Optical methods for characterizing interfaces

CNRS GDR 2799
Micropesanteur Fondamentale et Appliquée

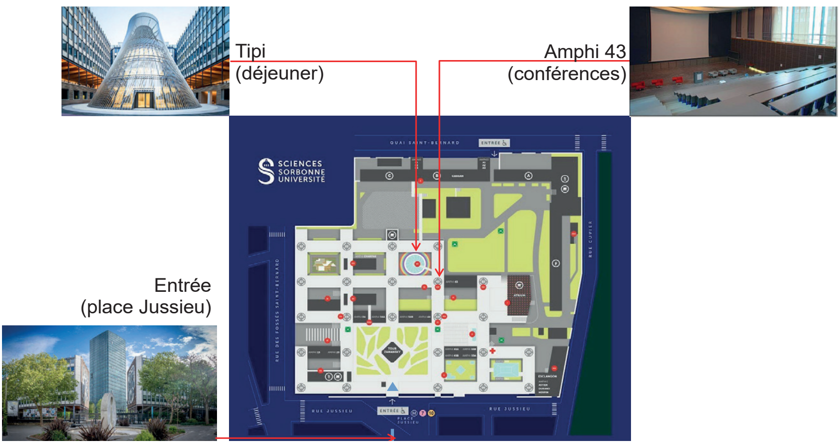
June 2nd, 2026
Sorbonne Université
Campus de Jussieu- Amphi 43

AGENDA

9 h 30	Welcome to participants
9 h 50	Introduction to the Day, Guillaume Legros, Catherine Colin
10 h 00	Optical Techniques for Investigating Interfacial Phenomena in Nucleate Boiling, Cassiano Tecchio
11 h 00	Characterization of solidification in transparent model materials: interface observation and shape analysis using interferometry, Nathalie Bergeon
12 h 00	Lunch at the Tipi
14 h 00	Optical Tomography Imaging: Basic Principles and Applications in Microgravity, Michael Antoni
15 h 00	Visualizing interfacial phenomena in freezing systems with confocal fluorescence microscopy, Sylvain Deville
16 h 00	End of the day

Free admission, registration required

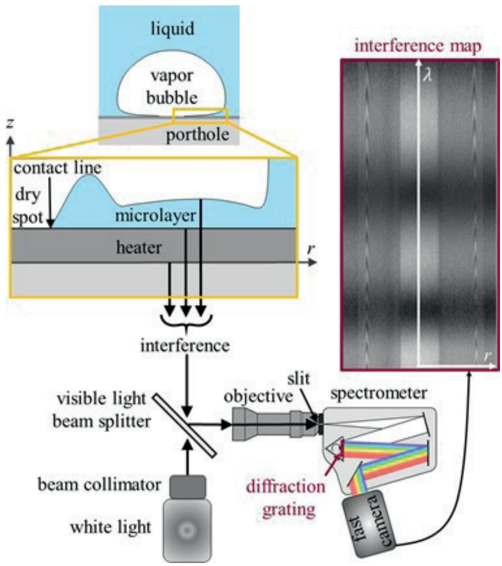
https://docs.google.com/spreadsheets/d/1oj4og9W0aA_vM8GCfZtrmgt-GI-I-nzXbR4NXb9yTwuM/edit?usp=sharing



Optical Techniques for Investigating Interfacial Phenomena in Nucleate Boiling

Cassiano TECCHIO - STMF, CEA, Université Paris-Saclay, 91191 Gif-sur-Yvette Cedex, FRANCE

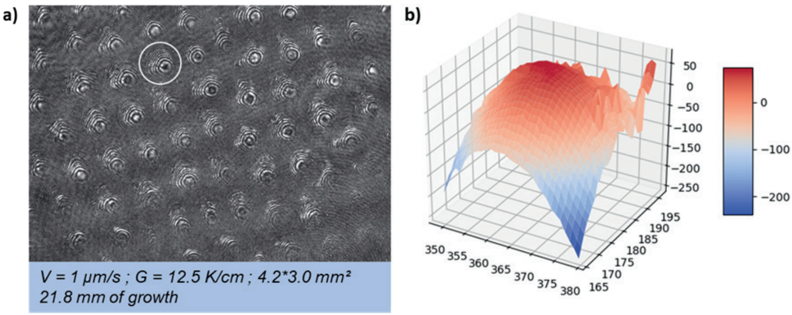
Among the various modes of heat transfer, nucleate boiling is known to provide the highest heat transfer coefficients. This regime is encountered in numerous industrial applications, including nuclear power reactors, phase separation in chemical processes, and the thermal management of high-power electronics. Under certain conditions, a thin liquid film—commonly referred to as the microlayer—with a thickness on the order of a few micrometers forms between the heated surface and the vapor bubble interface. The evaporation of this microlayer can contribute significantly to both bubble growth and heat removal from the heated wall. The physical mechanisms governing microlayer formation and evaporation remain poorly understood. Consequently, accurate characterization of the microlayer, particularly its spatio-temporal thickness evolution, is essential for improving our understanding of nucleate boiling heat transfer. In this talk, I will present the development of a spectrally resolved, high-resolution, and high-speed optical measurement technique based on white-light interferometry. This method enables precise measurement of key physical parameters required to investigate microlayer dynamics during the growth of a single bubble in nucleate boiling. The integration of this approach with complementary diagnostic techniques will also be discussed, along with several illustrative experimental results.



Characterization of solidification in transparent model materials: interface observation and shape analysis using interferometry.

Nathalie Bergeon
Institut Matériaux Microélectronique Nanosciences de Provence UMR 7334, Marseille

The MISOL3D (3D Solidification Microstructures) scientific project, conducted in collaboration between the IM2NP laboratory, CNES and NASA, aimed to perform directional solidification experiments on bulk samples (1 cm diameter cylinders) aboard the International Space Station (ISS). To enable in situ and real-time observation of solid-liquid interface dynamics, this research focused on transparent organic alloys with microstructures analogous to those of metallic alloys. The DECLIC-DSI instrument developed for this purpose allowed characterization of the solid-liquid interface using various complementary observation modes, which will be explained in the presentation. Interferometric diagnostics will be discussed in particular detail. This observation method allows the interface to be imaged as interferometric fringes analogous to contour lines, enabling the reconstruction of the three-dimensional shape of the structures. Its use and the associated analyses will be illustrated with various examples.



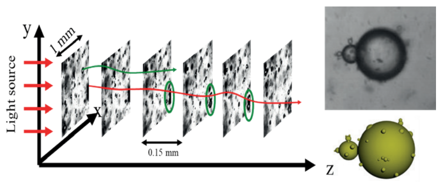
Example of an interferometric analysis of a dendrite tip. In the interferometric image shown in (a), the circled dendrite is analyzed to reconstruct its 3D shape (in (b)). (SCN - 0.46% by weight camphor, DECLIC DSI-R campaign aboard the ISS)

Optical Tomography Imaging:
Basic Principles and Applications in Microgravity

Mickaël Antoni - Laboratoire MADIREL - Aix Marseille Unniversité

Constantly evolving thanks to technological advances in data acquisition and storage, tomography has established itself as an indispensable tool for exploring complex environments. Its applications span fields as diverse as medicine, biology, and materials engineering.

One of the main advantages of tomography, and more specifically of optical tomography, lies in its ability to provide three-dimensional visualization. It is based on measuring the intensity of light transmitted or scattered through a sample and, provided the phenomena under study are not too fast, allows for near-real-time imaging over extended periods of time. Furthermore, its micrometer-scale resolution and non-invasive nature make it a particularly well-suited tool for studying the kinetics of evolving complex systems.

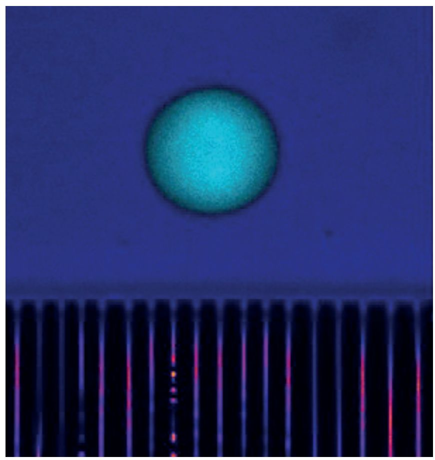


This presentation aims to highlight the interest of optical tomography for studying the physicochemistry of dispersed media in microgravity. It will be illustrated in particular by experiments on emulsions and recent results obtained with aerosols. These latter experiments aim to contribute to a better understanding of cloud microphysics and the mechanisms underlying global warming.

Visualizing interfacial phenomena in freezing systems with confocal fluorescence microscopy

Sylvain Deville, Institut Lumière Matière, Lyon

The characterization of interfaces during freezing processes is critical for understanding the interactions between ice and diverse particles, ranging from biological particles to bubbles or synthetic particles. Confocal fluorescence microscopy emerges as a powerful tool to probe these interfaces at the micrometer scale, offering high-resolution, time-resolved, three-dimensional imaging capabilities. This technique enables the visualization of spatial distribution, structural organization, and dynamic behavior of fluorescently labeled components at ice-particle interfaces, providing insights into mechanisms such as particle nucleation, deformation, and interaction with the ice. These results demonstrate the potential of confocal fluorescence microscopy to advance our understanding of interfacial phenomena in freezing systems, with implications for cryopreservation, materials science, and environmental sciences.



In situ confocal fluorescence microscopy imaging of an oil droplet interacting with a moving ice/water interface