1. Optical interferometer realized with a 3D printer

Summary: Optical interferometry is used in numerous fields as in fluid physics, biomedicine and environment. This optical technique provides very accurate information on the samples under investigation. One of the limitations of interferometry is the flexibility of the instrumentation and there is a need to improve the usual manufacturing schemes. Recently, the 3D printers were developed and became in few years a unique way to manufacture and produce parts or complete objects that cannot be realized otherwise. In this Master Thesis, we propose the realization of an optical interferometer with the new emergent technology of the 3D printers. This work will involve the design, the realization and the test of the interferometer.

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2. Functional patterning of surface by multi-layer/drops deposition

Summary: Additive manufacturing – a technique for manufacturing complex 3D object “layer-by-layer” – was first introduced in the ‘70, but it is only at the beginning of the XXI century that this technique became widely used in many industrial applications, thanks to the introduction of more advanced tools and processes such as stereo-lithography and laser sintering. In recent years, 3D-printing triggered a real technological revolution still on-going.

An intriguing possibility to achieve layered structures opportunely functionalized could consist in depositing and evaporating successive layers/drops of fluid dispersed with micro/nano particles. Playing on the dispersed phase concentration and modulating the environmental conditions (temperature, pressure, speed of deposition, and wettability of the substrates) it will be possible to create peculiar particle assemblies. The proposed work will then focus on characterizing those assemblies and their properties respect to some external stimuli (e.g. light wavelength selection in the case of a photonic crystal structure)

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3. Production of Hydrogen from Microalgae for fuel cell applications

Summary: In the last decades, the search for new sources of energy created an increasing interest for a special class of eukaryotic cells: microalgae. This interest was more than justified by considering that microalgae are a tremendous source of lipids (in proportion to their mass) but also of other very valuable by-products such as vitamins and proteins. More recently, it has been proved that some strains of microalgae (e.g. clamydomonas reinarditii) are able to up-regulate the expression of the enzyme hydrogenase – allowing for hydrogen production, when their culture media is deprived of sulphur based constituents and in anaerobic conditions.

The work proposed in the frame of this master thesis will consists in quantifying the amount of hydrogen one or more microalgae cultures are able to release in a specific period of time as a function of the development evolution of the culture.

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4. Mixing by vibrations

Summary: Microfluidics has recently motivated both fundamental and applied researches. The challenge is to find an optimal process to manipulate small liquid quantities, down to the nanoliter scale where convection is negligible. One of the ways to progress in the understanding the underlying phenomena is to perform experiments in microgravity where convection is also absent.
The work proposed in master thesis will focus on experiments on vibration in binary mixtures in order to control pattern and flow structures, mixing, observe onset of instability regimes that lead to creation frozen waves. All laboratory and numerical findings are verified in series of parabolic flights, which prepared and performed by the whole team in Novespace, Bordeaux. This work is considered as a one of step in frame of preparation space experiment VIPIL (Vibrational phenomena in liquids) which is planned on-board of the International Space Station.

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5. An experimental study on accumulation of particles into dynamic coherent structures in periodic flows

Summary: The student(s) working on the proposed project will be participating in preparation of the upcoming Japanese European Research Experiment on Marangoni Instability space experiment. This International scientific effort is dedicated to the study of an exciting phenomenon of appearance of coherent structures formed by a large number of small particles. It is known that they are a mere illusion of a rigid rotating body. Each of the structure-forming particles, in response to the repeatable interaction with the flow, performs an identical periodic motion. Since their first observation in periodic flows, scientists put much effort into explaining why such structures are formed. One of the theories explains the phenomenon to the general mechanism of synchronization, which is encountered everywhere in nature, e.g., in biological and astronomical systems. The work proposed in the frame of this master thesis will consist in performing experiments using the existing and functional experimental setup, and analyzing the obtained results. The periodic flow is created in a small-scale liquid column by imposing a temperature gradient along the liquid-air interface. The student(s) will be thoroughly supervised by experienced scientists and all the necessary help and guidance will be constantly provided.

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6. Controlling liquid phase behaviour for improvement of material processing by solidification // Liquid bridge

Summary: Directional solidification/crystallization and its subset, floating zone technique, are widely used technological processes for growing of technically valuable crystals with specially designed properties or for deep purification of electronic materials. All processes occurring in bulk of liquid phase are key players in getting desired properties/structure of obtained crystalline solid product. And in never ending chain of improvements, scientists and engineers are looking for new ways of affecting behaviour of the liquid phase. As typical technological processes of that kind happen at high temperatures and often with non-transparent melts, a common approach to understand phenomena inside liquid is to model it with low-temperature transparent emulator allowing easy access and observation. The proposed work will focus on a novel technique of affecting convection and heat transfer in the model of floating zone crystal growth based on forced external gas flow around liquid zone. Combined effect of improved heat exchange, evaporation and mechanical stresses should suppress or localize undesirable instabilities of fluid motion.

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7. Investigation of thermodiffusion (Soret) effect

Summary: The effect, named after discovered scientist, develops inside liquid mixture with non-uniform temperature distribution in the bulk. Then the molecules of the mixture redistribute, forming concentration gradient that normally follows thermal one. The effect is slow and can play a visible role in large, geological, scales. In some cases it can be responsible for redistribution of species in underground oil reservoirs staying millions of years in geothermal gradient; it can affect redistribution of salinity in ocean, possibly giving impact on climate change. Finally, it serves now for solar energy storage in so called solar ponds.
Apart of technical applications, studying of this effect is of great interest for science as it allows deeper insight into properties and behaviour of liquid and improvement of models of liquid state which now are still a long way off perfection.

Since the effect is small, its measuring poses high demands to experimental technique. It is based on optical diagnostics of superior sensitivity and precision, namely interferometry. Set of specific requirements to experimental cell turns its design into non-trivial engineering task as well. And the measurements of thermodiffusion coefficients for a set of liquid mixtures along with further improvement of the setup will be the objective of proposed work.

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