# Physics of Complex Fluids
# Department of Mechanics and Physics of Fluids
# Institute of Fundamental Technological Research
# Polish Academy of Sciences (IPPT PAN)
# Warsaw, Poland

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Team Presentation – Annual Workshop, COST Action MP1106
Dublin, September, 2012

Research Team Name: Complex Fluids, IPPT PAN, Poland

Number of team members: 8

Brief description of team studies:

- hydrodynamics of micro and nano objects of different shapes and internal structure, also close to planar interfaces
- destabilization of clusters, periodic orbits, migration of flexible fibers
- transport properties of concentrated and dilute suspensions
- diffusion of particles in non-isotropic permeable media

Our expertise: HYDROMULTIPOLE numerical codes (E. Wajnryb), point-particle and Rotne-Prager simulations, analytical results, simple experiments

Project leaders: Eligiusz Wajnryb and Maria L. Ekiel-Jeżewska, physicists

- 3 post doctoral fellows
- 2 Ph.D. students
- 1 undergraduate student

Research interests related to MP1106:

- Hydrodynamic interaction between various types of micro and nano objects (solid, fluid, gas, permeable, core-shell) in viscous fluids at low-Reynolds-number

- Hydrodynamic interactions of particles with planar interfaces (solid, free, fluid-fluid, with and without surfactant),

- Diffusion, sedimentation and viscosity of suspensions

- Particles moving in permeable media

- Theoretical and numerical results, based on solving the Stokes equations by the multipole method, implemented in the accurate HYDROMULTIPOLE numerical codes

- Searching for comparison with experiments

Examples of questions

- How to discriminate a contaminated fluid-fluid interface from a pure one?

- How long do particles settling under gravity stay together to each other in a swarm before destabilizing?

- Can one sort fibers using their migration across the channel to different accumulation planes?

- How does a slip on a particle surface influence its mobility close to an interface?

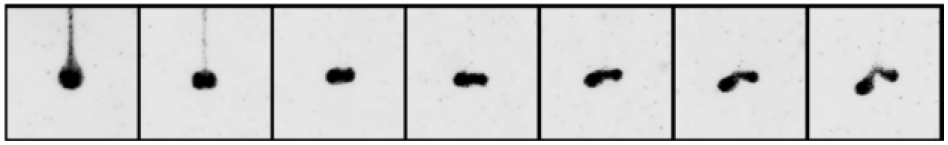
- Can suspensions of permeable particles be approximated by core-shells?

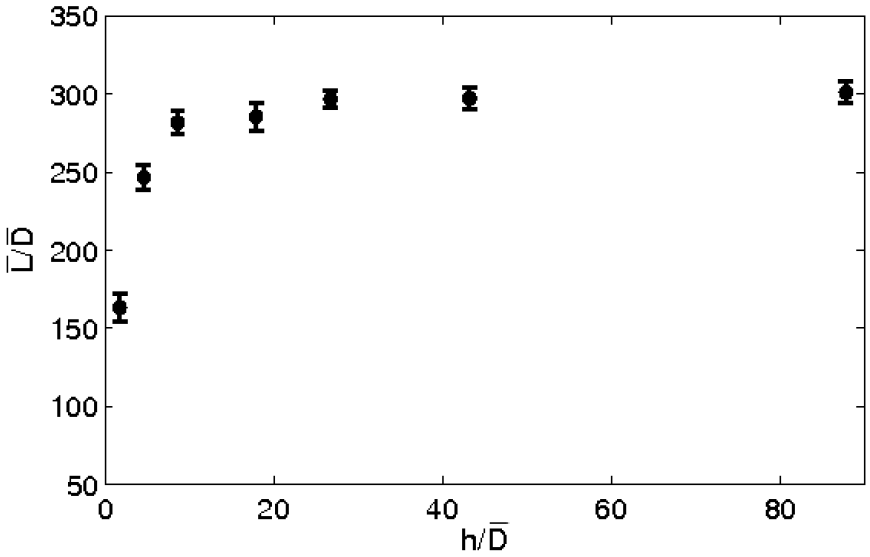
Basic facilities, equipment, devices:

- HYDROMULTIPOLE numerical codes
- Rotne-Prager, point-particle numerical cods
- Simple experiments with sedimenting particles and their groups

#1 project: Gravitational settling of suspension drops in a viscous fluid close to a vertical wall - evolution and destabilization

People: A. Myłyk (postdoc) and M. L. Ekiel-Jeżewska. Experiments in collaboration with Günter Brenn and Walter Meile, University of Technology, Graz, Austria
Facilities/equipment: point-particle simulations, experiments



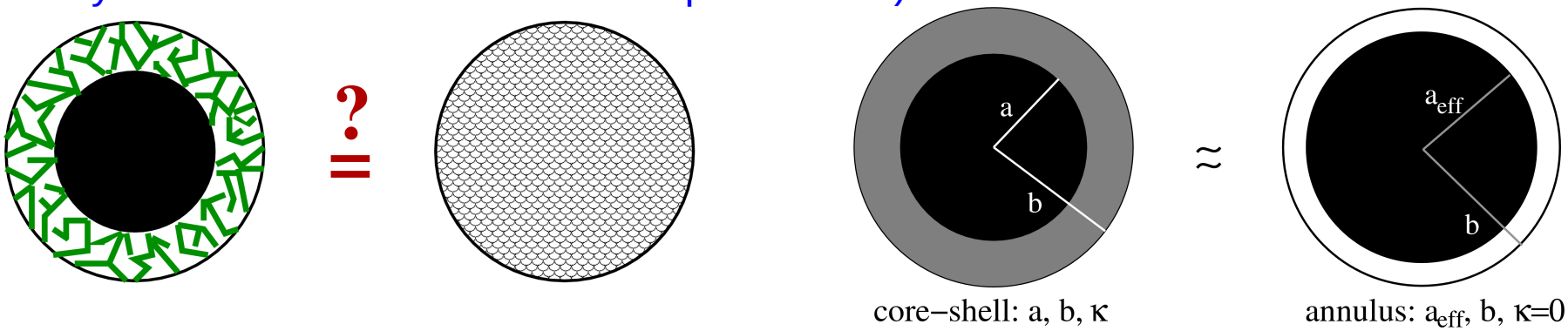



Most interesting results:
The closer the wall, the shorter the drop lifetime and the shorter distance L it settles until destabilization.

Left: experimental results, A. Myłyk. W. Meile, G. Brenn, Phys. Fluids 2011 (h – distance from the drop center to the wall)

#2 project : Diffusion, sedimentation and viscosity of suspensions made of uniformly permeable particles or core-shell particles

People from our lab: M. L. Ekiel-Jeżewska, E. Wajnryb, and Bogdan Cichocki, Faculty of Physics, University of Warsaw, Poland, Gerhard Naegele, Research Centre Juelich, Germany, Gustavo Abade, University of Brasilia, Brazil (J. Chem. Phys.,Phys. Fluids, Phys. Rev. E, J. Phys. Condens. Matter, Colloids Surf. A, 2010-2012)
Facilities/equipment: HYDROMULTIPOLE numerical codes
Most interesting results: accurate values of the translational and rotational self-diffusion, sedimentation and effective viscosity of suspensions of uniformly permeable or core-shell non-deformable spherical particles, in a wide range of the parameters, are well-approximated by the hydrodynamic radius (annulus) model (hard core with the hydrodynamic radius and the no-overlap fluid shell)

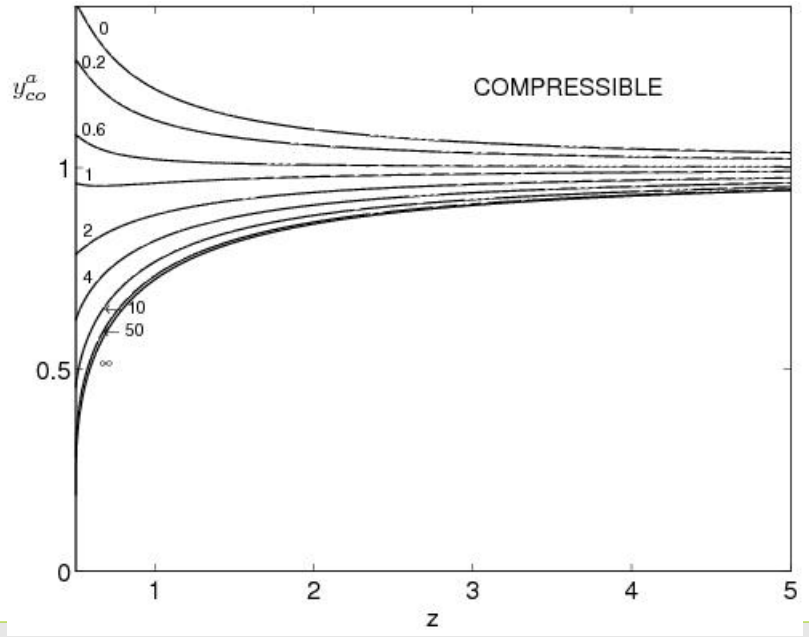


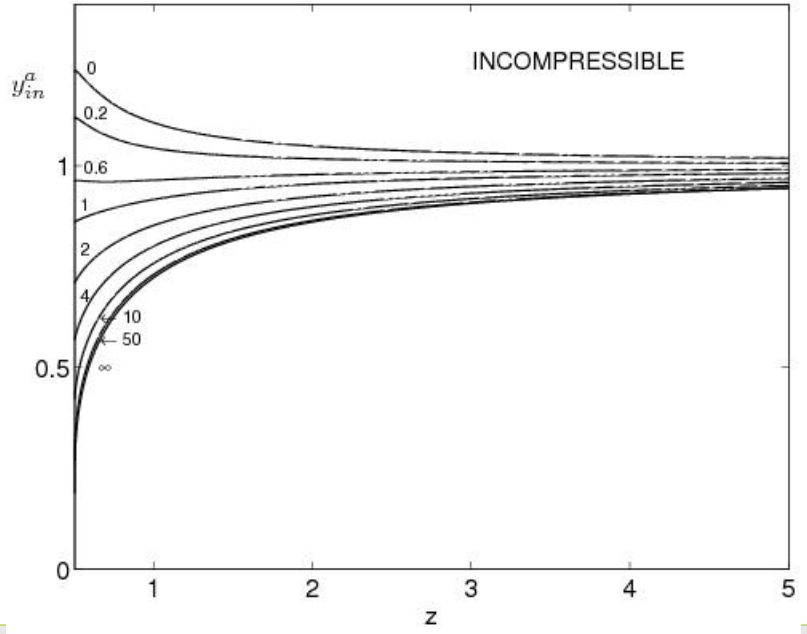

core–shell: a, b, κ

annulus: $a_{eff}$, b, κ=0

#3 project : Hydrodynamic interactions of spherical solid particles close to a fluid-fluid interface, pure or covered with a surfactant

People from our lab: M. L. Ekiel-Jeżewska and E. Wajnryb together with Jerzy Blawzdziewicz, Texas Tex University, Lubbock, U.S.A. (J. Chem. Phys. 133, 2010)
Facilities/equipment: HYDROMULTIPOLE numerical codes
Most interesting results: a method to discriminate between pure and contaminated interfaces. Plots: single-particle mobility along pure (left) and contaminated (right) Interfaces vs. the distance z of the particle center from the planar interface between fluids of the indicated viscosity ratio.



#4 project: Self-diffusion of a spherical particle in an effective axisymmetric medium of rods

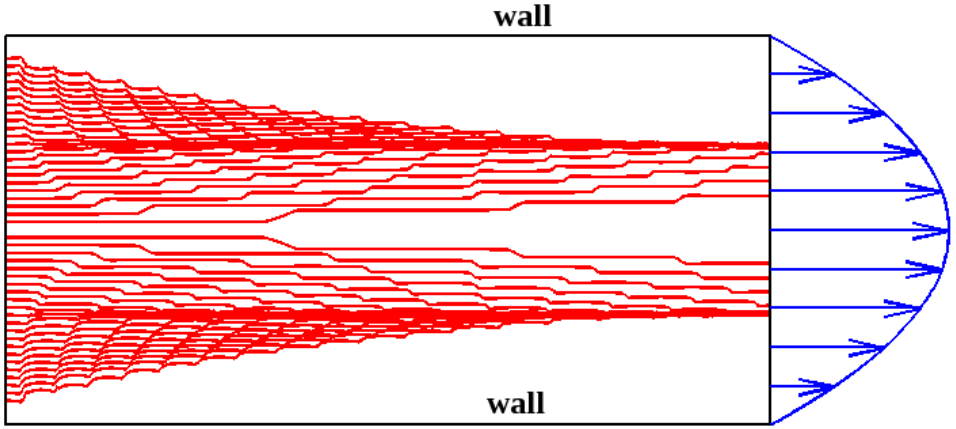
Authors from our lab: M. L. Ekiel-Jeżewska and Bogdan Cichocki, Faculty of Physics, University of Warsaw, Poland (J. Chem. Phys. 2009, J. Math. Phys. 2010)

Facilities/equipment: analytical results

Most interesting results: The Green tensor of the Debye-Bueche-Brinkman equations was generalized for axisymmetric medium, with the explicit exact solution for the case of no friction along the symmetry axis, Self-diffusion of a sphere in a network of rods was analyzed theoretically. Hydrodynamic interactions were taken into account based on the Debye-Bueche-Brinkman equation.

#5 project: Dynamics of deformable particles entrained by Poiseuille flow

Authors and their function: A. Słowicka (postdoc), E. Wajnryb and M. L. Ekiel-Jeżewska
Facilities/equipment: HYDROMULTIPOLE numerical codes
Most interesting results: Thin elastic micro-objects of a different length and flexibility entrained by the Poiseuille flow in a microchannel tend to accumulate at different distances from the wall. Theoretical evaluation of this relation is essential for sorting fibers, vesicles or other deformable micro-objects (submitted to EPJ E 2012)




Trajectories of flexible particles in Poiseuille flow

# Topics for Research Proposal

#1 Topic

Title: Dynamics and rheology of many-particle systems moving in fluids and permeable media at low-Reynolds number, for different particle shapes and internal structures

# Topics for Research Proposal

#2 Topic

Title: Hydrodynamic interactions between micro and nano particles and interfaces