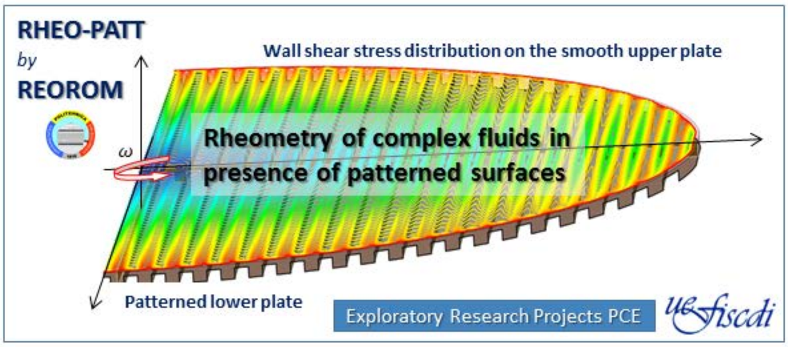

Objectives

The experimental rheology of bulk materials is based on the assumption that samples can be tested in simple flows (shear or extensional) without any interference from the "end effects" induced by the finite working geometry or by the domain boundaries. Tacitly, it is always considered that wall adhesion condition is not violated, therefore we have no slip at the boundary.

Especially in the last two decades (when both stress and strain controlled experiments became commercial available) there were observed anomalous effects in rheometry of complex fluids, mainly generated by wall depletion phenomena. Observations disclose slipping or apparent slipping at the wall which induces uncertainty on the characterization of the bulk rheology[1]. It is important to mention that all fluids characterized by yield stress manifest such behavior.

The distinction between real slip at the boundary and bulk material instability of complex fluids is one of the most challenging problem in rheometry.

*The **main objective** of the project is to elucidate if is any relation between the boundary conditions at the wall and macroscopic constitutive relation of fluids which disclose wall depletion phenomena.* This is a fundamental topic for fluid mechanics which might elucidates if slip at the wall of rheometer plates is associated with (i) an interfacial properties manifested exclusively at the contact *wall – fluid* (independent on the bulk rheology of the fluid), (ii) local dynamics of the fluid in vicinity of patterned walls (dependent on the surface micro-geometry) or, (iii) it is a phenomena generated inside the fluid (apparent slip), for a particular distribution of wall shear stress and adhesion forces. We believe that answer to this problem is given by

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[1] Barnes H.A. (1995) A review of the slip (wall depletion) of polymer solutions, emulsions and particle suspensions in viscometers: its cause, character and cure, J. Non-Newtonian Fluid Mech. **56**, 221–251
Joshi Y.M., Lele A.K., Mashelkar R.A. (2000) Slipping fluids: a unified transient network model, J. Non-Newtonian Fluid Mech. **89**, 303–335
Buscall, R. (2010) Letter to the Editor: Wall slip in dispersion rheometry, J. Rheol. **54**(6), 1177-1183

dynamics analysis of the Newtonian and complex flows in vicinity of smooth and patterned/structured surfaces.

*The **central goal** of the project is to establish the experimental procedures to characterize the rheology of complex fluids in rotational rheometers, where the plates are patterned with controlled structured micro-geometries*. We are looking to understand and to quantify the wall depletion phenomena in relation to the wall micro-geometry and material bulk properties. The influences of local wall patterns on the measured stresses/velocities distributions are studied for some families of complex fluids, samples with controlled chemical formulation and well defined surface properties. Our project is a fundamental research in the rheology of complex fluids with direct impact in developing novel directions for the design of rotational rheometers and applications in microfluidics.

To follow the announced objective, the project will investigate flows in five configurations: (a) shear between smooth or patterned plates (or cone-plate), (b) flow in close vessel generated by a bi-conic rotational geometry in the presence of an interface, (c) microchannels flows, (d) immersed jet impact on solid walls, (e) flows in vicinity of immersed patterned surfaces.

The objective and the main goal of the project define implicitly the areas of rheology and rheometry where are expected to be obtained value results:

1. **To establish an experimental procedure in order to detect and to quantify the slipping at smooth and patterned walls using rotational shear rheometers.**
2. **To model the flow of complex fluids in the very vicinity of solid and liquid interfaces, using the theoretical framework of the latest H. Brenner's papers**[2].
3. **To correlate the measurements in presence of smooth and patterned surfaces with the bulk constitutive relation and the corresponding local dynamics of the tested flows.**
4. **To analyze the "induced hydrophobicity" influence due to the presence of patterned surfaces on: (i) the rheological characterization of complex fluids in rotational rheometers, (ii) the fluid dynamics in microgeometries., (iii) the jet impact on solid walls and vortex ring formation.**

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[2] Brenner H. (2009) Bi-velocity hydrodynamics: Single-component fluids, Int. J. Eng. Scie. 47, 930–958
Brenner H. (2009) Bi-velocity hydrodynamics: Multicomponent fluids, Int. J. Eng. Scie. 47, 902–929
Brenner H. (2011) Beyond the no-slip boundary condition, Phys. Rev. E 84, 046309
Brenner H. (2012) Beyond Navier-Stokes, Int. J. Eng. Scie. 54, 67–98
See also:
Garcia-Colin L.S., Velasco R.M., Uribe F.J. (2008) Beyond the Navier-Stokes equation: Burnett hydrodynamics, Physics Reports 465, 149-189
Goddard J. (2010) On material velocities and non-locality in the thermo-mechanics of continua,Int. J. Eng. Scie. 48, 1279–1288

The proposed project has two particularities which make the approach innovative, especially for the domain of applied rheology and rheometry:

1. The experience and education of the project director in the fields of rheometry and continuum mechanics. The project director was educated in the spirit of Truesdell and Oldroyd works, he is familiar with the papers of Brenner and Rajagopal, spent a long time making experiments in the laboratories of Ken Walters, H. M. Laun and Ch. Macosko and has contributions (minor but decent) in developing novel techniques in rheometry. I am familiar with the concepts of *intermediate configuration* (Rajagopal) and *bi-velocity theory* (Brenner), but at the time I am able to recognize that more than 90% of the viscosity curves publish today are not obtained in steady state and I know how to determine the flow curve of fluids with yield stress at low and very low shear rates. One major aim of the project is to integrate the experimental investigations (performed with smooth and controlled patterned surfaces) in a theoretical framework suggested by Brenner[10].

2. The experimental program proposed in this project is new for rheometry. We intend to develop on a Paar-Physica Platform a system to measure simultaneous the torques on both plates. We shall investigate the influences of patterned walls on the measurements (in shear and squeezing) and propose a novel quantitative coefficient to characterize the induced slip due to the presence of micro-geometry on the surface of working plates. The measurement will be performed in close and controlled atmosphere to avoid any interference of external phenomena (e.g. evaporation or gas/moisture presence in the sample). We believe that experimental investigations will produce value results for the progress of rheometry.

3. The experimental investigations will be also focused to microfluidics applications. The study and modelling of fluid behavior in vicinity of patterned surfaces can offer a new insight of the possible generation of dynamic hydrophobic surfaces and the control of adherence/slip phenomena in the transport of complex fluid in micro-configurations.