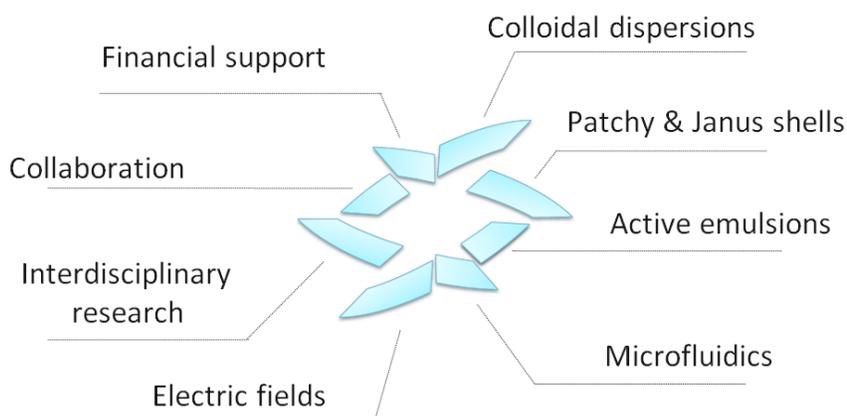


Project proposals for master students (2014/2015)



The following research projects are in experimental physics, and more precisely in **physics of colloids** being a subfield of soft matter physics. We are currently at the cutting edge of the research related to formation and manipulation of **Janus and patchy colloidal shells**. The fabrication of these structures serves as a starting point for producing patchy colloidosomes with domains of anisotropic chemical surface properties, permeability or mixed liquid-solid phase domains, which could be exploited to produce **functional emulsions**, light and hollow supra-colloidosome structures, or scaffolds. We utilize **electric-field-induced** phenomena, such as electrohydrodynamic liquid flow, electrostatic interactions and electro-coalescence to assemble particles on drop surfaces in order to form a shell of desired pattern.

We are interested in describing and elucidating some of the presently observed phenomena that have not been understood yet (basic physics); and also finding new functionalities and applications for these shells (applied physics). We plan to integrate the currently used experimental setup into **microfluidic devices**.

In addition to accepting student to work in our local laboratory at PAN-ICHF, we are also looking for students who wish to work up to 6 months during their Master thesis in the labs of the groups of our established **collaborations** in Norway (IFE-Kjeller), and Poland (UAM).

We primary seek for students of physics. However, students from other related disciplines are also very welcome.

For two research projects we offer **financial support** of 1000 PLN/month financed from the FNP grant, Homing Plus 2013-7/13. In addition, there is a possibility of receiving financial support for short exchange visits.

Principal contact for the projects described below:

Dr Zbigniew Rozynek, email: zrozynek@ichf.edu.pl

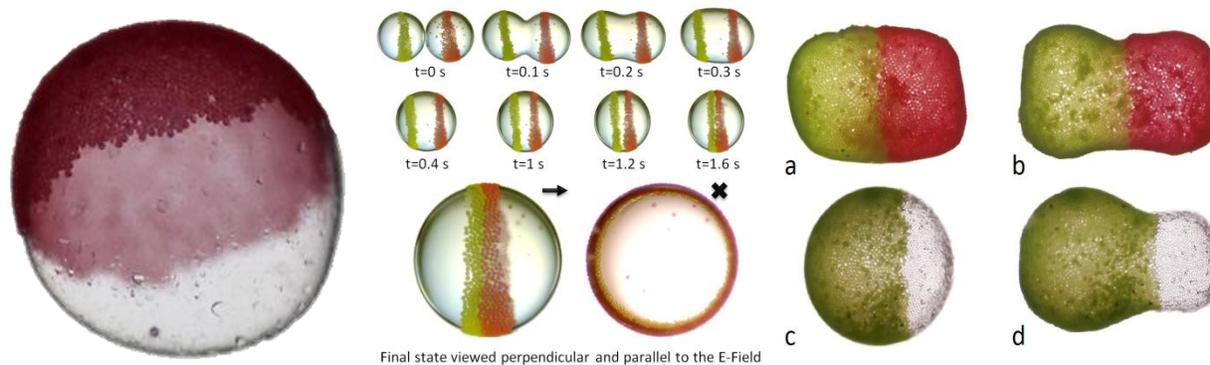
Mobile: (Polish) +48 503-775-401

Monodispersed Janus shells by microfluidics

Detailed description of project 1 (in collaboration with IFE)

This is a continuation of the research initiated at laboratory for soft and complex matter physics at NTNU, Trondheim. We have recently found, understood and published [1] how to structure and dynamically control colloidal particle assemblies at drop surfaces, including electric-field-assisted convective assembly of jammed colloidal ‘ribbons’ that enable us to obtain an interesting ‘pupil’-like effect. The assembly and manipulation of colloidal particles is achieved via controlled use of both electrohydrodynamic and electro-rheological effects. In the final remarks in [1] we anticipated that electric field manipulation of colloids in leaky dielectrics would have led to a design of new routes of colloidosome assembly and design for ‘smart armoured’ droplets. Therefore, shortly after publishing [1] we started utilizing the aforementioned phenomena to design Janus and patchy shells [2]. So far, we have worked with an experimental setup that allows fabricating and studying single drops and shells with diameter of around 1 mm. Now we wish to assemble colloidal particles at surfaces of smaller drops and produce them in larger amounts. Electric-field manipulation of droplets is often integrated in microfluidic circuits, and this includes drop electrocoalescence devices. We foresee that the route for designing patchy shells involving microfluidic systems will facilitate foundation for many advanced applications.

Fig. 1. From left: Janus shell made of hydrophobic colloidal polyethylene microbeads and hydrophilic clay minerals; Coalescence of two drops with ribbons; Different symmetric (a,b) and asymmetric (c,d) jammed shells.



Recommended literature to read:

- [1] P Dommersnes, Z Rozynek, A Mikkelsen, R Castberg, K Kjerstad, K Hersvik and J O Fossum, *Nat. Commun.* **4**, 2066, (2013).
Active structuring of colloidal armour on liquid drops
- [2] Z Rozynek, A Mikkelsen, P Dommersnes and J O Fossum, *Nat. Commun.* **5**, 3945 (2014)
Formation and Manipulation of Janus and Patchy Colloidal Shells
- [3] G I Taylor, *Proc. R. Soc. Lond. A* **291**, 159–166 (1966).
I. Studies in electrohydrodynamics. I. The circulation produced in a drop by electrical field.

Tentative schedule:

- 12.2014: reproducing the experiments, designing of a microfluidic chip with electrodes
- 01.2014: first simple shells made, short report written
- 02.2015: Janus shells made in a controlled fashion
- 03.2015: exchange visit at IFE, first chapters of Master’s thesis written
- 04.2015: more experiments, literature search
- 05.2015: Master’s thesis written is ready to be revised

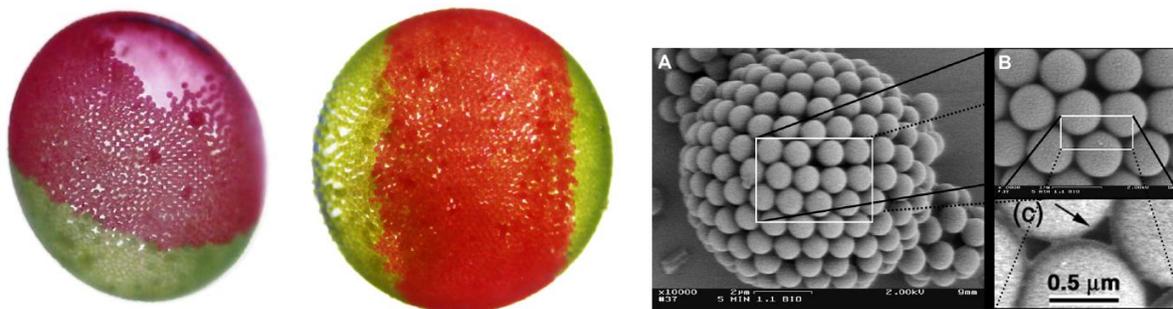
Formation, manipulation and properties of patchy colloidosomes

Detailed description of project 2 (in collaboration with UAM)

The route for designing of Janus and patchy colloidal shells described in [1] and [2] is a starting point for formation of patchy colloidosomes. The solid capsule fabrication will be performed in collaboration with IFE, since they have both the specialized equipment and expertise for/in UV curing and sintering methods. Colloidosomes will be then tested in terms of thermodynamical and mechanical properties.

Homogenous colloidosomes have been first time made and described by Dinsmore et al. [3]. However, to our knowledge, heterogeneous structures realization has not been described yet. Patchy colloidosomes with domains of anisotropic chemical surface properties, permeability or mixed liquid-solid phase domains, combine functionalities offered by patchy particles and those given by permeable shells, can be exploited to produce functional emulsions, light and hollow supra-colloidosome structures, or scaffolds.

Fig. 2. From left: Partly covered drop's surface by colloidal polyethylene microbeads; a shell with two active sides; SEM image of a dried homogenous colloidosome [3].



Recommended literature to read:

- [1] P Dommersnes, Z Rozynek, A Mikkelsen, R Castberg, K Kjerstad, K Hersvik and J O Fossum, *Nat. Commun.* **4**, 2066, (2013).
Active structuring of colloidal armour on liquid drops.
- [2] Z Rozynek, A Mikkelsen, P Dommersnes and J O Fossum, *Nat. Commun.* **5**, 3945 (2014)
Formation and Manipulation of Janus and Patchy Colloidal Shells.
- [3] Dinsmore, A. D. et al. *Science* **298**, 1006-1009, (2002).
Colloidosomes: selectively permeable capsules composed of colloidal particles.
- [4] G I Taylor, *Proc. R. Soc. Lond. A* **291**, 159–166 (1966).
I. Studies in electrohydrodynamics. I. The circulation produced in a drop by electrical field.

Tentative schedule:

- 12.2014: reproducing the experiments, designing of a microfluidic chip with electrodes
- 01.2014: first simple shells made, short report written
- 02.2015: Janus shells made in a controlled fashion
- 03.2015: exchange visit at UAM, first chapters of Master's thesis written
- 04.2015: more experiments, literature search
- 05.2015: Master's thesis written is ready to be revised