Fossum

## Foreword

Welcome to the **2nd International Workshop on “Complex Physical Phenomena in Materials**” at Hotel Armação, Porto de Galinhas, PE, Brazil, January 31 – February 03, 2012.

The 1st Workshop, held in Recife, Brazil, from December 14-17 2010, and organized by Prof. Mario Engelsberg, from the Physics Department of UFPE, Recife, Brazil, and by Prof. Jon Otto Fossum from the Department of Physics at NTNU, Trondheim, Norway, grew out of good and productive scientific collaborations over the last five years or so. As it turned out, that first workshop went well beyond the context of this bilateral collaboration and served as a venue for discussions on a wider range of complex phenomena in materials. The success of the 1st Workshop was a clear evidence of the importance of having meetings that promote interaction between scientists from (seemingly) different fields and from different working environments (universities, research institutes, and industry research centers). In organizing this 2nd Workshop we have tried to follow these same guiding principles. We have also tried to expand its scope not only with respect to the scientific contributions themselves but also including a roundtable session to discuss the translation of academic research within complex matter physics into industrial applications.

This 2nd Workshop was made possible because of funds from the Brazilian agencies CAPES, FACEPE, and CNPq, and from the Research Council of Norway (RCN) through the RCN BILAT Program, and the Centre for Advanced Studies (CAS) of the Norwegian Academy of Sciences and Letters in Oslo. This workshop is part of a series of workshops organized by the Norwegian COMPLEX network project at CAS in 2011-2012, the next workshop in the series will be held in Havana, Cuba, in March 2012 (see: www.cas.uio.no).

We express our gratitude to all of our sponsors. We would also like to thank the Physics Department and the Physics Graduate Program at UFPE for their support.

In addition to this booklet of abstracts, we will also pubslish proceedings from this workshop: Proceedings from 2nd International Workshop on “Complex Physical Phenomena in Materials”, Hotel Armação, Porto de Galinhas - PE, Brazil, January 31 - February 3, 2012, eds. J O. Fossum and G. L. Vasconcelsos. ISBN: 978-82-93224-05-1 (webedition) and 978-82-93224-06-8 (printed version).

We conclude by repeating the wish expressed in the last sentence of the Foreword to the Book of Abstracts of the 1st Workshop: “We hope that this is not the last workshop of its kind.”

Welcome to Porto de Galinhas.

Giovani L. Vasconcelos (UFPE, Brazil) and Jon Otto Fossum (NTNU, Norway)


Hotel
ARMAÇÃO
Porto de Galinhas

# Program

**2nd International Workshop on Complex Physical Phenomena in Materials**
Porto de Galinhas, PE, Brazil – January 31 – February 03, 2011

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<tr><td>21:00 - 22:00</td></tr>
<tr><td>22:00 - ?</td><td>Discussions</td><td>Discussions</td><td>Discussions</td></tr>
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# 31/1 Tuesday:

| | |
|---|---|
| **1215-1515** | **Registration** |
| **1515-1530** | **Opening:**<br>**Jon Otto Fossum, NTNU-Trondheim/CAS-Oslo, Norway**<br>**Giovani Vasconcelos, UFPE - Recife, Brazil** |
| **1530-1630** | **Afternoon session:**<br>**Chair: Arne Skjeltorp, IFE, Norway** |
| 1530-1600 | Françoise Brochard-Wyart (Institute Curie, Paris, France)<br>*Mechanosensitivity and motility of cellular aggregates* |
| 1600-1630 | Ernesto Altshuler (Univ. Havana Cuba / CAS - Oslo, Norway):<br>*Flow-controlled densification of E. Coli through a microfluidic constriction* |
| **1630-1700** | **Coffee break** |
| 1700-1915 | **Evening session:**<br>**Chair: Antonio Figueiredo, USP - Sao Paulo, Brazil** |
| 1700-1730 | Mario Engelsberg (UFPE, Recife, Brazil)<br>*Dynamics of Surface Pattern Formation in a Gel* |
| 1730-1800 | Paul Dommersnes (Univ. Paris 7, France / CAS - Oslo, Norway):<br>*Electro-hydrodynamic and electro-rheological effects in clay-oil droplets* |
| 1800-1830 | Marcio Carvalho (Pontificia Universidade Catolica do Rio de Janeiro, Brazil)<br>*Delaying the onset of dynamic wetting failure through meniscus confinement* |
| 1830-1845 | Domingos Salazar (UEADTec, UFRPE, Recife, Brazil)<br>*Stochastic Dynamical Model of Intermittency I: Applications to Turbulence* |
| 1845-1900 | Henrik Mauroy (IFE, Kjeller, Norway)<br>*Synthesis and Characterization of Polystyrene-Clay Nanocomposites* |
| 1900-1915 | Irep Gözen (Univ. Chalmers, Gothenburg, Sweden)<br>*Calcium-Ion-Controlled Nanoparticle-Induced Tubulation In Supported Flat Phospholipid Vesicles* |
| **1915-2000** | **Discussions** |
| **2000-2100** | **Welcoming cocktail** |
| **2100 - ?** | **Discussions** |

# 1/2 Wednesday:

**0900-1030** **Morning session:**
**Chair: Mario Engelsberg, UFPE - Recife, Brazil**
0900-0930 Dan Rothman (MIT, Cambridge, MA, USA)
*Ramification of stream networks*
0930-1000 Hans Hermann (UFC, Fortaleza, Brazil)
*Fracturing Ranked Surfaces*
1000-1030 Arne Skjeltorp (IFE, Kjeller, Norway)
*Simple and complex micro- and nanoparticle pattern formation in fluids induced by external fields*

**1030-1215** **Poster session (including coffee break)**

**1215-1500** **Lunch and discussions**

**1500-1710**: **Afternoon session:**
**Chair: Roger Pynn, Univ. Indiana, USA**
1500-1530 Sergio Rezende (UFPE, Recife, Brazil)
*Dynamics and coherence of a microwave driven magnon condensate*
1530-1600 Wilson Grava (CENPES, Petrobras, Rio de Janeiro, Brazil)
*CO2 management on pre salt: Overview of main research topics*
1600-1615 Henrik Hemmen (NTNU, Trondheim, Norway)
*X-ray Studies of Carbon Dioxide Intercalation in Na-Fluorohectorite Clay at Near-Ambient Conditions*
1615-1630 Pawel Sobas (IFE, Kjeller, Norway)
*$CO_2$ and porous media - SANS*

**1630-1700** **Coffee break**

**1700-1915** **Roundtable discussions:**
**Chair: Jon Otto Fossum, NTNU-Trondheim/CAS-Oslo, Norway**
1700-1730 André Galembeck (CETENE/UFPE, Recife, Brazil)
*Technology transfer, insertion and diffusion: where are the opportunities?*

1730-1745 Sergio Rezende (UFPE, Recife, Brazil)
1745-1800 Wilson Grava (CENPES, Petrobras, Brazil)
1800-1815 Arne Skjeltorp (IFE, Kjeller, Norway)
1815-1830 Erling Fjær (SINTEF – Brasil, Rio de Janeiro, Brazil)
1830-1845 Dan Rothman (MIT, Cambridge, MA, USA)
1845-1915 Comments/Discussions

**1915-2000** **Discussions**

**2000-2200** **Dinner**

**2200 - ?** **Discussions**

# 2/2 Thursday:

**0900-1030** **Morning session 1:**
**Chair: Giovani Vasconcelos, UFPE, Recife, Brazil**
0900-0930: José Andrade Jr. (UFC, Fortaleza, Brazil)
*Flow and navigation in complex media*
0930-1000 Mark Mineev-Weinstein (NMC, Los Alamos, USA)
*New class of exact solutions and bubble selection in a Hele-Shaw cell*
1000-1030: Yves Meheust (Univ. Rennes 1, Geosciences, France)
*The viscous instability between two immiscible fluids in a disordered two-dimensional porous medium*

**1030-1100** **Coffee break**

**1100-1215** **Morning session 2:**
**Chair: Paul Dommersnes, Univ. Paris 7 France/ CAS – Oslo, Norway**
1100-1130 Fernando Oliveira (UnB, Brasilia, Brazil)
*Anomalous Diffusion and Relaxation Phenomena*
1130-1145 Nuno Araújo (IfB, ETH Zurich, Switzerland)
*How dense can one pack spheres of arbitrary size distribution?*
1145-1200 Pablo Damasceno (Univ. Michigan, USA)
*Self-Assembly of non-spherical colloids, a theoretical investigation*
1200-1215 Jon Alm Eriksen (Univ. Oslo, Norway)
A Numerical Approach to Stick-Slip dynamics in Granular Fluids

**1215-1600** **Lunch/excursions/discussions**

**1600-1800** **Afternoon session:**
**Chair: Ernesto Altshuler, Univ. Havana, Cuba**
1600-1630 J. Albino Aguiar (UFPE, Recife, Brazil)
*Non-conventional vortex configurations in a mesoscopic flat disc*
1630-1700 Jørn Inge Vestgården (Univ. Oslo, Norway)
*Dendritic flux avalanchs in superconducting films*
1700-1730 Adriaan Schakel (UFPE, Recife, Brazil)
*To see a World in a Strand of Polymer*
1730-1800 Wilson Ortiz (UFScar, São Carlos, Brazil)
*Threshold Critical Current Density to Trigger Flux Avalanches in Superconducting Thin Films*

**1830-1900**: **Poster session continued**

**1900-2000:** **Evening session:**
**Chair: Dan Rothman, MIT, USA**
1900-1930 Antonio M. Figueiredo Neto (USP, São Paulo, Brazil)
*Structural characterization of liquid crystalline cellulosic networks*
1930-2000 Roger Pynn (Univ. Indiana, USA)
*Probing Correlations in Colloidal Fluids Induced by Depletion Interactions*

**2000-2200** **Dinner**

2200 - ? Discussions

# 3/2 Friday:

**Optional excursion to DF-UFPE and CETENE in Recife.**

**Optional excursion to Recife/Olinda.**

## Poster presenters (26 posters):

Ernesto Altshuler (Univ. Havana, Cuba):
*Clay-based composites for drug delivery: preliminary studies*

Diego M. Campana (Universidad Nacional del Litoral, CONICET, Santa Fe, Argentina)
*Numerical Computations under Visco-Inertial Regime of The Dip Coating on Fibers*

Sérgio Campello (UFPE, Recife, Brazil)
*Oil Source Rock Microstructure by OCT*

Sérgio Campello (UFPE, Recife, Brazil)
*Morphology and dynamics of craterlike structures created by recoiling elongated particles*

R. Droppa Jr. / J. F. Q. Rey (UFABC, São Paulo, Brazil)
*The Multiuser Experimental Center at UFABC*

Miguel A. Durán (Instituto Federal do Sertão Pernambucano, Ouricuri, PE, Brazil)
*Fingering in a Hele-Shaw channel and tripolar Loewner evolutions*

Jon Alm Eriksen (Univ. Oslo, Norway)
*A Numerical Approach to Stick-Slip dynamics in Granular Fluids*

Daniel Espinosa (USP, São Paulo, Brazil)
*Absorptive and refractive optical nonlinearities in ferrofluid of magnetite nanoparticles*

Rogelma Ferreira (UFC, Fortaleza, Brazil)
*Analytical results for long time behavior in anomalous diffusion*

Jon Otto Fossum (NTNU, Trondheim, Norway, CAS – Oslo, Norway)
*Nanostructural Alterations and Rheology of Clay Dispersions in Response to Heating*

Irep Gözen (Univ. Chalmers, Gothenburg, Sweden)
*Calcium-Ion-Controlled Nanoparticle-Induced Tubulation in Supported Flat Phospholipid Vesicles*

Henrik Hemmen (NTNU, Trondheim, Norway)
X-ray Studies of Carbon Dioxide Intercalation in Na-Fluorohectorite Clay at Near-Ambient Conditions

Paulo N. Lisboa Filho (UNESP, Bauru, Brazil)
*Magnetic Structure of Spinel-Type* $NiMn_2O_4$ *Compound*

Henrik Mauroy (IFE, Kjeller, Norway)
*Synthesis and Characterization of Polystyrene-Clay Nanocomposites*

Yves Méheust (Univ. Rennes 1, Geosciences, France)
*The diffusion of vapor inside the mesoporosity of a dry clay*

Leander E. Michels (UnB, Brasilia, Brazil)
*Dynamics of humidity uptake by meso-, and nano-porous synthetic clay Lithium-Fluorhectorite*

Maycon Motta (UFScar, São Carlos, Brazil)
*Onset of flux avalanches in superconducting films triggered by ac magnetic fields*

Marcel N. Moura (UFPE, Recife, Brazil)
*Vortex motion around multiple obstacles*

Hygor Piaget (UFC, Fortaleza, Brazil)
*Emergence of conservatism as an efficient strategy for consensus*

Saulo D. S. Reis (UFC, Fortaleza, Brazil)
*Non-Local Product Rules for Percolation*

Domingos Salazar (UEADTec, UFRPE, Recife, Brazil)
*Stochastic Dynamical Model of Intermittency II: Applications to Financial Markets*

Marcus B. L. Santos (UnB, Brasilia, Brazil)
*Texture evolution of drying clay gel samples*

Antônio M. P. Silva (UFPE, Recife, Brazil)
*Efficient Algorithm for counting Loops in Loop Models*

Arne T. Skjeltorp (IFE, Kjeller, Norway)
*Complex Colloidal Flow*

Pawel A. Sobas (IFE, Kjeller, Norway)
*$CO_2$ and porous media - SANS*

Jørn Inge Vestgården (Univ. Oslo, Norway)
*Micro- and macro-avalanches in superconductors*

# Abstracts

# Talks and posters

Françoise Brochard-Wyart

**31/1 Tuesday: Afternoon session:**

**1530-1600**

## Mechanosensitivity and motility of cellular aggregates

Françoise Brochard-Wyart, Louise Bonnemay, Damien Cuvelier, Stéphane Douezan, Sylvie Dufour, Julien Dumond, David Gonzalez-Rodriguez, and Karine Guevorkian

Institute Curie, Paris, France

We describe the biomechanics of multicellular aggregates, a model system for tissues and tumors. We first characterize the tissue mechanical properties (surface tension, elasticity, viscosity) by a new pipette aspiration technique. The aggregate exhibits a viscoelastic response but, unlike an inert fluid, we observe aggregate reinforcement with pressure, which for a narrow range of pressures results in pulsed contractions or "shivering". We interpret this reinforcement as a mechanosensitive active response of the acto-myosin cortex. Such an active behavior has previously been found to cause tissue pulsation during dorsal closure of Drosophila embryo.

We then describe the spreading of aggregates on decorated glass substrates, varying both intercellular and substrate adhesion. We find both partial and complete wetting regimes. For the dynamics, we find a universal spreading law at short time, analogous to that of a viscoelastic drop. At long time, we observe, for strong substrate adhesion, a precursor film spreading around the aggregate. Depending on aggregate cohesion, this precursor film can be a dense cellular monolayer ("liquid state") or consist of individual cells escaping from the aggregate body ("gas state"). The transition from "liquid" to "gas state" appears also to be present in the progression of a tumor from noninvasive to metastatic, known as the epithelial-mesenchymal transition. Moreover, we describe the effect of the substrate rigidity on the phase diagram of wetting. Aggregates do not spread on soft gels. We will also describe the dewetting of a cellular cohesive monolayer on a soft substrate.

Finally, we characterize the cell-cell and cell-substrate adhesion energies by studying aggregate detachment. We investigate i) the detachment of a cellular aggregate from a fibronectin-decorated glass surface, and ii) the fracture between two partially fused aggregates. We interpret the results by an analogy with the tack of a polymer melt.


<u>Ernesto Altshuler</u>

**31/1 Tuesday: Afternoon session:**

**1600-1630**

## Flow-controlled densification of *E. Coli* through a microfluidic constriction

E. Altshuler[1,2,3] , G. Miño[1], C. P´erez-Penichet[2], L. del Río[2], A. Lindner[1], A. Rousselet[1], and E. Clément[1] ¤

[1]PMMH, UMR 7636 CNRS-ESPCI-Université Paris 6 and 7, 10, rue Vauquelin - 75231 Paris Cedex 5, France
[2]"Henri Poincaré" Group of Complex Systems and Superconductivity Laboratory, Physics Faculty-IMRE, University of Havana, 10400 Havana, Cuba
[3]Centre for Advanced Study, Norwegian Academy of Sciences and Letters, NO-0271, Oslo, Norway

Dispersion and migration under flow in tortuous and confined structures such as porous or fractured materials, is related to a large spectrum of practical interests. In such environments, the lack of basic knowledge on the microscopic mechanisms controlling the bacterial transport is still hampering the establishment of reliable models in the context, for example, of pollution and de-pollution of ground water supplies, bio corrosion or bio-contamination in relation with many medical applications.

The recent use of microfluidic tools has revolutionized the way the question of motility of microorganisms can be approached experimentally. The fabrication of microscopic scale channels of different forms is enabling observations of high spatial and temporal resolution and thus, many crucial hypotheses on transport properties can be directly tested. For bacteria fluids, such tools have recently been used to describe re-concentration due to wall shape, upstream trajectories in the presence of flow or chemotactic response in well controlled chemical gradients.

Here, we address the question of transport and dispersion of an *E. Coli* suspensions flowing though a microfluidic channel with a funnel-like constrictions in its center. We show that the flow induces a counter-intuitive symmetry breaking in the bacteria concentration which increases significantly past the funnel. This concentration enhancement persists over large distances from the funnel and its amplitude increases linearly with the flow rate and disappears at large flow values. We show that the effect is reversible when the flow direction is reversed. We explain qualitatively the effects by considering interactions between the swimming bacteria and the channel boundaries. We map our results onto a one dimensional convection/diffusion equation introducing a source/sink term representing a long range non-local effect due to the presence of the central constriction. Our experiments open the possibility to control the concentration of bacteria suspensions in microfluidic channels by simply tuning the flow intensity.

Mario Engelsberg

**31/1 Tuesday:Evening session:**

**1700-1730**

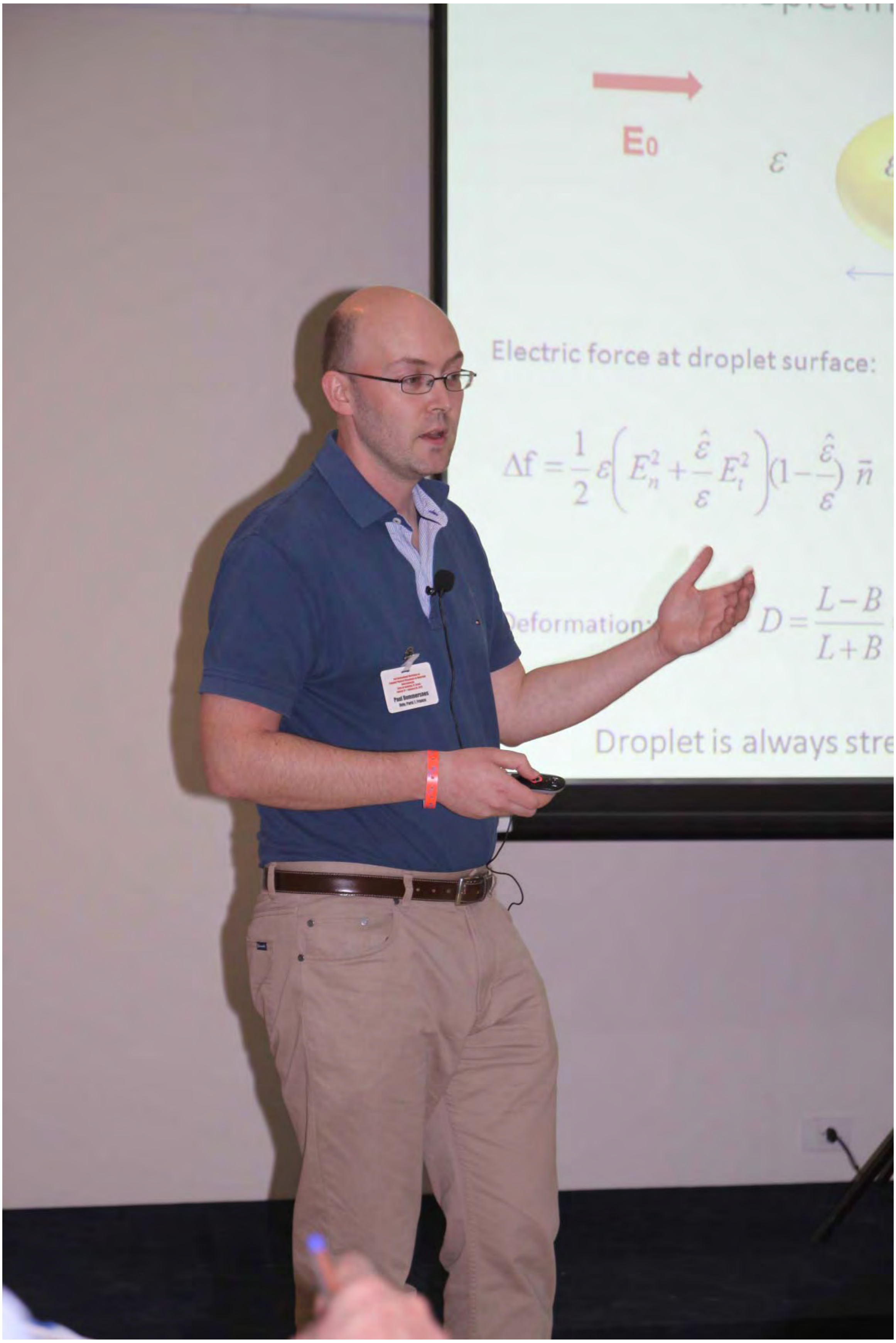
# Dynamics of Surface Pattern Formation in a Gel

Wilson Barros Jr[1]., Eduardo N. de Azevedo[2], M. Engelsberg[1]

1 Departamento de Física, Universidade Federal de Pernambuco, Recife, Pernambuco, Brazil.
2 Campus do Agreste, Universidade Federal de Pernambuco, Caruaru, Pernambuco, Brazil.

The folding structures which form on the surface of swelling gels have been known for many years [1] but have recently attracted considerable interest both theoretically and experimentally. Heterogeneous growth can cause spontaneous deformation leading to a characteristic buckling which is believed to be involved in a variety of phenomena with biological and technological significance [2,3]. Most of the experimental studies have tried to characterize the folding patterns from a morphological point of view using mostly macroscopic observations. We have studied the correlation between the dynamics of surface pattern formation and the mobility of water molecules in the bulk of a swelling gel using nuclear magnetic resonance imaging of water protons. $T_1$ - weighted images of anionic polyacrylamide spherical gels were most revealing. It was possible to obtain spin-lattice relaxation ($T_1$) maps and correlate them to a local, time-dependent swelling degree. The undulations of the folding patterns were found to persist for as long as gradients of local swelling existed and their average wave-length was found to be determined by such gradients.

[1] T. Tanaka *et al.*, Nature (London) **325**, 796 (1987).
[2] J. Dervaux *et al.*, Phys. Rev. Lett. **107,** 018103 (2011).
[3] Wei Hong *et al.*, Int. J. Solids Struct. **46**, 3282 (2009).




<u>Paul Dommersnes</u>

**31/1 Tuesday:Evening session:**

**1730-1800**

## Electro-hydrodynamic and electro-rheological effects in clay-oil droplets

Paul Dommersnes[1]*, Knut Kjerstad[2], Kjetil Hersvik[2], Alexander Mikkelsen[2], Rene Castberg[3], Zbigniew Rozynek[2], Jon Otto Fossum[1]*

[1] MSC - Univ. Paris 7, France
[2] Department of Physics, NTNU, Trondheim, Norwau
[3] Physics Department, University of Oslo, Norway
* Centre for Advanced Study, Norwegian Academy of Sciences and Letters, NO-0271, Oslo, Norway

Electric field manipulation of droplets has many applications, for example in emulsion technology and microfluidics. The response of an isolated droplet dispersed in another liquid depends both on the electric properties and viscosity of the two liquids. For perfect dielectrics the electric surface stress at the liquid interface results in prolate droplet deformation. In "leaky-dielectrics" the electric surface stress can induce hydrodynamic flow in and around the droplets, resulting in oblate droplets (G.I. Taylor 1964).

Here we present experiments on clay-oil droplets dispersed in another oil. The clay-oil droplet is an electro-rheological liquid where both electric properties and viscosity change dynamically in response to the applied electric field. The experimental observations are discussed within the framework of existing theories for electro-hydrodynamics and electro-rheology.


Marcio Carvalho

**31/1 Tuesday: Evening session:**

**1800-1830**

# Delaying the onset of dynamic wetting failure through meniscus confinement

Eric Vandre[2], Satish Kumar[2] and Marcio Carvalho[1]

[1] Department of Mechanical Engineering, Pontificia Universidade Catolica do Rio de Janeiro
[2] Department of Chemical Engineering and Materials Science, University of Minnesota

Dynamic wetting is crucial to processes where liquid displaces another fluid along a solid surface, such as the deposition of a coating liquid onto a moving substrate. Numerous studies report the failure of dynamic wetting past some critical process speed. However, the hydrodynamic factors that influence the transition to wetting failure remain poorly understood from an empirical and theoretical perspective. The objective of this investigation is to determine the effect of meniscus confinement on the onset of dynamic wetting failure.

A novel experimental system is designed to simultaneously view confined and unconfined wetting systems as they approach wetting failure. The experimental apparatus consists of a scraped steel roll that rotates into a bath of glycerol. Confinement is imposed via a gap formed between a coating die and the roll surface. Flow visualization is used to record the critical roll speed at which wetting failure occurs. Comparison of the confined and unconfined data shows a clear increase in the relative critical speed as the meniscus becomes more confined.

A hydrodynamic model for wetting failure is developed and analyzed with (i) lubrication theory and (ii) a two-dimensional finite element method. Both approaches do a remarkable job of matching the observed confinement trend, but only the two-dimensional model yields accurate estimates of the absolute values of the critical speeds due to the highly two-dimensional nature of the stress field in the displacing liquid. The overall success of the hydrodynamic model suggests a wetting failure mechanism primarily related to viscous bending of the meniscus.


<u>Domingos Salazar</u>

**31/1 Tuesday: Evening session:**

**1830-1845**

## Stochastic Dynamical Model of Intermittency I: Applications to Turbulence

Domingos Salazar (a), Giovani Vasconcelos (b)

(a) UEADTec, UFRPE, Recife, PE, Brazil.
(b) Departamento de Física, UFPE, Recife, PE, Brazil.

A stochastic dynamical model is proposed for intermittency in fully developed turbulence [1]. The model is based upon the phenomenological notion of the energy cascade in turbulence, whereby energy is injected at the integral scale by an externally driving mechanism, forming large coherent structures (eddies) that eventually break up into smaller eddies, which then split into even smaller eddies, and so on, all the way down to the dissipative scale, where energy is dissipated by viscous effects. In this way, energy is transferred essentially without dissipation along the cascade through a hierarchy of eddies of decreasing size.

The dynamics of the energy fluxes between successive scales in the energy cascade is described by a system of coupled stochastic differential equations that is derived from physically reasonable assumptions. Under the additional hypothesis that the characteristic time scales for the dynamics at the successive scales are well separated apart, it is possible to compute the probability density function (pdf) for the energy flux at a given step $N$ of the energy cascade as a multiple integral involving the energy fluxes at all scales above. It is shown that the Kolmogorov lognormal model of intermittency is obtained from our model in the limit of an infinite cascade. The probability distribution of velocity increments is also calculated explicitly and expressed in terms of generalized hypergeometric functions of the type ${}_NF_0$. Such distributions are a natural extension of the Gaussian and the so-called q-Gaussian distributions, corresponding to ${}_0F_0$ and ${}_1F_0$, respectively, and represent (for $N > 0$) a large class of probability distributions with power-law tails and finite variance.

The model predictions are found to be in excellent agreement with experiments on both Eulerian and Lagrangean turbulence. The model is also applied to describe fluctuations in financial asset prices, where our intermittency model is reformulated as a multi-scale stochastic volatility model.

[1] Domingos S. P. Salazar, Giovani L. Vasconcelos, Phys. Rev. E 82, 047301 (2010).


Henrik Mauroy

**31/1 Tuesday: Evening session:**

**1845-1900**

# SYNTHESIS AND CHARACTERIZATION OF POLYSTYRENE-CLAY NANOCOMPOSITES

H. Mauroy[1], K.D. Knudsen[1], G. Helgesen[1], J.O. Fossum[2] and Z. Rozynek[2]

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Recent progress in polymer science has demonstrated that remarkable changes in material properties are achievable by combining polymer systems with miniature particles, where at least one of the particle dimensions is in the nanosize range. Even minute quantities (sometimes less than 1 %) can drastically modify the overall system behavior if the surface of the incorporated particles has been made to interact sufficiently with the polymer chains. Fu et al [1] dispersed organically modified montmorillonite clay into polystyrene (PS), and increased the dynamic modulus of the nanocomposite by over 60 %, with only 8 wt-% filler material. We recently started to build upon Fu et al's work on PS-clay systems, by incorporating other types of smectic clays, such as Laponite and Fluorohectorite, and also manipulating the orientation and super structure of the clay particles with electric fields. The presentation will give a brief summary of the synthesis and characterization of such composites.

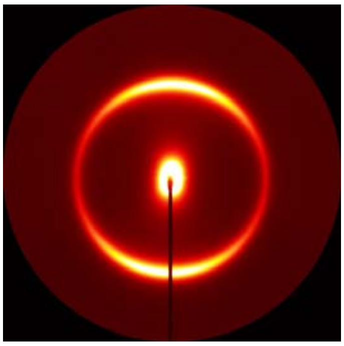

Figure 1: SAXS scattering pattern of PS-fluorohectorite composite.

[1] X. Fu and S. Qutubuddin, Materials Letters 42 (2000) 12.


Irep Gözen

**31/1 Tuesday:Evening session:**

**1900-1915**

# CALCIUM-ION-CONTROLLED NANOPARTICLE-INDUCED TUBULATION IN SUPPORTED FLAT PHOSPHOLIPID VESICLES

Irep Gözen[a], Celine Billerit [a], Paul Dommersnes[ab], Aldo Jesorka[a] and Owe Orwar[a]

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[b]Matieres et Systemes Complexes,Universite Paris Diderot, Paris, 75013, France

Biological nanotubes (e.g. tunneling nanotubes) accomplish important functions within the cell, for instance by supplying cell components, transducing signals and transporting virus particles and bacteria. Many functions are still not well understood, which has placed these nanostructures in the focus of recent investigation. We created an experimental model system, featuring lipid nanotube formation in nanoparticle-containing, supported flat giant unilamellar vesicles (FGUVs). Our model represents several theoretical and practical aspects of reported tubulation phenomena in biological or biomimetic systems: The encapsulation of nanoparticles in FGUVs with low concentrations (1–4 mM) of $Ca^{2+}$ in the ambient buffer solution caused transient lipid nanotube formation. Tubes extended from the FGUV up to a length of several hundred micrometers and exhibited, in some instances, vesicle compartmentalization.

Daniel H. Rothman

**1/2 Wednesday: Morning session:**

**0900-0930**

## Ramification of stream networks

Olivier Devauchelle, Alexander P. Petroff, Hansjörg Seybold, and
Daniel H. Rothman

Lorenz Center and Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139, USA

Flows shape landscapes and landscapes shape flows. In time, streams form, channelize, and organize into highly ramified networks. The geometric complexity of such networks has been a source of fascination for centuries. Yet a comprehensive understanding of ramification↓the mechanism of branching by which these networks grow↓remains elusive. Progress requires quantitative theory and comparison with unambiguous observations.

Here we show that streams incised by groundwater seepage branch at a characteristic angle of $2\pi/5=72°$. Our theory represents streams as a collection of paths growing and bifurcating in a Laplacian field. Our observations of several hundred bifurcated streams growing in a 100-$km^2$ groundwater field yield a mean bifurcation angle of 72.2° ± 1.5°.

This good accord between theory and observation suggests that network geometry is determined by the external flow field rather than flow within the streams themselves.

Hans Herrmann

**1/2 Wednesday: Morning session:**

**0930-1000**

## Fracturing Ranked Surfaces

Hans Herrmann

Departamento de Física, Universidade Federal do Ceará, Fortaleza, CE, Brazil.

When the sites of a lattice get a random ranking the number of possible configurations does grow faster than exponentially with the system size. This describes the limit of infinite disorder for a number of models including optimal paths and fuse networks. Interestingly the resulting critical behavior is the same as that of the watershed of random landscapes and that of the cuttings bonds of percolation in the limit of p –> 0 or of the bridges in the limit p –> 1.

At the percolation threshold $p_c$ tricritical behavior is obtained. Other realizations within the same universality class are the surfaces of various explosive percolation clusters at the transition point, including the Gaussian model and the largest cluster model.

In dimensions above two and below the upper critical dimension six two different universality classes can be identified.

<u>Arne T. Skjeltorp</u>

**1/2 Wednesday: Morning session:**

**1000-1030**

# Simple and complex micro- and nanoparticle pattern formation in fluids induced by external fields

Arne T. Skjeltorp[1,2], Geir Helgesen[1,2], Matti Knaapila[1], Henrik Høyer[1], Jozef Cernak[3]

[1]Institute for Energy Technology, Kjeller, Norway

[2]Department of Physics, University of Oslo, Norway

[3]P.J. Safaric University, Kosice, Slovak Republic

Magnetic and electric fields can be used to create microparticle structures within fluids such as water, oil, ferrofluids or polymers. The particle pattern formations in the fluids are highly dependent on the time and space variations of the external fields.

A review will be given of the dynamics of such pattern formation for various types of particles, such as colloidal microspheres and carbon nanoparticles.


Sergio M. Rezende

**1/2 Wednesday: Afternoon session:**

**1500-1530**

# Dynamics and coherence of a microwave driven magnon condensate

Sergio M. Rezende

Departamento de Física, Universidade Federal de Pernambuco, Recife, PE, 50670-901, Brazil

Clear evidences of room-temperature Bose-Einstein condensation (BEC) of magnons in films of yttrium iron garnet films under microwave driving have been reported in recent years.

We have developed a microscopic theoretical model for the interacting magnon gas driven out of equilibrium that provides rigorous support for the formation of the BEC. The theory relies on the cooperative mechanisms created by the nonlinear magnetic interactions and explains the spontaneous generation of quantum coherence and magnetic dynamic order when the microwave driving power exceeds a critical value.

The results fit very well the experimental data for the intensity and decay rate of the Brillouin light scattering and for the microwave emission from the BEC as a function of driving power.

<u>Wilson Mantovani Grava</u>

**1/2 Wednesday: Afternoon session:**

**1530-1600**

## CO2 management on pre salt: Overview of main research topics

Wilson Mantovani Grava

PETROBRAS/CENPES, Rio de Janeiro, Brazil

Brazilian oil and gas production had mainly been focused in offshore activities since the 70s, with major contribution from Campos basin deep water fields development. To achieve the actual production of around 2 million barrels per day of oil, Petrobras—as the brazilian major oil company—had always been committed to overcome technical challenges through the work of its research and development center: CENPES.

More recently, the new production frontier known as pre-salt increased the dimension of challenges by pushing the production into even deeper waters, deeper reservoirs and presence of CO2.

Therefore, the objective of the presentation is to show some of those new challenges, focusing into CO2 related issues, and picture how CENPES is structured with the R&D community (universities and research centers) to move forward pre-salt production in the upcoming years.


<u>Henrik Hemmen</u>

**1/2 Wednesday: Afternoon session:**

**1600-1615**

# X-ray Studies of Carbon Dioxide Intercalation in Na-Fluorohectorite Clay at Near-Ambient Conditions

Henrik Hemmen,*[,†] Erlend G. Rolseth,[†] Davi M. Fonseca,[†,‖] Elisabeth L. Hansen,[†] Jon Otto Fossum,*[,†,‡] and Tomás S. Plivelic.[§]

[†]Department of Physics, Norwegian University of Science and Technology, Trondheim, Norway. [‡]Centre for Advanced Study (CAS) at the Norwegian Academy of Science and Letters, Oslo, Norway. [§]MAX IV Laboratory , Lund University, Lund, Sweden. [‖]Department of Cancer Research and Molecular Medicine, Norwegian University of Science and Technology, Trondheim, Norway

Due to current awareness of global warming and the challenges related to carbon capture and sequestration, the interactions between clays and $CO_2$ are attracting attention in the scientific community. A recent molecular dynamics study by Cygan et al.[1] shows the possibility of intercalation and retention of $CO_2$ in smectites at 37 $^oC$ and 200 bar. This has led the authors to suggest that clay minerals may prove suitable for carbon capture and carbon dioxide sequestration.
In this work [2] we add to the so far scarce experimental results in this field, by showing from x-ray diffraction measurements that gaseous $CO_2$ intercalates into the interlayer space of the synthetic smectite clay Na-fluorohectorite at conditions close to ambient. The mean interlayer repetition distance of the clay when $CO_2$ is intercalated is found to be 12.5 Å for the condition -20 °C and 15 bar. The magnitude of the expansion of the interlayer upon intercalation is indistinguishable from that observed in the dehydrated-monohydrated transition for $H_2O$, but the possibility of water intercalation is ruled out by also exposing the clay to nitrogen gas. The dynamics of the process is observed to be dependent on the pressure, with a higher intercalation rate at increased pressure. The rate of $CO_2$ intercalation at the studied conditions is found to be several orders of magnitude slower than the intercalation rate of water or humidity at ambient pressure and temperature.
The conditions studied are different from most of the simulations in the literature related to geological storage, but demonstrating intercalation at less extreme conditions could prove very useful in understanding the processes involved. By avoiding extreme conditions, experimental verification of theory and simulations should become much easier, and the low pressures involved here enable the use of Kapton windows on the sample cell, thus allowing investigations with laboratory x-ray equipment instead of synchrotron sources. The observation of the slow dynamics of intercalation should be considered when doing surface area measurements on clays, as the vapor uptake into the interlayers could continue for days if the conditions favor intercalation

[1] Cygan, R. T.; Romanov, V. N.; Myshakin, E. M. *Natural materials for carbon capture*; Techincal report SAND2010-7217; Sandia National Laboratories: Albuquerque, New Mexico, November, 2010.
[2] Hemmen, H.; Rolseth, E. G.; Fonseca, D. M.; Hansen, E. L.; Fossum, J. O.; Plivelic, T. S. *Langmuir, DOI: 10.1021/la204164q* 2012.

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<u>Pawel A. Sobas</u>

**1/2 Wednesday: Afternoon session:**

**1615-1630**

# $CO_2$ and porous media - SANS

Pawel A. Sobas[1], Kenneth D. Knudsen[1], Geir Helgesen[1], Arne Skjeltorp[1], Jon Otto Fossum[2*]

[1] Physics Department, Institute for Energy Technology, 2027 Kjeller, Norway.
[2] Department of Physics, Norwegian University of Science and Technology, Trondheim, Norway.
* Centre for Advanced Study (CAS) at the Norwegian Academy of Science and Letters, Oslo, Norway.

We are presently involved in research activities focusing on physical processes that are important for the understanding of $CO_2$ transport and storage into the ground. The relevant geological structures may show large variations in composition (water saturated porous materials, such as sandstone in a sedimentary basin, caprock, clays). $CO_2$ trapped in such porous materials relies on different mechanisms of confinement that act on different time scales. Some important factors to consider are: 1) an impermeable caprock that keeps the fluid underground (supercritical $CO_2$ fluid), 2) the solubility of the $CO_2$ in the water, 3) intercalation (absorption) into clay nanopores, 4) chemical reactions that bind the carbon in mineral form to the rock.

Small Angle Neutron Scattering (SANS) is a technique highly valuable for studying nanostructures (1-100nm), such as clays nanoparticl*es*, and this technique is available at Institute for Energy Technology (IFE). For the investigations on CO2 and porous materials we will make use of a specially designed cell to be used in combination with SANS. The cell allows studying nanoporous materials together with $CO_2$ in the supercritical state, up to 150°C and $CO_2$ pressure up to 410 bars. A specially adapted setup has now been made in order to integrate this $CO_2$ cell into the SANS apparatus. In addition, the instrument has been upgraded by the implementation of a new element - a so-called bender. This is designed to deflect neutrons with wavelengths above 4.5 Å by a certain amount (4°), thus removing fast neutrons and gamma radiation, in order to improve the quality of the neutron beam.

André Galembeck

**1/2 Wednesday: Roundtable discussions**

**1700-1730**

# Technology transfer, insertion and diffusion: where are the opportunities?

André Galembeck

CETENE – Centro de Tecnologias Estratégicas do Nordeste, UFPE – Universidade Federal de Pernambuco

The translation of academic research to industrial applications follows the process known as technology transfer, in which existing knowledge, facilities or capabilities are utilized and marketed to fulfill public and private needs. The complete picture has three mainstreams: (i) science and technology; (ii) marketing and, (iii) financing. The whole process has a timeline that is strongly related to the technology(ies) involved and geographic and cultural issues are still essential even in a globalized world.

Each of the above components require the inputs of different organizations in a market, bringing to the process different resources and skills that will eventually lead to the success of the technology and product being developed [1].

Scientists lie at the basis, providing the fundamental knowledge. Sometimes they give the seed ideas and they are, indeed, essential to prove the technological feasibility that comes with concept proofs. Innovation, however, is very broad term from economics rather than from science and does not necessarily involves inventions.

In Brazil, things changed a lot in the last decade. Important regulatory landmarks such as the "Lei da Inovação", (intellectual property, 2004), the "Lei de Biossegurança" (biosafety, 2005) and the "Lei do Bem" (R&D investment by corporations, 2005/07) are recent and funding for applied research is increasing. Since 2009, over than fifty thousand students concluded graduate courses each year and the scientific production growth rate is three times bigger than the global average [2]. Brazil is, currently, the 13$^{th}$ in scientific production (ISI) but only the 47$^{th}$ in the Global Innovation Ranking. There is a strong correlation between a country development and it's strength in science, technology and, innovation and no developed tropical country. If Brazil wants to be the first one, we have to find our way while the whole world is experiencing important changes and it is our task to find the opportunities.

Translating academic, cutting-edge, research into industrial applications takes time and many people with different skills are needed. To apply more settled, but specialized, knowledge to impair competitive advantages to our industry should be considered as a real alternative to speed up our development and can effectively work if the academy-industry relationship can be established as a win-win situation.

[1] http://www.gdrc.org/techtran/tt-process.html, accessed in Dec, 2011.
[2] www.mct.gov.br, accessed in Dec, 2011.

Jose S. Andrade Jr.

**2/2 Thursday: Morning session 1:**

**0900-0930**

# Flow and Navigation in Complex Media

José S. Andrade Jr.
*Departamento de Física, Universidade Federal do Ceará, 60451-970 Fortaleza, Ceará, Brazil*

In the first part of this talk, we will present our recent study on the flow of non-Newtonian fluids through three-dimensional disordered porous media by direct numerical simulation of momentum transport and continuity equations. Our results for power-law fluids indicate that the flow, when quantified in terms of a properly modified permeability-like index and Reynolds number, can be successfully described by a single (universal) curve over a broad range of Reynolds conditions and power-law exponents. In the case of Bingham fluids described in terms of the Herschel-Bulkley model, our simulations reveal that the interplay of (i) the disordered geometry of the pore space, (ii) the fluid rheological properties, and (iii) the inertial effects on the flow is responsible for a substantial enhancement of the macroscopic hydraulic conductance of the system at intermediate Reynolds conditions. In the second part of the talk, we will present results on the navigation problem in lattices with long-range connections and subject to a cost constraint. Our network is built from a regular two-dimensional ($d = 2$) square lattice to be improved by adding long-range connections (shortcuts) with probability $P_{ij} \sim r_{ij}^{-\alpha}$ where $r_{ij}$ is the Manhattan distance between sites $i$ and $j$, and $\alpha$ is a variable exponent. We introduce a cost constraint on the total length of the additional links and find optimal transport in the system for $\alpha = d + 1$ established here for $d = 1$ and $d = 2$. Remarkably, this condition remains optimal, regardless of the strategy used for navigation, being based on local or global knowledge of the network structure, in sharp contrast with the results obtained for unconstrained navigation using global or local information, where the optimal conditions are $\alpha = 0$ and $\alpha = d$, respectively. The validity of our results is supported by data on the U.S. airport network.

Mark Mineev-Weinstein

**2/2 Thursday: Morning session 1:**

**0930-1000**

## New class of exact solutions and bubble selection in a Hele-Shaw cell

Mark Mineev-Weinstein

NMC, Los Alamos, USA and MPIPKS, Dresden, Germany

Pattern formation selection problems (far from equilibrium) was a long-standing challenge for theoretical physics since 1950s, when pioneering experiments of Sir G.I. Taylor were conducted. The main problem was the absence of conventional mathematical tools to describe dynamics in unstable condensed media. Still, in 1980s the significant efforts of several theoretical groups produced results on the pattern selection via the surface tension by using the so-called "Asymptotic beyond all orders" (M. Kruskal and H. Segur, 1983), which is based on a subtle quasiclassical technique, developed in 1960s by Pokrovsky and Khalatnikov for an electron reflection above a potential barrier.

In this talk I will report new class of solutions recently obtained with G.L. Vasconcelos (UFPE, Brazil) in a problem of a velocity and shape selection of Taylor-Saffman bubble from a continuous family of admissible solutions without using surface tension. The results are in a full agreement with experiments. This results were possible to obtain due to a remarkable and powerful integrable structure of the non-linear interface dynamics equations, which we (and others) have developed earlier.

The presentation will be free of unnecessary technical details and will contain various pattern illustrations related to the reported results.

<u>Yves Méheust</u>

**2/2 Thursday: Morning session 1:**

**1000-1030:**

# The viscous instability between two immiscible fluids in a disordered two-dimensional porous medium

Yves Méheust[1], Grunde Løvoll[2], Renaud Toussaint[3], Knut Jørgen Måløy[2], Jean Schmittbuhl[3]

(1) Université Rennes 1, Geosciences Rennes (UMR CNRS 6118), Rennes, France
(2) Department of Physics, UiO, Oslo, Norway
(3) Institut de Physique du Globe (IPGS), CNRS and University of Strasbourg (EOST), Strasbourg, France

In a now famous article, P. G. Saffman and G. Taylor (1958) studied the stability of the interface between two immiscible fluids when one of them is displacing the other one in a Hele-Shaw cell. Depending on the density- or viscosity- contrast between the two fluids and the direction of the flow, fingering of the displacing fluid into the defending fluid can develop at the interface. Surface tension then acts as a mechanism of selection for unstable wavelengths. On the contrary, when the cell is occupied by a two-dimensional disordered porous medium, capillary forces drive the interface displacement at the pore scale, by selection of areas that least resist the interface displacement. The observed displacement structures are then much rougher and complex topologically, and exhibit some type of scale invariance.

We address the case of drainage when a liquid is displaced by a gas, using experiments in which the porous medium consists of a single layer of glass beads. Quasi-static displacements give rise to capillary fingering, which is well modeled by invasion percolation. Displacements that are sufficiently fast lead to the development of a branched displacement structure that is typical of viscous fingering, to which diffusion limited aggregation (DLA) has long been considered equivalent. If gravity can act against the instability, the latter only occurs above a velocity threshold that corresponds to the onset of instability as found by Saffman and Taylor. Yet the two fingering growth processes are not necessarily equivalent.

Considering occupation density maps of the medium by the displacing fluid, comparing the pressures measured in the experiments and the pressure field around a Saffman-Taylor finger and measuring also the branching angles in the experiments, we show that Saffman-Taylor fingering and the viscous fingering inside a disordered two-dimensional porous medium belong to two different universality classes for growth processes: the former is laplacian growth, while the latter corresponds to a dielectric breakdown model (DBM) of exponent 2. We also address the upscaling of these displacement structures: whatever the imposed mean displacement velocity, viscous fingering is always observed provided that sufficiently large scales be investigated.

<u>Fernando A. Oliveira</u>

**2/2 Thursday: Morning session 2:**

**1100-1130:**

## Anomalous Diffusion and Relaxation Phenomena

Fernando A. Oliveira

Instituto de Física and International Center for Condensed Matter Physics, Universidade de Braslia; faooliveira@gmail.com

A recent paper [1] has called attention to the fact that irreversibility is a broader concept than ergodicity, and that therefore the Khinchin theorem (KT) may fail in some systems. In this work [2], we have shown that the KT (proved by Khinchin for normal diffusion) holds for all kinds of diffusive processes, which are ergodic in the range of diffusive exponents $0 < \alpha < 2$ [2,3]. This result may have deep consequences in many areas. Moreover, it could be verified and applied to experimental systems, such as the electron subdiffusive dynamics within a single protein molecule, which has recently been modelled by a Generalized Langevin Equation (GLE). Such a model successfully explains the equilibrium fluctuations and its broad range of time scales, being in excellent agreement with experiments. The KT gives the Ergodic Hypothesis a practical character, since it is expressed in terms of response functions: our results apply for real-valued relaxation functions $R(t)$; on the other hand, if the relaxation function assumes complex values, e.g. conductivity, the KT may fails, as proposed in Ref. [1].
In principle, it is generally possible to investigate relaxation phenomena for Non-Markovian systems by eliminating variables, whose effects are incorporated in the memory kernel and in the colored noise. Altogether, some results obtained for the GLE formalism should be valid for diffusion described by fractional Fokker-Planck equations, since both formalisms yield similar results. The violation of ergodicity may leed to the lack of a detailed balance relation wich may require a specific analysis of each case [2,4], as well pattern formation in bacterial diffusion follows similar ideas[5]. Further research in this direction is needed and will open new perspectives.

[1] M. H. Lee, Phys. Rev. Lett. **98, 190601 (2007).**

**[2] L. C. Lapas, R. Morgado, M. H. Vaintein, J. M. Rubí, and F. A. Oliveira, Phys. Rev. Lett. 101, 230602 (2008).**

**[3] R. Morgado, F. A. Oliveira, G. G. Batrouni, and A. Hansen, Phys. Rev. Lett. 89, 100601 (2002).**

**[4]L. C. Lapas, I. V. L. Costa, M. H. Vainstein, and F. A. Oliveira, Europhysics Lett. 77, 37004 (2007).**

**[5] J. A. R. da Cunha, A. L. A. Penna, and F. A. Oliveira, Phys. Rev. E 83, R015201 (2011).**

Nuno A. M. Araújo

**2/2 Thursday: Morning session 2:**

**1130-1145**

## How dense can one pack spheres of arbitrary size distribution?

Saulo D. S. Reis (1), Nuno A. M. Araújo (2), José S. Andrade jr. (1, 2), and Hans J. Herrmann (1, 2)

(1) Departamento de Física, Universidade Federal do Ceará, Brasil
(2) Computational Physics for Engineering Materials, IfB, ETH Zurich, Switzerland

We present the first systematic algorithm to estimate the maximum packing density of spheres when the grain sizes are drawn from an arbitrary size distribution. With an Apollonian filling rule, we implement our technique for disks in 2d and spheres in 3d. As expected, the densest packing is achieved with power-law size distributions. We also test the method on homogeneous and on empirical real distributions, and we propose a scheme to obtain experimentally accessible distributions of grain sizes with low porosity. Our method should be helpful in the development of ultra-strong ceramics and high performance concrete.

[1] S. D. S. Reis, N. A. M. Araújo, J. S. Andrade jr., and H. J. Herrmann. Accepted for publication in EPL. Preprint: arxiv:1109.0966

Pablo F. Damasceno

**2/2 Thursday: Morning session 2:**

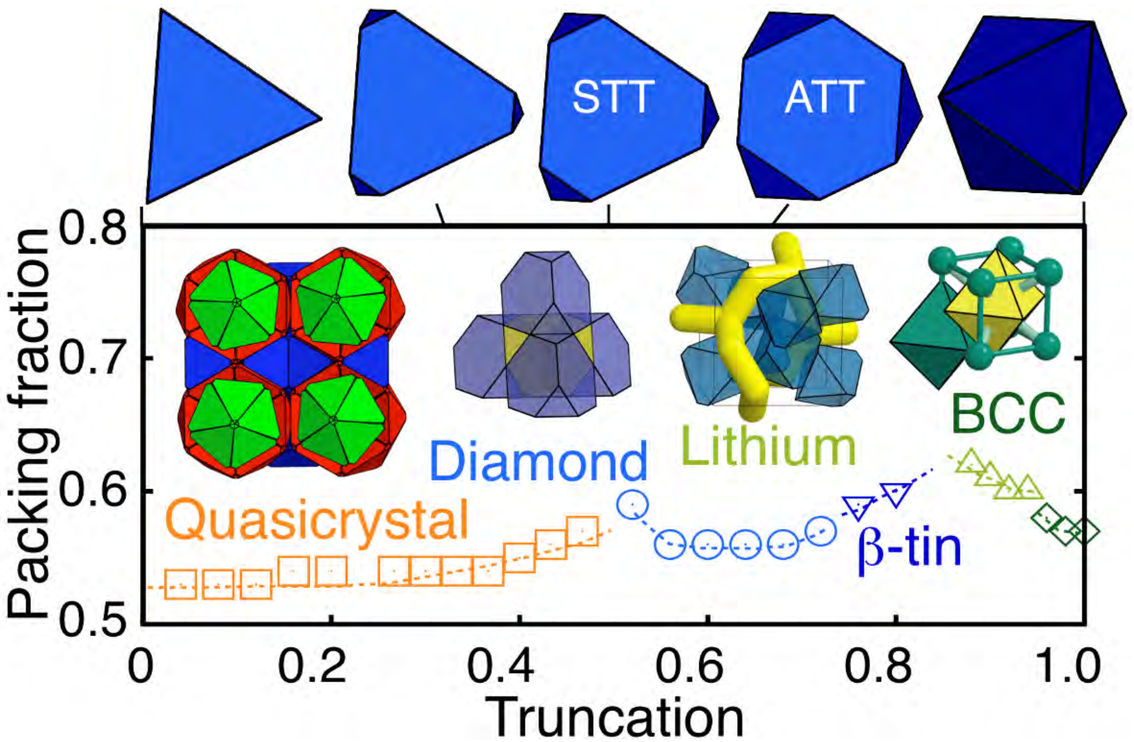
**1145-1200**

## Self-Assembly of non-spherical colloids, a theoretical investigation

Damasceno, PF; Engel, M; Glotzer, SC;

University of Michigan - USA

Entropic forces are effective forces that result from a system's statistical tendency to increase its entropy. Hard rods and disks spontaneously align and can assemble into layers and columns if those structures increase the configurational space available to the particles. Hard spheres, cubes and even tetrahedra order for the same reason. Here we extend those findings by showing that hard polyhedra can self-assemble into a variety of complex phases, most of them never before reported in systems of single-component hard particles. The role of shape and directional entropic forces in stabilizing these structures will be discussed. Our results suggest new possibilities for self-assembling complex target structures from colloidal building blocks.




**References:**
Damasceno, PF; Engel, M; Glotzer, SC; Crystalline Assemblies and Densest Packings of a Family of Truncated Tetrahedra and the Role of Directional Entropic Forces; ACS Nano (2011). **DOI:** 10.1021/nn204012y.

Jon Alm Eriksen

**2/2 Thursday: Morning session 2:**

**1200-1215**

# A Numerical Approach to Stick-Slip dynamics in Granular Fluids

Jon Alm Eriksen (1), Eirik Grude Flekkøy (1), Knut Jørgen Måløy (1) and Bjørnar Sandnes (2)

1) Department of Physics, University of Oslo
2) Department of Physics, NTNU, Trondheim

Pattern formation in granular materials is a curious result of the dissipative interactions between grains. A recent study by B. Sandes [1] points to an extraordinary diversity in the dynamics of the flow of wet granular materials displaced by air in a Hele-Shaw cell. By varying the air injection rate and the granular filling fraction several distinct morphologies were observed, and the study mapped out a tentative dynamical phase diagram.

We investigate a transition in that phase diagram, from frictional fingering to Stick-slip bubbles. By integrating the surface tension, pressure and frictional forces, we trace the displacement of the interface, and reproduce the experimentally observed patterns. The numerical scheme offers a method to study the transition in detail, complimentary to the experimental observations. The simulation use a dynamical version of a quasi static algorithm developed by H.A. Knudsen and others [2], developed to simulate labyrinth patterns in granular fluids.

[1] B. Sandnes, E.G. Flekkøy, H.A. Knudsen, K.J. Måløy and H. See Patterns and flow in frictional fluids. Nat. Commun. 2 : 288 doi: 10.1038/ncomms1289 (2011).

[2] H.A. Knudsen, B. Sandnes, E.G. Flekkøy and K.J. Måløy. Granular labyrinth structures in confined geometries. Phys. Rev. E. 77, 021301. doi:10.1103/PhysRevE.77.021301 (2008)

J. Albino Aguiar

**2/2 Thursday: Afternoon session:**

**1600-1630**

# Non-conventional vortex configurations in a mesoscopic flat disk*

J. Albino Aguiar

Departamento de Física, Universidade Federal de Pernambuco, 50670-901, Recife-PE, Brazil

Vortex configuration in mesoscopic superconducting samples has been the focus of many experimental and theoretical studies. As is well known a potential barrier appears on the surface of type-II superconductors which prevents vortices both from leaving the sample once is inside and entering the sample if it is about to nucleate. For finite samples the vortices are formed at the surface and then pulled to the sample center by the Meissner shielding currents. Near to the sample edge, a vortex is strongly attracted by the interface due to the interaction with its anti-vortex image virtually placed outside the sample. These competing interactions give rise to an energy barrier, the so-called Bean-Livingston surface barrier. Nevertheless, surface roughness or defects in the interface may cause the local destruction of the surface barrier when a vortex enters a superconductor. For instance, it was show that, in mesoscopics disk, vortices are, in general, size dependent. Thus, finite size effects in conjunction with shape effects can determine vortex configurations in mesoscopic superconductors. In this work we investigate how the number and position of defects into the sample affects the vortex properties. To do this we use the link variable method and implemented an algorithm to solve the time dependent Ginzburg-Landau equation in a thin superconductor mesoscopic disk.

We calculate and compare quantities such as the free energy, the magnetization, vorticity and the Cooper pair density for a thin superconducting disk with radius R = 6.5 and with 1 to 5 small metallic defects on its surface in the presence of an perpendicular applied external magnetic field. We show that there one can find some non-conventional vortex configurations which are not are compatible with the sample geometry.

*In collaboration with J. Barba-Ortega and Edson Sardella.
Work financed by the Brazilian agencies, CAPES, CNPq and FACEPE (APQ-0589-1.05/08).

Jørn Inge Vestgården

**2/2 Thursday: Afternoon session:**

**1630-1700**

# Dendritic flux avalanchs in superconducting films

Jørn Inge Vestgården, Daniil Shantsev, Yuri Galperin, Tom Henning Johansen

Department of Physics, University of Oslo, Norway

In type II superconducting films magnetic field enters in form of vortices, each carrying exactly one quantum of magnetic flux, h/2e. When external magnetic field is increased transverse to the film, the vortices penetrate gradually from the edges and form a well-defined critical state region, where the force on the vortices from the electrical current is exactly balanced by the pinning by microscopic material defects.

However, such gradual flux penetration is occasionally interrupted when large amounts of magnetic flux suddenly burst in from the edges and "floods" the previously flux-free region inside the sample, forming large, complex, branching structures. These are dendritic flux avalanches. In the talk, I will explain the mechanism behind the flux avalanches and how the full dynamical process can be accurately simulated by a continuum formalism based on nonlinear, classical electrodynamics and a heat propagation equation. I will show that the large spectrum of different avalanches morphologies---ranging from thin fingers to highly branched structures---observed experimentally, e.g., by magneto-optical imaging, can be found by tuning the simulation parameters.

I will further show that material disorder contributes strongly to the formation of the dendritic structures, and makes sure that the flux patterns are irreproducible. The disorder is on the other hand not the main mechanism behind the branching. Finally, I will discuss the development of avalanches and the branching process.

<u>Adriaan M. J. Schakel</u>

**2/2 Thursday: Afternoon session:**

**1700-1730**

# To see a World in a Strand of Polymer

Adriaan M. J. Schakel

Departamento de Física, Universidade Federal de Pernambuco, Recife, PE, Brazil.

Two pillars of the theory of soft matter, viz. percolation theory and the theory of self-avoiding random walks, are argued to provide an alternative to the standard field-theoretic description of the O(N) spin and related models. An entirely geometric characterization of the phase transitions which these models undergo is shown to emerge. Upon combining with the Prokofiev-Svistunov worm algorithm, this geometric approach is argued to result in a powerful and efficient Monte Carlo paradigm.

Wilson A. Ortiz

**2/2 Thursday: Afternoon session:**

**1730-1800**

# Threshold Critical Current Density To Trigger Flux Avalanches In Superconducting Thin Films

W.A. Ortiz

Departamento de Física, Universidade Federal de São Carlos
São Carlos, SP, Brazil

Under certain conditions of temperature and magnetic field, sudden flux bursts (avalanches) develop into superconducting films, as a consequence of thermomagnetic instabilities, which occur when heat dispersion is slower than magnetic diffusion. Based on a systematic study of the magnetic response (including magneto-optical imaging) of two Nb films - one plain and the other decorated with a square array of square antidots - we have found the existence of a threshold critical current density above which vortex avalanches are triggered.

The experimental results reveal that this threshold value is nearly constant within the whole range of temperatures and magnetic fields investigated. The fact that an avalanche is triggered once the critical current reaches the threshold is in close correspondence with the behavior of granular material in sandpiles, which slides down whenever the slope exceeds the threshold repose angle.

Our results are in perfect agreement with the predictions of a model for thermomagnetic instabilities in superconducting films, published previously by Yurchenko and coworkers [PRB 76, 092504 (2007)].

<u>Antonio M. Figueiredo Neto</u>

**2/2 Thursday: Evening session:**

**1900-1930**

## Structural characterization of liquid crystalline cellulosic networks

A.M. Figueiredo Neto[1], C. Sena[1], M.H. Godinho[2], and C.L.P. Oliveira[1]

[1] Instituto de Física, Universidade de São Paulo, caixa postal 66318, 05314-970, São Paulo, São Paulo, Brazil
[2] Faculdade de Ciências e Tecnologia e CENIMAT/I3N, Universidade Nova de Lisboa, Quinta da Torre, P-2829-519 Caparica, Portugal

Cellulose and their derivatives attract the attention of researchers due to their outstanding physical-chemical properties. Cellulose derivatives lightly cross linked can form lyotropic and thermotropic cholesteric phases. Godinho and co-workers partially investigated the structure of those cellulosic materials in thin films analysing the X-ray diffraction patterns in a limited range of scattering vectors [1]. In this paper we make a deep X-ray diffraction and scattering investigation of the local ordering and structure of a thin free-standing film obtained from a thermotropic cellulose derivative cross linked with a diisocyanate. Mechanical and optical microscopy assays complement this work. The study is performed with the films initially in the relaxed state, during and after a mechanical uniaxial stress applied along or perpendicular the casting direction, and under relaxation. The X-ray diffraction patterns of the free standing, unstretched, celluloseic films present three diffraction peaks, anisotropically disposed around the z-axis, as shown in Fig 1. The characteristic distances associated to the peaks are,  and. Peak 1 is associated with the distance between cellulosic main chains, preferentially oriented along the casting direction, in a "nematic-type" ordering. Peak 2 is associated with the average distance between  segments of the molecules that form the cellulosic matrix and links the glucose molecules. These segments were also partially oriented along the casting direction. Peak 3 indicates the existence of an ordered structure with a large correlation length , which is oriented perpendicular to that of the nematic-like ordering. This characteristic distance is associated with a smectic-like ordering inside correlation volumes of typical dimension , where the glucose molecules are stacked. . Interestingly, small-angle X-Ray scattering studies indicated the presence of domains with radius of gyration of ~16nm which is in good agreement with these results. These correlation volumes should be preferentially oriented with the normal to the smectic layers parallel to the casting direction. Therefore we propose that in the film there is a bundle of helicoidal fiber-like structure where the cellobiose block spins around the axis of the fiber, like a string-structure in a smectic-like packing, with the pitch defined by the smectic-like layer. The fibers are perpendicular to the smectic-like planes. The distance between the fibers should be of the order of , corresponding to peak 1 of the diffraction pattern.

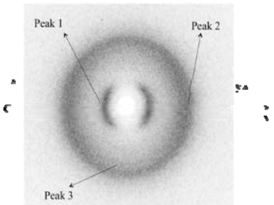



*Figure 1. X-ray diffraction pattern of the unstretched cellulose film. The single arrow represents the casting direction.*

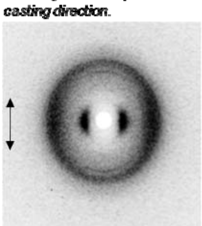


*Figure 2: X-Ray diffraction pattern of stretched film along the casting direction. The double arrow points out the stretching direction.*

[1] M. H. Godinho, D. Filip, I. Costa, A.-L. Carvalho, J.L. Figueirinhas, E.M. Terentjev, Cellulose 16, 199 (2009).

Financial support: FAPESP, INCT-FCx, CNPq, Portuguese Science and Technology Foundation project PTDC/CTM/099595/2008

Roger Pynn

**2/2 Thursday: Evening session:**

**1930-2000**

# Probing Correlations in Colloidal Fluids Induced by Depletion Interactions

A. L. Washington[1], X. Li[1], A. B. Schofield[2], K. Hong[3], and Roger Pynn[1,4]

[1]Center for Exploration of Energy and Matter, Indiana University, Bloomington, IN 47408, USA
[2]School of Physics and Astronomy, University of Edinburgh, Edinburgh, EH9 3JZ, Scotland
[3]Center for Nanophase Materials Science, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA
[4]Neutron Sciences Directorate, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA

Correlations between ~ 250-nm-diameter, surfactant-stabilized poly(methyl methacrylate) (PMMA) spheres have been measured in concentrated suspensions using a new neutron scattering technique called Spin Echo Small Angle Neutron Scattering (SESANS). This method directly yields a projection of the Patterson correlation function in real space over distances between ~50 nm and several microns. It is a more sensitive measure of correlations than conventional Small Angle Neutron Scattering (SANS). The refractive indices of the PMMA spheres and the carrier fluid were approximately matched, suppressing Van der Waals attractions between the spheres.

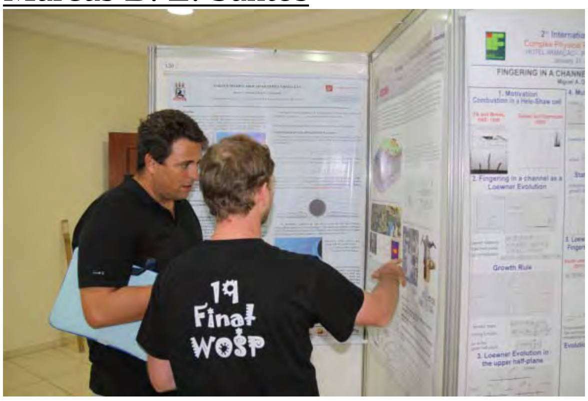
For PMMA volume fractions up to 40%, the Percus-Yevick hard-sphere approximation gave a good description of the data, whereas for 50% volume fraction, significant departure from this theory was observed. A small concentration of molecular polystyrene (PS) added to the suspension caused depletion-induced attraction between the spheres when the carrier fluid was a good solvent for PS. At sufficiently low concentration of PS (0.2 % by weight), the depletion interaction caused enhanced short-range correlations between spheres but little other change in the correlation function. For slightly higher concentrations (0.5 % by weight), the correlations between PMMA spheres became fractal in nature and extended over many particle diameters.

## Poster Session:

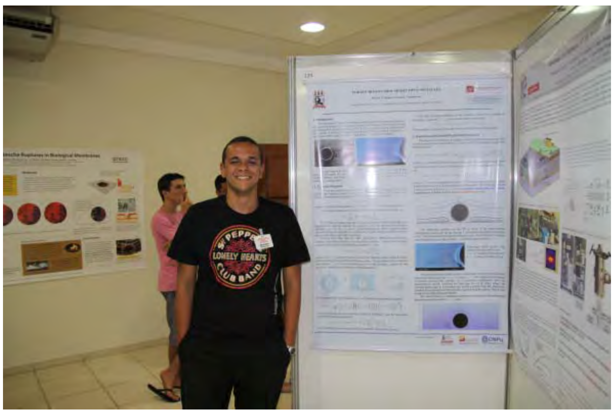
Rogelma Ferreira

Geraldo Jose da Silva
Marcus B. L. Santos

Giovanni Grassi
Arne Skjeltorp
Leander Michels




J. Fernando Q. Rey
Pawel Sobas



Marcel Moura

**Poster:**

## Clay-based composites for drug delivery: preliminary studies

A. Rivera[1*], Z. Rozynek[2], E. Lindbo Hansen[2], E. Altshuler[3,4], J. O. Fossum[2,5*]

[1]Zeolites Engineering Laboratory, Institute of Materials Science and Technology (IMRE), University of Havana, Cuba; [2]Department of Physics, Norwegian University of Science and Technology (NTNU), Trondheim, Norway; [3]Superconductivity Laboratory and "Henri Poincaré" Group of Complex Systems, [4]Physics Faculty, University of Havana, Cuba; [5]Center for Advanced Study (CAS) at the Norwegian Academy of Science and Letters, Oslo, Norway.

[*]aramis@fisica.uh.cu, jon.fossum@ntnu.no

Controlled drug delivery systems have been introduced in pharmacotherapy, showing several advantages over conventional dosage forms, besides the possibility to manipulate the release rate: protection from drug hydrolysis and other types of chemical degradation, reduction of toxicity, and so on. In the last years different porous materials have been used as hosts for drugs [1]. Very recently, clays have been incorporated to the list of host materials, with the use of synthetic hectorites. When compared to natural smectites, synthetic hectorites show a number of advantages, such as a controllable pore size distribution, purity and composition, which results in higher reproducibility. In addition, these materials have been shown to be non-toxic for trans-dermal application and oral administration [2,3]. We have successfully incorporated the antibiotic ciprofloxacin (a broad-spectrum antibacterial agent for oral administration used to treat various bacterial infections) into Li-fluorohectorite (Li-Fh) and Laponite (Lp) [4]. As far as we know, this is the first successful attempt to incorporate an antibiotic into clay. The wide-angle X-ray scattering method was used to monitor the drug molecule intercalation. Our preliminary wide-angle X-ray diffraction data suggests true intercalation of the drug molecules between the clay layers. In addition, thermogravimetric analysis was performed as a complementary method, and the obtained results confirm the observation from the scattering data. We have also investigated the release of the drug molecules from clay (controlled by temperature) and the obtained profiles meet the pharmaceutical standards for these kinds of systems (fig.1).

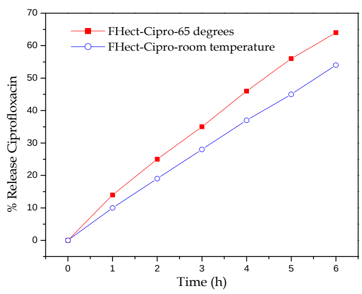



Figure 1. Ciprofloxacin release from two different types of clays (Laponite and Li-Fluorohectorite).

[1] A. Rivera and T. Farías, *Micropor. Mesopor. Mater.* **80** (2005) 337.
[2] T. Takahashi Y. Yamada, K. Kataoka, Y. Nagasaki,, *J. Control. Release*, **107** (2005) 408.
[3] G. V. Joshi *et al*., *Micropor. Mesopor. Mater.* **142** (2011) 542.
[4] A. Rivera, Z. Rozynek, E. Lindbo Hansen, E. Altshuler, J. O. Fossum, *in preparation* (2012).

**Poster:**

# NUMERICAL COMPUTATIONS UNDER VISCO-INERTIAL REGIME OF THE DIP COATING ON FIBERS

Diego M. Campana*, **, Sebastián Ubal*, **, María Delia Giavedoni* and Fernando Saita*

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(**) Facultad de Ingeniería, Ruta 11, Km 10, (C.C. 47 - Suc. 3 – 3100, Paraná), Otro Verde, Entre Ríos, Argentina

Dip coating is a method used to deposit a thin uniform film on a solid by withdrawing it at a constant speed from a bath containing the liquid to be coated. It has been one of the most extensively studied coating processes since the pioneering work carried out by Landau and Levich (1942), who developed an approximate expression for the film thickness valid at very low withdrawal speeds and when the effects of gravity are negligible (visco-capillary regime). Since then, many works were devoted to extend this solution by including other forces (gravity, inertia, surface elasticity, etc.).

In industrial applications, the withdrawal velocity is frequently very high (tens of m/s), inertia being a dominant force on the system mainly in the dynamic menisci where the film is formed (visco-inertial regime). Experimental works show that there is a limiting velocity from which the film thickness and the size of the meniscus grow abruptly. In this work we present the first 2D axi-symmetric numerical solution of the Navier-Stokes equation that shows the onset of the inertial regime.

We use an ALE framework appropriate to work with large mesh deformations and the finite elements method to discretize the equations. Predictions obtained for the visco-capillary regime are in very good agreement with the Landau-Levich law as well as with published experiments; while those obtained for the visco-inertial regime agree surprisingly well with published experimental data.

**Poster:**

# Oil Source Rock Microstructure by OCT

Sérgio Campello[1], Ricardo Souza[2], Wellington Pinheiro[3], Cláudia Brainer[4], Anderson Gomes[2]

[1]Programa de Pós-graduação em Ciência de Materiais, CCEN, UFPE
[2]Departamento de Física, CCEN, UFPE
[3]Núcleo de Engenharia Biomédica, CTG, UFPE
[4]Departamento de Odontologia, CCS, UFPE

Oil recovery performance on mature wells depends fundamentally on microstructure of the source rocks. Oil is distributed within source rocks that are mineral porous media. In order to obtain detailed structural information from porous media several techniques have been developed. The capability to get this information non-destructively is very desirable. Early methods based on cutting techniques can cause mechanical deformations on the sample surface. OCT (Optical Coherence Tomography) is a powerful tool for non-destructive and non-invasive characterization of several materials such as biomaterials, polymers, and organic porous media [1].

OCT provides structural information based on changes in optical scattering and alterations in refractive index as a function of depth [2]. In several materials, optical properties are different for distinct homogeneous layers. In these materials, OCT imaging intensity decreases gradually from maxima to minima. In contrast, an OCT spectrum of a mineral porous medium, like a rock sample, presents a spread and strong number of spikes due to transitions from existing materials regions to empty one and vice versa, along with beam light path. Therefore, it becomes more difficult to get trusty structural information.

In this work, we present an image processing algorithm to get structural information from oil source rocks based on reasonable assumptions. OCT Images of the dry sedimentary rock plugs were obtained using a commercial OCT spectrometer operating at $\lambda$ = 930 nm (6 μm axial resolution). The images obtained were processed with filters and an amplitude correction as a function of depth. Finally, the images were converted into binary images and then a counting and measurement of the area pores (typical diameter $\approx$ 10 μm) were carried out. Porosity measurements and pore size distributions will be presented.

[1] Fabritius et al, Journal of Physics D-Applied Physics, 2006. 39(21): 4668-4672;
[2] Dunkers et al, Optics and Lasers in Engineering, 35 (2001), 135-147.

**Poster:**

# Morphology and dynamics of craterlike structures created by recoiling elongated particles

M. Engelsberg[1], R. E de Souza[1] and S. de Lemos Campello[2]

[1]Departamento de Física, Universidade Federal de Pernambuco, Recife, Pernambuco, Brazil.

[2]Programa de Pós-Graduação em Ciência de Materiais, Universidade Federal de Pernambuco, Recife, Pernambuco, Brazil.

We study the morphology and dynamics of craterlike structures formed when free-falling randomly oriented, elongated particles bounce off a flat surface in a single particle scattering mode. The origin of a sharply defined rim with its associated structure, the factors determining the rim diameter, and the scaling of the diameter with impact velocity are examined [1]. The probability distribution of rebounding particle ranges is calculated for a particular example and shown to provide a precursor description of structure formation.

There exists in this problem a surprising analogy with other mathematical singularities involving randomly oriented objects that have striking physical consequences. A classic example are the sharp peaks that can be observed in the nuclear magnetic resonance spectra of isolated proton pairs in a polycrystalline solid with randomly oriented proton-proton internuclear vectors [2,3].

[1] M. Engelsberg, R. E de Souza and S. de Lemos Campello, Phys. Rev. E 84, 041311 (2011).
[2] G. E. Pake, J. Chem. Phys. 16, 327 (1948).
[3] M. Engelsberg and C. S. Yannoni, J. Magn. Reson. 88, 393 (1990).

**Poster:**

## The Multiuser Experimental Center at UFABC

R. Droppa Jr.[*], J. F. Q. Rey[#], and M. T. Escote[#]

[*] Center of Natural and Human Sciences (CCNH), UFABC, Santo André-SP, Brazil.
[#] Center of Engineering, Modelling, and Applied Social Sciences (CECS), UFABC, Santo André-SP, Brazil.

The Multiuser Experimental Center (CEM) at the Federal University of the ABC Region (UFABC) comprises 13 laboratories that provide highly sophisticated infrastructure for carrying out experiments in the branches of physics, chemistry, biology, and engineering. The laboratories are equipped with around 30 state-of-art facilities that are shared by scientists, engineers and students. Among the CEM equipments, it is worth mentioning a JEOL JSM-6701F field emission scanning electron microscope, two Bruker D8-series diffractometers, a Quantum Design PPMS facility, etc.

Nowadays, the CEM has around 150 registered users, 30% of which are local researchers and the remaining comprises external researchers, postdocs, doctorate, master, and undergraduate students.

The CEM was designed with the mission of promoting interdisciplinary research and education in the several branches of sciences and engineering by providing conditions for characterizations of advanced materials and biosystems.
As a multiuser facility, the center can be used by the local scientific community (scientists, postdoctoral scholars, graduate students, and undergraduate students), as well as researchers from other universities, nonprofit research centers, organizations and industry that have collaborative research at UFABC.

**Poster:**

## Fingering in a Hele-Shaw channel and tripolar Loewner evolutions

[1]Miguel A. Durán and [2]Giovani L. Vasconcelos

[1]Instituto Federal do Sertão Pernambucano, Ouricuri, PE, Brazil.
[2]Departamento de Física, Universidade Federal de Pernambuco, Recife, Brazil.

The Loewner equation describes a rather general class of growth processes in two dimensions where a curve starts from a given point on the boundary of a certain "physical domain" in the complex $z$-plane and grows into the interior of this domain. The growth dynamics is then conveniently described in terms of a time-dependent conformal mapping $g_t(z)$ that satisfies a first-order ordinary differential equation—the so-called Loewner equation.

In this work [1], a class of Laplacian growth models in a Hele-Shaw channel is studied using the formalism of tripolar Loewner evolutions, in which three points, namely, the channel corners and the point at infinity, are kept fixed. Initially, the problem of fingered growth, where growth takes place only at the tips of slit-like fingers, is revisited and a class of exact solutions of the corresponding Loewner equation is presented for the case of stationary driving functions. A model for interface growth is then formulated in terms of a generalized tripolar Loewner equation and several examples are presented. It is shown that the growing interface evolves into a steadily moving finger and that tip competition arises for nonsymmetric initial configurations with multiple tips. Possible extensions, including stochastic tripolar Loewner evolutions, will be briefly discussed.

[1] Miguel A. Durán and Giovani L. Vasconcelos, "Fingering in a channel and tripolar Loewner evolutions". Physical Review. E **84**, 051602, 2011.

**Poster:**

# A Numerical Approach to Stick-Slip dynamics in Granular Fluids

Jon Alm Eriksen (1), Eirik Grude Flekkøy (1), Knut Jørgen Måløy (1) and Bjørnar Sandnes (2)

1) Department of Physics, University of Oslo
2) Department of Physics, NTNU, Trondheim

Pattern formation in granular materials is a curious result of the dissipative interactions between grains. A recent study by B. Sandes [1] points to an extraordinary diversity in the dynamics of the flow of wet granular materials displaced by air in a Hele-Shaw cell. By varying the air injection rate and the granular filling fraction several distinct morphologies were observed, and the study mapped out a tentative dynamical phase diagram. We investigate a transition in that phase diagram, from frictional fingering to Stick-slip bubbles. By integrating the surface tension, pressure and frictional forces, we trace the displacement of the interface, and reproduce the experimentally observed patterns. The numerical scheme offers a method to study the transition in detail, complimentary to the experimental observations. The simulation use a dynamical version of a quasi static algorithm developed by H.A. Knudsen and others [2], developed to simulate labyrinth patterns in granular fluids.

[1] B. Sandnes, E.G. Flekkøy, H.A. Knudsen, K.J. Måløy and H. See Patterns and flow in frictional fluids. Nat. Commun. 2 : 288 doi: 10.1038/ncomms1289 (2011).
[2] H.A. Knudsen, B. Sandnes, E.G. Flekkøy and K.J. Måløy. Granular labyrinth structures in confined geometries. Phys. Rev. E. 77, 021301. doi:10.1103/PhysRevE.77.021301 (2008).

**Poster:**

# Absorptive and refractive optical nonlinearities in ferrofluid of magnetite nanoparticles

Daniel Espinosa[1], Antônio Figueiredo Neto[1], Sarah Alves[2], Sérgio Zílio[3], Marco Vivacqua[1], Diogo Soga[1], and Leonardo De Boni[3]

[1] Instituto de Física, Universidade de São Paulo, São Paulo, SP, Brazil
[2] Instituto de Ciências Ambientais, Químicas e Farmacêuticas, Universidade Federal de São Paulo, Diadema, SP, Brazil
[3] Instituto de Física de São Carlos, Universidade de São Paulo, São Carlos, SP, Brazil

Nonlinear optical properties of materials are interesting from the fundamental and technological perspectives, because they can provide information about the material's electronic structure and they can be applied to optical and photonic devices. Ferrofluids are fluid materials that present third-order optical nonlinearities. In this work, we investigate nonlinear absorption and refraction of a ferrofluid made of magnetite nanoparticles suspended in isoparaffinic oil. The fluid sample is encapsulated in glass holder, and it is moved along the z-axis of a focused Gaussian laser beam, while the energy transmittance is measured (Z-Scan technique). We apply Z-Scan in different experimental conditions. In the experiments with femtosecond pulsed laser beam at the wavelength of $\lambda = 800$ nm, where our samples do not present linear absorption, the refractive and absorptive nonlinearities are caused by the optical Kerr effect and the two-photon absorption mechanism, respectively. We use the theoretical models corresponding to those mechanisms to experimentally achieve the values of the Kerr coefficient ($n_2$) and the two-photon absorption coefficient ($\beta$), and from those values we calculate the real and imaginary parts of the sample's third-order optical susceptibility ($\chi^{(3)}$). In the experiments with millisecond, picosecond and femtosecond laser beam, at the wavelength of $\lambda = 532$ nm, where our the samples present linear absorption, the absorptive nonlinearities are expected to be caused by free-carrier absorption. We use the theoretical model based on the free-carrier absorption mechanism to achieve the value of the sample's free-carrier absorption cross section ($\sigma$). However, if thermal nonlinear effects are present in the experiments, the application of those theoretical models are meaningless, and wrong values of $n_2$, $\beta$ and $\sigma$ are achieved. We find optimal experimental conditions of pulse width and pulse frequency to avoid those unwanted thermal effects.

**Poster:**

## Analytical results for long time behavior in anomalous diffusion

Rogelma Ferreira[1]; José S. Andrade Jr.[1], Fernando Oliveira[2]

[1]Universidade Federal do Ceará, [2]Universidade de Brasília

We investigate through a Generalized Langevin formalism the phenomenon of anomalous diffusion for asymptotic times. To confirm our analytical result, we have also developed a computational algorithm to calculate some quantities like correlation function, diffusion coefficient and mean square displacement, necessary to identify the type of diffusion mechanism [1]. The results are then compared through the introduction of a time scaling factor, and very good agreement is observed, between both methods for intermediate and long times. The result is general and may be applied to many types of diffusion regimes. This analytical result is important to discuss some important aspects of physics, such as the violation of the Ergodic Hypothesis discussed in recent investigations about diffusion [2,3,4].

[1] R.M. S. Ferreira et al., Phys. Rev. E, to be published.
[2] M. H. Lee, Phys. Rev. Lett. 98, 190601 (2007).
[3] L. C. Lapas, R. Morgado, M. H. Vainstein, J. M. Rubi and F. A. Oliveira, Phys. Rev. Lett. 101, 230602 (2008).
[4] J. A. R. da Cunha, A. L. A. Penna, F. A. Oliveira, Phys. Rev. E 83, R015201 (2011).

**Poster:**

# Nanostructural Alterations and Rheology of Clay Dispersions in Response to Heating

E. Lindbo Hansen[1], H. Hemmen[1], D. M. Fonseca[1], C. Coutant[2], K. D. Knudsen[3], T. S. Plivelic[4], D. Bonn[5], J. O. Fossum[1,6]

[1] Department of Physics, Norwegian University of Science and Technology - NTNU, Trondheim, Norway
[2] UFR Structure et Propriétés de la Matière, Université de Rennes 1, Rennes, France
[3] Department of Physics, Institute for Energy Technology, Kjeller, Norway
[4] MAX IV Laboratory, Lund University, Lund, Sweden
[5] Van der Waals-Zeeman Institute, University of Amsterdam, Amsterdam, Netherlands
[6] Center for Advanced Study – CAS, at the Norwegian Academy for Science and Letters, Oslo, Norway

Slow dynamics and the development with time of an elastic response in dispersions of clay platelets have been the subjects of detailed investigations over the past decade. In the present study we focus on aqueous dispersions of Na-fluorohectorite and explore the role that temperature plays in this system. We find to our knowledge for the first time that heating from 25 to 75 $^{o}C$ causes a tenfold increase in the yield stress and show that the underlying cause for this behaviour is related to a dramatic expansion of the interlayer space of stacked particles, approaching a state of complete particle delamination.

**Poster:**

# CALCIUM-ION-CONTROLLED NANOPARTICLE-INDUCED TUBULATION IN SUPPORTED FLAT PHOSPHOLIPID VESICLES

Irep Gözen [a], Celine Billerit [a], Paul Dommersnes [ab], Aldo Jesorka[a] and Owe Orwar[a]

[a]Department of Chemistry and Biological Engineering, SE-412 96, Göteborg, Sweden
[b]Matieres et Systemes Complexes,Universite Paris Diderot, Paris, 75013, France

Biological nanotubes (or tunneling nanotubes), accomplish important functions within the cell, for instance by supplying cell components, carrying out signals and transporting virus particles and bacteria. Many functions are still not well understood, which has placed these nanostructures in the focus of recent investigation. We report here on our observations of transient tubulation in nanoparticle-containing, supported flat giant unilamellar vesicles (FGUVs). The encapsulation of nanoparticles in FGUVs with low (1–4 mM) $Ca^{2+}$ in the ambient buffer solution caused transient tubulation. Tubes extended from the FGUV up to a length of several hundred micrometers and exhibited, on some occasions, vesicle compartmentalization. The model represents several features of reported theoretical and practical phenomena of tube formation in biological or biomimetic systems.

**Poster:**

# X-ray Studies of Carbon Dioxide Intercalation in Na-Fluorohectorite Clay at Near-Ambient Conditions

Henrik Hemmen,*[†] Erlend G. Rolseth,[†] Davi M. Fonseca,[†,‖] Elisabeth L. Hansen,[†] Jon Otto Fossum,*[†,‡] and Tomás S. Plivelic.[§]

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Due to current awareness of global warming and the challenges related to carbon capture and sequestration, the interactions between clays and $CO_2$ are attracting attention in the scientific community. A recent molecular dynamics study by Cygan et al. [1] shows the possibility of intercalation and retention of $CO_2$ in smectites at 37 $^oC$ and 200 bar. This has led the authors to suggest that clay minerals may prove suitable for carbon capture and carbon dioxide sequestration. In this work [2] we add to the so far scarce experimental results in this field, by showing from x-ray diffraction measurements that gaseous $CO_2$ intercalates into the interlayer space of the synthetic smectite clay Na-fluorohectorite at conditions close to ambient. The mean interlayer repetition distance of the clay when $CO_2$ is intercalated is found to be 12.5 Å for the condition -20 °C and 15 bar. The magnitude of the expansion of the interlayer upon intercalation is indistinguishable from that observed in the dehydrated-monohydrated transition for $H_2O$, but the possibility of water intercalation is ruled out by also exposing the clay to nitrogen gas. The dynamics of the process is observed to be dependent on the pressure, with a higher intercalation rate at increased pressure. The rate of $CO_2$ intercalation at the studied conditions is found to be several orders of magnitude slower than the intercalation rate of water or humidity at ambient pressure and temperature. The conditions studied are different from most of the simulations in the literature related to geological storage, but demonstrating intercalation at less extreme conditions could prove very useful in understanding the processes involved. By avoiding extreme conditions, experimental verification of theory and simulations should become much easier, and the low pressures involved here enable the use of Kapton windows on the sample cell, thus allowing investigations with laboratory x-ray equipment instead of synchrotron sources. The observation of the slow dynamics of intercalation should be considered when doing surface area measurements on clays, as the vapor uptake into the interlayers could continue for days if the conditions favor intercalation

[1] Cygan, R. T.; Romanov, V. N.; Myshakin, E. M. *Natural materials for carbon capture*; Techincal report SAND2010-7217; Sandia National Laboratories: Albuquerque, New Mexico, November, 2010.
[2] Hemmen, H.; Rolseth, E. G.; Fonseca, D. M.; Hansen, E. L.; Fossum, J. O.; Plivelic, T. S. *Accepted in Langmuir* 2012, *DOI: 10.1021/la204164q*.

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**Poster:**

# MAGNETIC STRUCTURE OF SPINEL-TYPE $NiMn_2O_4$ COMPOUND

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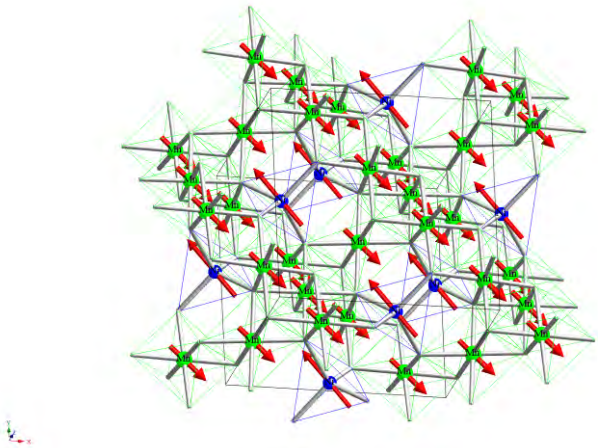
Advanced oxide materials with $NiMn_2O_4$ nominal composition and spinel-type structure were obtained by a modified polymeric precursors method. The magnetic structure was studied by crystallographic and magnetic methods using powder X-ray diffraction and neutron diffraction associated to Rietveld refinement. Magnetization measurements indicate that the $NiMn_2O_4$ system is associated to the interplay between two-sublattices, one, ferromagnetic and the other antiferromagnetic, and takes place due to the cations occupation at the tetrahedral and octahedral sites. Both components are present in the ZFC (antiferromagnetic) and FC (ferromagnetic) magnetizations, independent of the applied field. The neutron diffraction data suggests a complex star structure due to the competition of the magnetic moment of Ni and Mn atoms in the B spinel site.



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**Poster:**

# SYNTHESIS AND CHARACTERIZATION OF POLYSTYRENE-CLAY NANOCOMPOSITES

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Recent progress in polymer science has demonstrated that remarkable changes in material properties are achievable by combining polymer systems with miniature particles, where at least one of the particle dimensions is in the nanosize range. Even minute quantities (sometimes less than 1 %) can drastically modify the overall system behavior if the surface of the incorporated particles has been made to interact sufficiently with the polymer chains. Fu et al [1] dispersed organically modified montmorillonite clay into polystyrene (PS), and increased the dynamic modulus of the nanocomposite by over 60 %, with only 8 wt-% filler material. We recently started to build upon Fu et al's work on PS-clay systems, by incorporating other types of smectic clays, such as Laponite and Fluorohectorite, and also manipulating the orientation and super structure of the clay particles with electric fields. The presentation will give a brief summary of the synthesis and characterization of such composites.

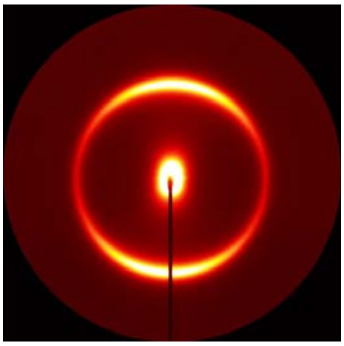

Figure: SAXS scattering pattern of PS-fluorohectorite composite.

[1] X. Fu and S. Qutubuddin, Materials Letters 42 (2000) 12.

**Poster:**

# The diffusion of vapor inside the mesoporosity of a dry clay

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We use space- and time-resolved X-ray diffraction as a tool for imaging the humidity content of a clay sample in situ, in a non-invasive manner. Imposing a humidity gradient between the two ends of a quasi-one-dimensional temperature controlled weakly-hydrated sample of synthetic swelling clay, we follow the transport of water by monitoring the individual swelling of clay particles.

The nano-layered clay crystallites are stacks of individual 1 nm-thick clay particles, and have the ability to incorporate water molecules in the nano-porosity between the layers, causing the interlayer repetition distance (*d*-spacing) of the stacks to depend on temperature and on the humidity present in the surrounding meso-porosity. A first experiment performed under controlled constant temperature and con trolled humidity level all around the sample, varying the ambient relative humidity by steps, allows us to map the monotonous evolution of the *d*-spacing as a function of the relative humidity surrounding the clay.

The reproducibility and reliability of this *d*-shift vs. RH curve enables us to use *d* as a measure of the local humidity surrounding the clay particles in the second experiment, which addresses quasi-one-dimensional water transport in the clay: we map the *d*-spacing in space and time as water progresses along the sample, and are able to extract profiles of the relative humidity along the sample length. Their time evolution describes the transport of water through the mesoporous space inside the clay: An analysis of the measured humidity profiles based on the Boltzmann transform, under certain simplifying assumptions, yields a diffusive behavior that is either normal or possibly weakly anomalous. It also provides the dependence of the effective diffusion coefficient $D$ of the water vapor in the clay mesoporosity as a function of the local concentration of water molecules.

That dependence of $D$ on the concentration impacts the transport process significantly. Another effect that potentially alters the process significantly is the removal of water molecules from the mesoporosity by intercalation inside the clay grains. Based on 2D finite element simulations we discuss the mechanisms and consequences of those two effects.

[1] X-ray studies of interlayer water absorption and mesoporous water transport in a weakly hydrated clay, H. Hemmen, L.R. Alme, J.O. Fossum and Y. Meheust, Phys.Rev. E 82, 036315 (2010)
[2] Erratum: X-ray studies of interlayer water absorption and mesoporous water transport in a weakly hydrated clay, H. Hemmen, Y. Meheust, J.O. Fossum, Phys.Rev. E 83, 019901(E) (2011)

**Poster:**

# Dynamics of humidity uptake by meso-, and nano-porous synthetic clay Lithium-Fluorhectorite

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The swelling of layered smectite clay particles consists of a change in the interlayer repetition distance (d-spacing) as a function of temperature and humidity. In this work, a fine scan of the relative humidity under room temperature was done for the synthetic clay Lithium fluorohectorite [1]. This sample has hydrodynamically stable hydration states with zero, one, one and half, two and three intercalated monolayers of water which is described in a similar work for the Sodium-fluorohectorite [2], with discrete jumps in d-spacing at the transitions between the hydration states. These changes are monotonous as a function of relative humidity, and one order of magnitude smaller than the shift in d-spacing that is typical of the transition between two hydration states. The reproducibility and reliability of this relative humidity controlled d-shift enables us to use the interlayer repetition distance d as a measure of the local humidity surrounding the clay particles. We provide an example of application of this observation: imposing a humidity gradient over a quasi-one-dimensional temperature-controlled sample, and using x-ray diffraction to record the d-spacing, we are able to extract profiles of the relative humidity along the sample length [3]. Their time evolution describes the transport of water through the mesoporous space inside the clay.

[1] Research Proposal XRD1-10795. June 1-6 (2011).
[2] H.Hemmen, L. R. Alme, J. O. Fossum and Y. Meheust, *Phys. Rev. E* **82**, 0363315 (2010) References therein.
[3] SAXS/WAXS experiment at Nanostar in the Physics Institute at NTNU/No October (2011)

**Poster:**

# Onset of flux avalanches in superconducting films triggered by ac magnetic fields

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Flux avalanches in type-II superconductors are characterized by sudden flux bursts which develop as a consequence of thermomagnetic instabilities that take place when heat dispersion is slower than magnetic diffusion. Under certain conditions of temperature and magnetic field one can recognize their fingerprints as jumps in magnetization curves, or as a paramagnetic reentrance in ac susceptibility measurements. In a recent work, Colauto and co-workers [1] have shown that the variation of the magnitude of those flux jumps can be quantitatively linked to magneto-optical (MO) images taken under equivalent experimental conditions.

In this work we carried out a systematic study of ac-susceptibility, residual magnetization (after application of an ac field, Mres), and MO imaging. Two Nb films were employed: samples AD04 and AD08, which are Nb films with thickness of 50 nm, each decorated with a square array of ADs, with a lattice constant of 1.5 μm. The square ADs in AD04 have 0.4 μm sides, whereas in AD08 the sides are 0.8 μm. A third Nb pristine film was also studied as a reference sample.
The ac-susceptibility and the residual magnetization after an applied ac field were measured at several temperatures in the presence of an ac-excitation field (h) and a DC applied field (H). For the pristine and AD04 samples, the response of Mres for low temperatures consists of short plateaus followed by small jumps (small avalanches) whereas for higher temperatures, both jumps and plateaus are larger (big avalanches). At high amplitudes of the ac field, the curves are always noisy, i.e., flux avalanches occur at every small increase of the ac-excitation. All curves for the AD08 film are noisy. These results were confirmed by MOI measurements.

The set of results imply that the ac magnetic field triggers avalanches on Nb films, regardless of the presence of ADs. Nonetheless, the sample with larger ADs exhibits avalanches in the whole range of temperatures, whereas for other samples the size and separation (in terms of the excitation field) of the avalanches depend on the temperature. Besides, avalanches appear only below a threshold temperature, whose value differs from sample to sample.

[1] F. Colauto et al. Supercond. Sci. Tech. 20, L48 (2007).

**Poster:**

# Vortex motion around multiple obstacles

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The problem of vortex dynamics in a fluid surrounding multiple solid obstacles is a problem of great theoretical interest and practical importance. In particular, the case of vortex motion in a fluid past a circular cylinder placed above a plane wall has attracted considerable attention recently. Here a stationary vortex is formed upstream of the cylinder, as found in experiments by Lin et al. (Journal of Engineering Mechanics **135**, 697, 2009), in contradistinction to the usual case without the plane where a vortex pair is observed behind the cylinder [1]. In the present work, the motion of a point vortex in an ideal fluid past a circular cylinder close to a plane boundary is studied from analytical and numerical standpoints.

Using complex analysis techniques devised by Crowdy and Marshall (Proc. R. Soc. A **461**, 2477, 2005) to analyze vortex dynamics in multiply connected domains in two-dimensional flows, we obtain the complex potential and the Hamiltonian (also called the Kirchhoff-Routh path function) for the problem of one point vortex placed in a uniform stream past a circular cylinder above a plane. The corresponding phase portrait is obtained and all equilibrium points, together with their stability nature, are determined.

We show that this point-vortex model can explain some of the qualitative features observed in the experiments, such as the variation of the stationary position as the gap between cylinder and the plane wall changes. It is also argued that the method can, in principle, be extended to study vortex dynamics around multiple cylinders (with or without a plane wall), although here the mathematical calculations become more involved.

[1] Giovani L. Vasconcelos, Marcel N. Moura, and Adriaan M. J. Schakel, "Vortex motion around a circular cylinder," Physics of Fluids **23**, 123601, 2011.

**Poster:**

## Emergence of conservatism as an efficient strategy for consensus

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A common feature of complex systems is global organization sustained without the aid of centralized control. In the case of social and biological systems, natural evolution theory is expected to predict the origin and explain the essence of global coordination. Here we develop a genetic algorithm approach to investigate the evolution of strategies for solving complex tasks in noisy environments. Precisely, the proposed algorithm finds highly efficient rules to reach consensus by inducing environmental changes and creating “evolutionary pressure”. Moreover, our results show that more complex rules spontaneously evolve towards a tendency to preserve current states when adapting to adverse environment with high level of noise. This behavior discloses a possible explanation for the emergence of conservatism as an efficient strategy for consensus in social experiments.

**Poster:**

# Non-Local Product Rules for Percolation

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Despite original claims of a first–order transition in the product rule model proposed by Achlioptas et al. [Science 323, 1453 (2009)], recent studies indicate that this percolation model, in fact, displays a continuous transition. The distinctive scaling properties of the model at criticality, however, strongly suggest that it should belong to a different universality class than ordinary percolation. Here we introduce a generalization of the product rule that reveals the effect of non–locality on the critical behavior of the percolation process. Precisely, pairs of unoccupied bonds are chosen according to a probability that decays as a power-law of their Manhattan distance, and only that bond connecting clusters whose product of their sizes is the smallest, becomes occupied. Interestingly, our results for two-dimensional lattices at criticality shows that the power-law exponent of the product rule has a significant influence on the finite-size scaling exponents for the spanning cluster, the conducting backbone, and the cutting bonds of the system. In all three cases, we observe a continuous variation from ordinary to (non-local) explosive percolation exponents.

**Poster:**

## Stochastic Dynamical Model of Intermittency II: Applications to Financial Markets

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A hierarchical stochastic volatility model is proposed for intermittency found in stock market prices. In view of the analogy between turbulence in fluids [1] and price fluctuations in financial markets, the model quantitatively describes for the first time the so-called information cascade in financial markets, where *N* coupled volatility variables are defined to evolve as a random process to model price fluctuations at different time scales. Under the additional hypothesis that the characteristic time scales for the dynamics of the successive volatilities are well separated apart, it is possible to compute the probability density function (pdf) for the volatility at a given step *N* of the information cascade as a multiple integral involving the volatilities at all scales above. The theoretical pdfs are shown to fit extremely well the empirical distribution of the Ibovespa (IBOV) returns for high-frequency data (intraday quotes). The probability distribution of returns is calculated explicitly and expressed in terms of generalized hypergeometric functions of the type ${}_NF_0$. Such distributions are a natural extension of the Gaussian and the so-called q-Gaussian distributions, corresponding to ${}_0F_0$ and ${}_1F_0$, respectively, and represent (for $N > 0$) a large class of probability distributions with power-law tails and finite variance. The model also predicts some stylized facts of asset dynamics, such as the sum of decaying exponential terms for volatility auto-correlation and the "volatility smile" found in option pricing. The same model predictions are found to be in excellent agreement with experiments on both Eulerian and Lagrangean turbulence.

[1] Domingos S. P. Salazar, Giovani L. Vasconcelos, Phys. Rev. E 82, 047301 (2010).

**Poster:**

## Texture evolution of drying clay gel samples

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Among the synthetic clays, laponite is the most widely studied in its structural properties, here featuring the presence of polar platelets in the nanometric scale [1]. In dehydrated states these platelets tend to stack, while in presence of enough water they tend to disperse. In the present study we performed texture observations of different preparations originated from a single sample of a gel phase composed of laponite 4% wt. and salt-water (10^-3 M). This particular choice of concentrations falls around the (outlined) boundary between the nematic gel and isotropic gel phases, according to a published [2] phase diagram. In preliminary tests with a particular sample cell which combines good optical flat windows and a reasonable degree of sealing, we have observed textures that evolved as the sample becomes aged of several days or weeks, and we took photographs in the millimetric range (macro photos) using polarized white light. The observations have been carried out at room temperature (around 23ºC).  Further, by using different types of sample cells and monitoring the samples also in the submillimetric range using a polarized light microscope, we have demonstrated the role of the desiccation rate to the texture evolution. We quote two other features from our texture observations which link the aging effect with self-organization phenomena. Firstly, the fact that all samples looked like isotropic in the beginning but evolved by desiccation not only to a definite anisotropic texture, as expected for the nematic gel phase, but also to one showing a higly ordered alignment. Secondly, the directional character of the structures (or cracks), featuring situations of well defined angulosities.

[1] Jon Otto Fossum, "Physical Phenomena in Clays", Phys. A, v. 270 (1999) 270
[2] A. Mourchid, E. Lécolier, H. Van Damme and P. Levitz, Langmuir, 14 (1998) 4718.

**Poster:**

## Efficient Algorithm for counting Loops in Loop Models

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In statistical physics, various lattice spin models, such as the Ising model, possess a diagrammatic representation where contributions to the partition function correspond to closed random walks, or loops on the underlying lattice. The statistical weight of each loop configuration in general depends on the combined length of the loops, on the number of (self-)intersections, as well as on the number of loops present. About a decade ago, Prokofiev and Svistunov proposed a Monte Carlo update algorithm to generate new loop configurations through the motion of the endpoints of an open chain.

Despite using a local update, this so-called worm algorithm shows hardly any critical slowing down near the critical point of models with loop fugacity equal to unity. For models where this fugacity is not unity, the number of loops present must be known at each step of the worm update. Since keeping track of this number is a nonlocal task, the efficiency of existing algorithms for such models is limited. In this work, we present an algorithm, based on a new data structure, that keeps track of the number of loops present in a dramatically more efficient way.

**Poster:**

# Complex Colloidal Flow

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A "two-fluid" system consisting of concentrated "slurry" of polystyrene microspheres dispersed in water as fluid No. 1 and water as fluid No. 2 is used to study colloidal flow. As the specific weight of polystyrene is about 4% larger than that of water, the "slurry" will flow under the influence of gravitation. The flow is studied in Hele-Shaw cells (closely spaced glass plates). This produces various interfacial instabilities which may be related to viscous fingering.

**Poster:**

# $CO_2$ and porous media - SANS

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We are presently involved in research activities focusing on physical processes that are important for the understanding of $CO_2$ transport and storage into the ground. The relevant geological structures may show large variations in composition (water saturated porous materials, such as sandstone in a sedimentary basin, caprock, clays). $CO_2$ trapped in such porous materials relies on different mechanisms of confinement that act on different time scales. Some important factors to consider are: 1) an impermeable caprock that keeps the fluid underground (supercritical $CO_2$ fluid), 2) the solubility of the $CO_2$ in the water, 3) intercalation (absorption) into clay nanopores, 4) chemical reactions that bind the carbon in mineral form to the rock.

Small Angle Neutron Scattering (SANS) is a technique highly valuable for studying nanostructures (1-100nm), such as clays nanoparticl*es*, and this technique is available at Institute for Energy Technology (IFE). For the investigations on CO2 and porous materials we will make use of a specially designed cell to be used in combination with SANS. The cell allows studying nanoporous materials together with $CO_2$ in the supercritical state, up to 150°C and $CO_2$ pressure up to 410 bars. A specially adapted setup has now been made in order to integrate this $CO_2$ cell into the SANS apparatus. In addition, the instrument has been upgraded by the implementation of a new element - a so-called bender. This is designed to deflect neutrons with wavelengths above 4.5 Å by a certain amount (4°), thus removing fast neutrons and gamma radiation, in order to improve the quality of the neutron beam.

**Poster:**

# Micro- and macro-avalanches in superconductors

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Magnetic field does not always enter superconducting films in a smooth manner and often the penetration happens in form of avalanche. The macro-avalanches create spectacular, complex, dendritic flux structures and they have been well studied for decades. However, less attention has been paid to micro-avalanches, also present in superconducting films. The micro-avalanches can be detected as localized jumps in the flux penetration, with sizes ranging from one two tens of thousands of magnetic vortices. Several studies have reported that the number of avalanches distribute as a power law with regards to size, but it is not clear if this is a general feature of micro-avalanches. Neither is it clear what is the origin of the avalanches. In the presentation, I will show that disorder combined with strongly nonlinear material characteristics will give flux penetration in form of small avalanches. The sizes of the avalanches tend to be larger if the material is thermomagnetically unstable. In this way, the micro-avalanches are also potential triggers for dendritic flux avalanches.

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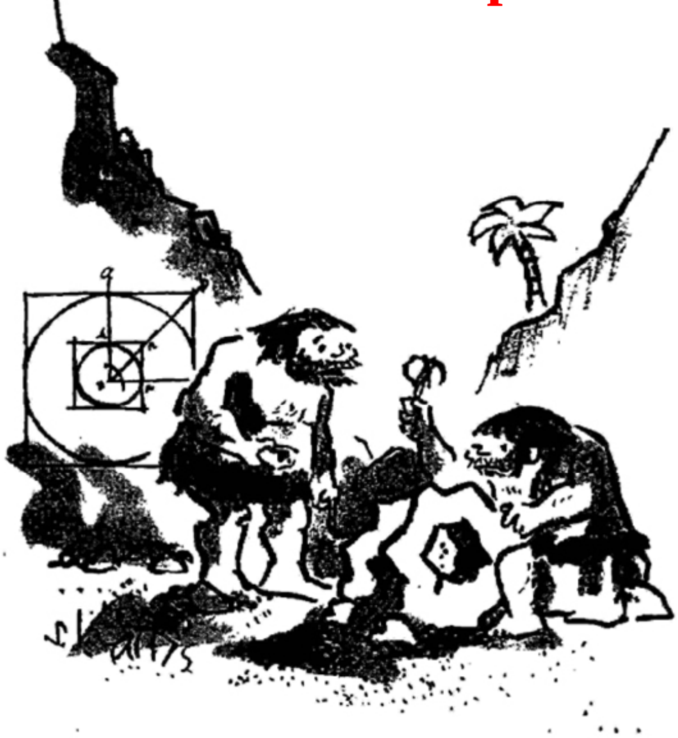
Roger Pynn (Univ. Indiana)
Dan Rothman (MIT, Cambridge, MA)
Mark Mineev-Weinstein (NMC, Los Alamos)

**Roundtable discussion:** ***Technology Transfer from Academia to Applications and Industry.***
Inspired by the article:
***Brazil aims for its science to have greater impact***, Physics Today 64, 26 (2011)
doi: 10-1063/PT.3.1259

# Roundtable Topic of the day:



"I GUESS THERE'LL ALWAYS BE A GAP BETWEEN SCIENCE AND TECHNOLOGY."

We want to discuss how to close this gap?


**Roundtable discussion:** ***Technology Transfer from Academia to Applications and Industry.***
Inspired by the article:
***Brazil aims for its science to have greater impact***, Physics Today 64, 26 (2011)
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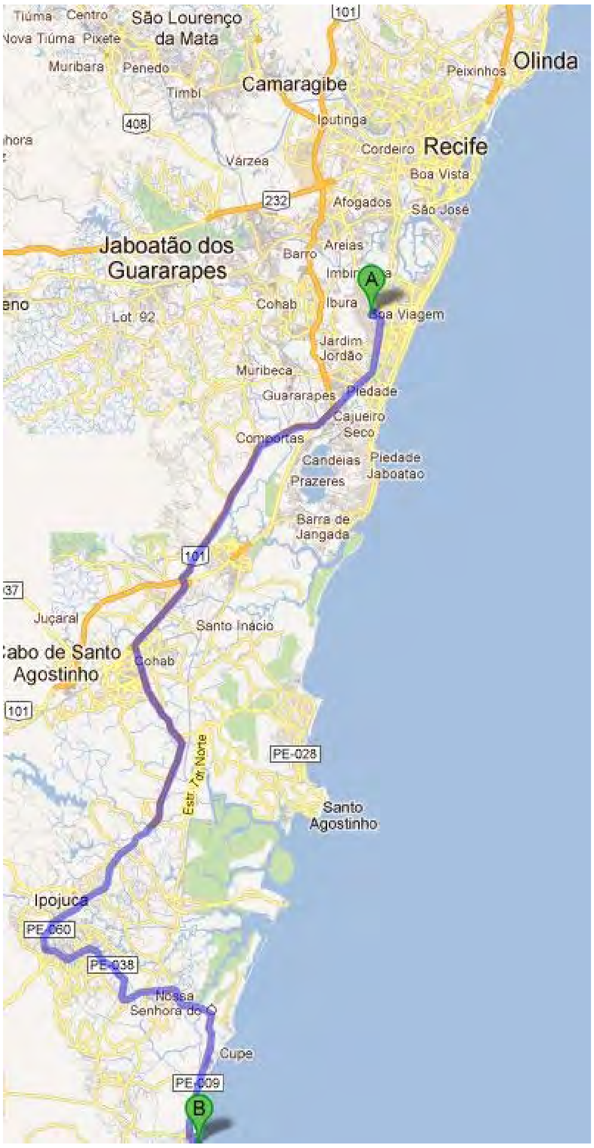
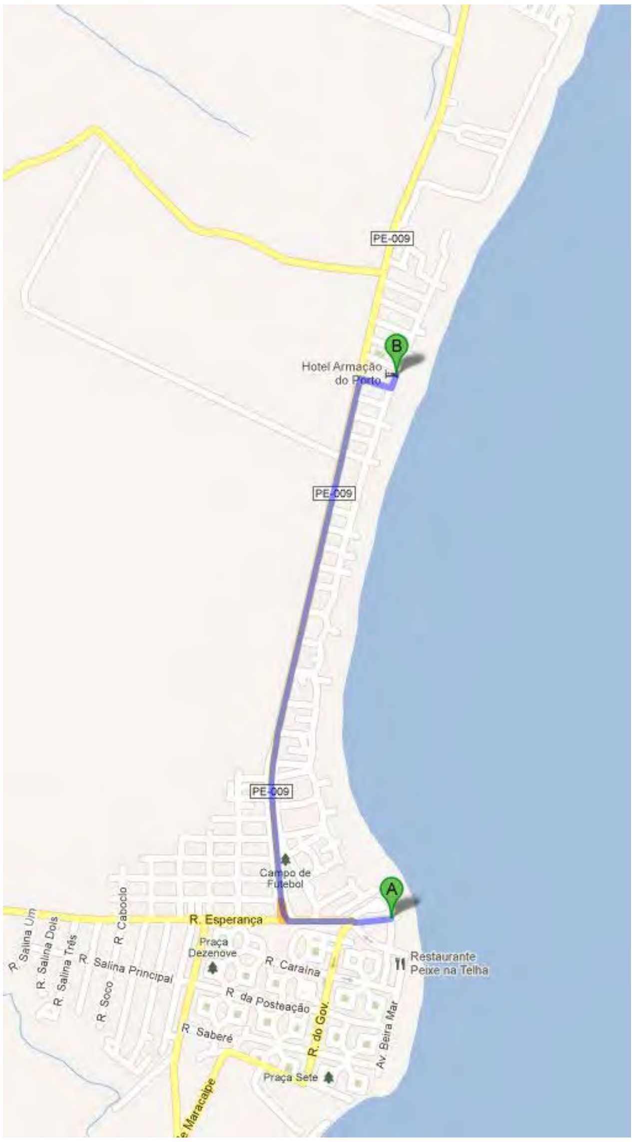
**Maps:**




**B** = Hotel Armação, Porto de Galinhas

Left map: Distance from Recife Airport (**A**) about 60 km.
Right map: Distance from Porto de Galinahs center (**A**) about 2.5 km.


IT DOESN'T
MATTER,
as long
as its
COMPLEX
MATTER!

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# 2nd International Workshop on
# Complex Physical Phenomena in Materials
## Hotel Armação, Porto de Galinhas - PE, Brazil
## January 31- February 3, 2012

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