PhD in physics 2014 - 2017

Wetting at nanometer scale investigated by atomic force microscopy

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The study of the behaviour of liquids at nanometer scale is an emerging area of science. Many questions remain unanswered due to the lack of physical models coupling macroscopic hydrodynamics to molecular processes. In particular, the structure and dynamics of the contact line (the edge of a droplet) are poorly understood while they condition the physics of wetting. Experimentally, it is necessary to overcome the lack of experimental techniques allowing to probe liquids at nanometer scale.

We showed recently that atomic force microscopy (AFM), used in non conventional conditions, allow to address these issues and to give quantitative information on the shape of the liquid interface and on the dissipation processes in the vicinity of the contact line.

The aim of this thesis is the experimental and theoretical study of nanohydrodynamics of viscous liquids. The PhD student will in particular investigate wetting processes at nanometer scale using an AFM. Two approaches will be used:

- Direct imaging of droplets by AFM coupled with numerical modelling of tip – liquid interaction (fig. 1).

- Measurement of the mechanical properties of nanomeniscus obtained by immersion in a liquid interface of an AFM tip terminated by a nanoneedle or nanotube (fig. 2).

These original experiments will allow a systematic study of the elementary mechanisms of spreading of droplets at molecular scale. The project will also benefit from the development of multiscale physical modelling of wetting.

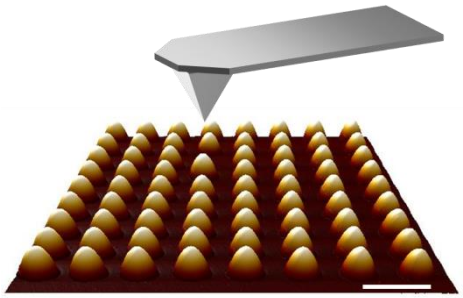

Fig. 1 :Array of nanodroplets with a diameter of 400 nm imaged by an AFM tip represented schematically.

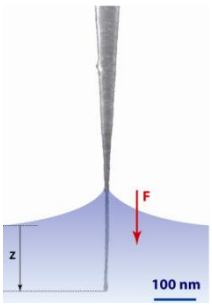

Fig. 2 : Représentation schématique d'un nanoménisque formé autour d'un nanocone de carbone.

This multidisciplinary thesis will take place in two labs (CEMES and IMFT) which have state-of-the-art equipment in scanning probe microscopy as well as a recognized expertise in numerical modeling.

It is funded in the framemork of an ANR project entitled NANOFLUIDYN involving CEMES, IMFT, the laboratory of physics of ENS Lyon and CBMN Bordeaux.

Recent publications:

"Nanoscale liquid interfaces", livre édité par T. Ondarçuhu et JP Aimé, Pan Stanford Publishing, 2013.
"Nanoscale Deformation of a Liquid Surface"
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"Contact angle hysteresis at the nanometer scale",
M. Delmas, M. Monthioux, T.Ondarçuhu, ***Phys. Rev. Lett.*** **106** (2011) 136102.
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R. Ledesma-Alonso, D. Legendre, P. Tordjeman, ***Phys. Rev. E.*** **85** (2012) 061602.
"Numerical simulation of spreading drops"
Legendre, Dominique; Maglio, Marco, ***Coll. Surf. A.*** **432** (2013) 29.
"Writing with liquid using a nanodispenser: spreading dynamics at the sub-micron scale"
L. Fabié, T. Ondarçuhu, ***Soft Matter*** **8** (2012) 4995-5001
"Capillary forces during liquid nanodispensing"
L. Fabié, H. Durou, T. Ondarçuhu, ***Langmuir*** **26** (2010) 1870-1878

Keywords

Physics of liquids, wetting, nanosciences, atomic force microscopy, numerical modelling.