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Main fields of research

- Dynamics of gas-liquid, gas-liquid-solid and solid-fluid mixtures (experiments and numerical simulations)
- Effect of surface active agents on the multiphase systems
- Bubble/drop breakup and coalescence phenomena
- Complex rheology of microdispersions, powders and granular mixtures
- Flow of gas-liquid dispersions in channels and microchannels
- Hydroacoustic detection of bubbles in shallow water reservoirs
- Stability and behavior of complex beverage foams

Research projects

Bubble break-up in a turbulent flow

(J. Vejražka, vejrazka@icpf.cas.cz, supported by GACR, project No. 15-15467S)

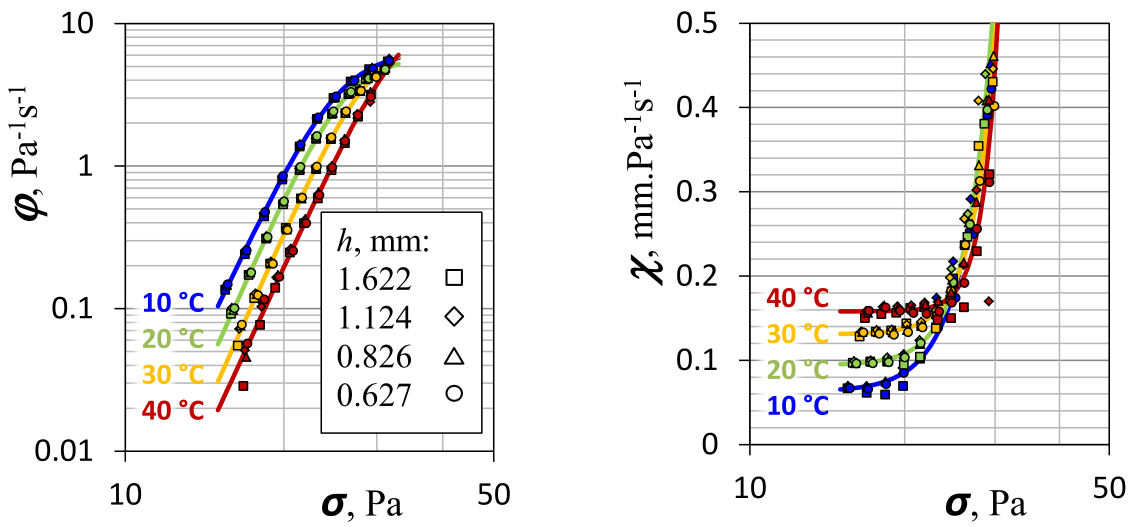
In frame of proposed project, breakup of fluid particles (bubbles and drops) in a turbulent liquid flow is studied. The probability of particle breakup and size distribution of daughter particles is established. It will be tested how the breakup process is affected by presence of surfactants in the system. Experiments are carried out in a channel, in which turbulent energy can be controlled. Velocity field and turbulence characteristics are measured using PIV. The particle breakup is recorded by means of high-speed camera. The experiment allows determining the breakup frequency and the size distribution of daughter particles in dependence on local mean shear, turbulence properties (ε, two-point cross-correlations) and on properties of bubble or drop interface. The final result should be the validation of current models for particle breakup or a new model, useable as breakup kernel in Population Blance Modelling (PBM) simulations.

Visualization of break-up sequence of a bubble in an experimental turbulent channel

Interface transport phenomena in microdisperse liquids

(V. Pěnkavová, J. Tihon, O. Wein, penkavova@icpf.cas.cz, supported by ICPF)

Flow of microdisperse liquids along a solid wall can be accompanied by the flow anomaly in proximity of the wall called apparent wall slip (AWS). Experimental detection of AWS effects is possible by performing a series of viscometry measurements over the same range of shear stresses in sensors with different gap thicknesses. These measurements must be executed precisely and a proper data treatment must be made to evaluate flow and slip functions reliably. A parametrical study of aqueous kaolin suspensions are made, where the fluidity and slip functions are obtained from the results of AWS viscometry. This parametrical study covers wide range of the kaolin concentration, temperature and surface quality of used sensors. The influence of deflocculating electrolytes, which are used for increasing flow-ability of kaolin suspension, is also studied. [Refs. 9, 13]

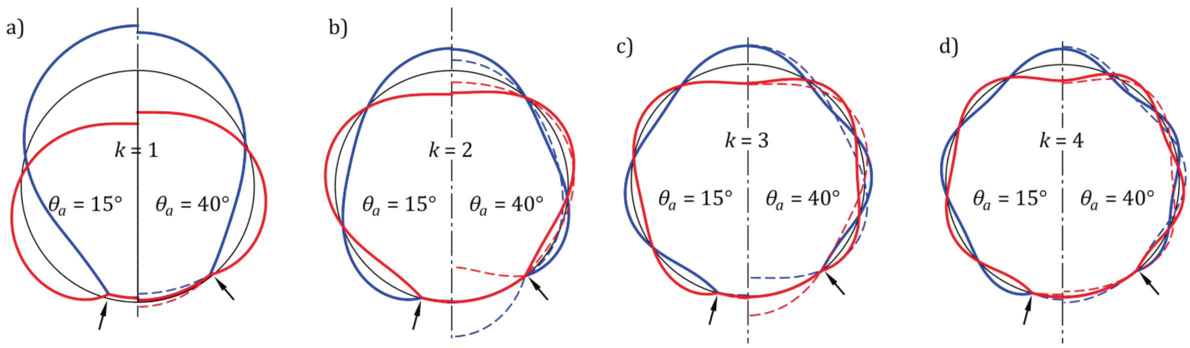


Fluidity φ and slip χ material functions evaluated for 30% aqueous kaolin suspension in sensor made from stainless steel with smooth surfaces at different temperatures. σ corresponds to applied shear stress, the legend inform about gap thickness h during measurement

Properties of the phase interface – their measurement and their influence on the behavior of macroscopic flows

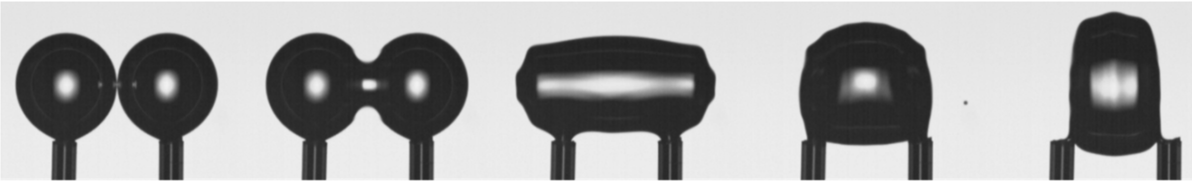
(J. Vejražka, S. Orvalho, vejrazka@icpf.cas.cz, international project COST, Smart and Green Interfaces, also supported by MŠMT, project No. MP1106)

The project aims to improve methods used for characterization of phase interfaces, and further to deepen the knowledge about the interface properties links to the behavior of macroscopic systems. Specifically a methodology for determination of the phase interface properties is developed, based on the evaluation of the shape oscillations of bubbles and drops. [Ref. 5]



Shape of the first four eigenmodes of a pinned bubble. Left halves of figures represent attachment angle θ = 15°, right halves of figures are for θ = 40°. The attachment positions are indicated by arrows. Solid lines are for the Strani & Sabbeta constraint, dashed lines are for the Bostwick & Steen constraint. Blue and red lines correspond to positive and negative displacement of the interface at the apex, respectively

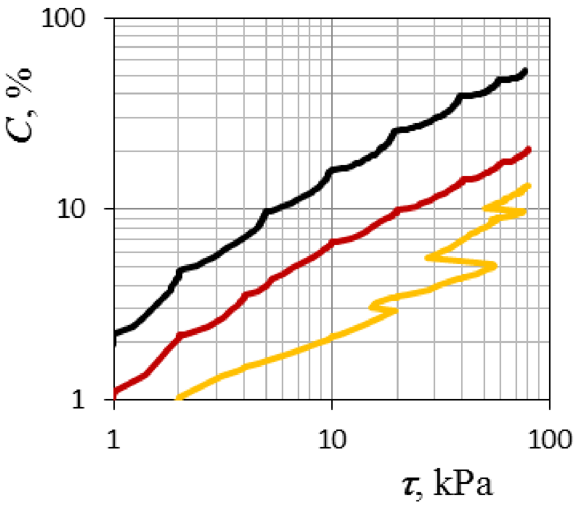
A devices with small channel instrumented with wall-mounted electrodiffusion sensors for diagnostics of multiphase flows in small channels is developed. Further, the effect of surfactants and electrolytes on the coalescence probability of bubbles and droplets is studied. The relation between dynamic parameters (bubble approach velocities, liquid viscosity) and bubble coalescence probability is found [Ref. 8]. Last but not least, the behavior of foams in dependence on interfaces properties is studied in order to clarify the stability of the beverage foams. [Ref. 7]

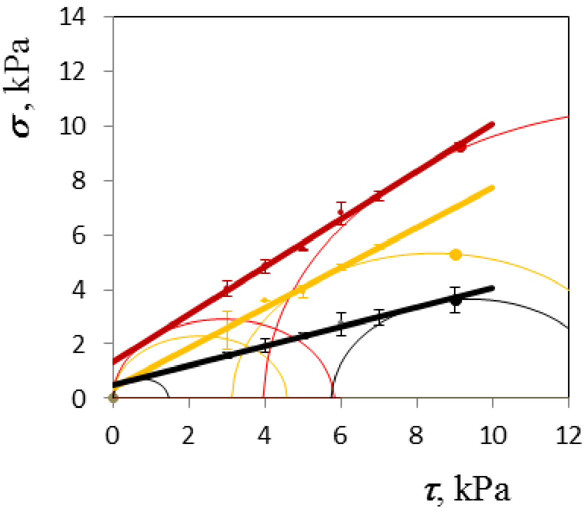


The bubbles synchronously grow on the capillaries till they touch. It marks the end of the inflation interval and the beginning of the contact time interval. Eventually, the bubbles either coalesce or detach from the capillaries separately [Ref. 8]

Structure-property relationships and breakage dynamics of complex granular material
(M. Růžička, M. Punčochář, V. Pěnkavová, L. Kulaviak, ruzicka@icpf.cas.cz, penkavova@icpf.cas.cz, supported by GACR, project No. 15-05534S)

A granular material in the form of a layer of particles or granules with a complex internal structure is common in many engineering applications. As compressive and shear stress field is applied, the material undergoes structural changes associated with deformation, breakage, and particle rearrangement within the layer. The present understanding of the link between primary particles properties, applied stress field, and the structure evolution, is mostly based on empirical knowledge only. The proposed research project consists of Discrete Element Method (DEM) simulation of different scenarios, where a granular material is subjected to stress field. For a subset of suitable scenarios, measurements in powder rheometer will be carried out in parallel with the simulations to verify their validity. An extensive data set generated by both the simulations and the experiments will be analyzed in a search for fundamental principles and relations describing granular material structure evolution.



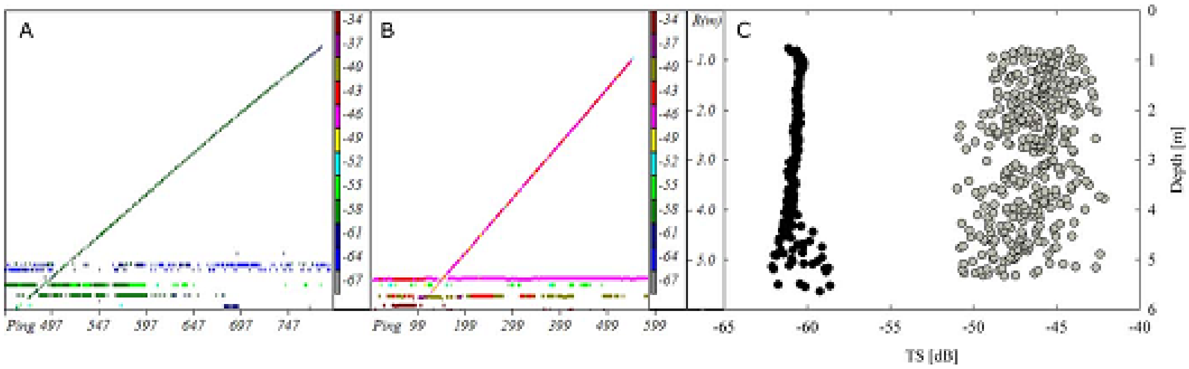


Compressibility *C* and shear stress *σ* in dependence on applied normal stress *τ* measured using powder rheometer FT4 for three different granular materials with needle-like shaped particles. High compressibility and low friction are exhibited by the elastic material (glass fibres – black lines), less compressibility and the highest friction are exhibited by cohesive material (terephtalic acid – red lines), and the fractures on compressibility curve and high friction exhibit the breakable material (rod-like pasta – yellow lines)

Hydroacoustical distinguishing between fish and bubbles, and quantification of methane bubble ebullition in freshwater reservoirs of temperate zone

(P. Stanovský, stanovsky@icpf.cas.cz; joint project with Institute of Hydrobiology and Biology Centre of the CAS; supported by GACR, project No. P504/12/1186)

The method for estimation of methane ebullition from bottom sediments of shallow freshwaters was subject of presented research. Artificially prepared methane bubbles of various sizes were released from a bottom in a freshwater reservoir. An acoustic target strength (TS) of these bubbles was measured using both the vertical and horizontal beams of a 120 kHz frequency split-beam sonar used by fisheries. Relationship of the mean TS variation with bubble volume was obtained in both modes of observation. Further, TS distribution around mean value was presented as well and its width and shape was discussed in relation to the bubble path and change of bubble size during rise. TS changes during rise for both the vertical and horizontal mode of observation was within the range of standard deviation of TS measurement and model for dissolution have shown that gas exchange is compensated by expansion of bubble during rise. Hence depth effect could be neglected for evaluation of acoustic target strength regression models used in shallow waters down to 6m. [Ref. 2]

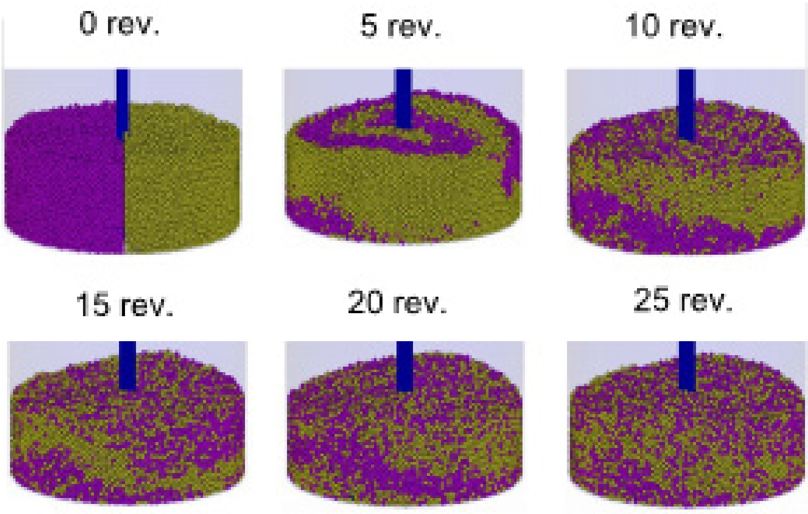


Echograms depicting a rising single bubble with initial size (A) D = 1.7 mm and (B) D = 9.8 mm from vertical acoustic observation. The (C) is chart of their acoustic target strength (dB) depending on depth, black dots mark bubble A and grey ones bubble B

Hydro-mechanical interactions of particles in solid-fluid systems

(J. Havlica, T. Trávníčková, havlica@icpf.cas.cz; joint project with UCT, Prague; supported by GACR, project No. P105/12/0664)

The behavior of granular media has been studied for a long time, due to their omnipresence and practical importance (rocks, soil, sand, cement, coal, food materials, technology media, pharmaceutical powders, etc.). Granular media are after water the second most widely used material in human activities. Many industries, such as agriculture, food processing, constructional, chemical or pharmaceutical, use granular materials on a large scale. From the physical point of view, granular materials are complex systems, whose are governed by mutual interactions. These interactions have crucial importance for prediction of flow behavior in process apparatuses or for correct design of industrial technologies. The main objective of this project is to suggest physical concepts for describing dynamical behavior of granular systems and suspensions. These concepts will be used for describing global macroscopic characteristics of unit chemical engineering operations. In the project we focus especially on the mixing of granular material, the process of the particle settling and fluid flow through the settled substrates. We expect that the project will bring important original results of description of granular system behavior. [Refs. 1, 4]



Snapshots of mixed granular bed initially radially divided into two halves with differently colored particles for the first 25 revolutions. The blade rotational speed is 15 rpm

International co-operations

Institute of Fluid Mechanics, Toulouse, France: Effect of surfactants on multiphase flows

Norwegian Institute of Technology (NTH), SINTEF, Trondheim, Norway: Bubble columns, bubble/drop breakup

Centre de Recherché et de Transfert de Technologies, Saint Nazaire, France: Microfluidics

Aristotle University of Thessaloniki, Thessaloniki, Greece: Microfluidics

Manufacturing and Process Technologies Research Division, University of Nottingham, United Kingdom: Experimental diagnostics in gas-liquid flows, bubble columns

Università degli Studi di Napoli Federico II., Italy: Bubble coalescence, effect of surfactants on flow in bubble columns

Publications

Original papers

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Patents

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