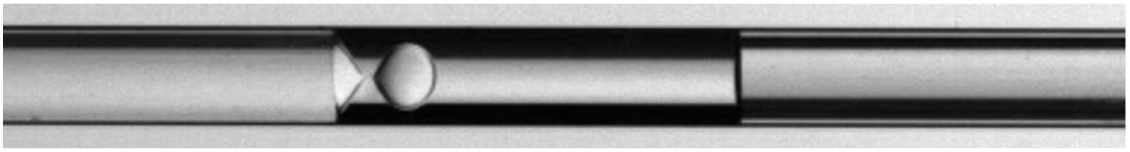
Abstract

Transport phenomena below the capillary length scale

- habilitation thesis -

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The thesis addresses interfacial transport phenomena and their intrinsic dynamics at length scales associated with surface tension. The research activity in this subfield of fluid mechanics targets capillarity in the context of self-sustaining flows, controlled droplet production processes, interfacial phenomena associated with droplet formation, the description of novel flow regimes, liquid recovery from narrow spaces, the rheology of viscoelastic fluids, and mathematical modeling of capillary flows. These studies contribute to a deeper understanding of phenomena that occur at the capillary length scale.

The fundamental research area associated with this subfield of fluid mechanics represents an active research direction at an international level with multiple ramifications in adjacent fields, such as physical modeling, numerical simulations, the dynamic nature of the contact angle, fluid transport enhancement strategies, rheology and microfluidics. From a technical perspective, these studies have the potential to provide innovative solutions to critical problems in heat and mass transfer, controlled and efficient droplet production techniques, and energy storage.

The first chapter of the thesis considers multiple technical applications of capillary flows, showcasing how these applications demonstrate and support research in the field of capillarity and interfacial phenomena as an essential and integral part of energy engineering studies.

The second chapter of the thesis shows the scientific output through an extensive analysis of published and ongoing scientific studies, with emphasis on the research projects implemented as a coordinator. The studies encompass transport processes

in partially prefilled capillary tubes, capillary flows in the presence of air cavities, underwater capillary flows, surfactant-induced capillary flows, capillary extractions, emptying of containers through capillary orifices, processes of bubble or droplet deposition on solid surfaces and various instabilities associated with surface tension. The chapter explains in detail the direct connection between the quality of the scientific results and the corresponding articles published in prestigious journals in the field (Journal of Fluid Mechanics, Physical Review Fluids, Physics of Fluids, Scientific Reports, Chemical Engineering Research and Design), and also the ability of these results to attract research grants.

Next, the thesis presents the main academic and professional results concerning the review activities for journals or scientific events, national awards obtained in the field of research, membership in scientific organisations or advisory committees, and books published in the field of research. Special attention is given to the teaching process that also involves the management of human resources in an academic environment, a subchapter in which the following essential aspects are presented in detail: participation as a coordinator of students at international and national scientific communication sessions, awards obtained with students as a coordinator, studies implemented as a coordinator, bachelor's/dissertation theses as a coordinator, Q1/Q2 articles published as author and coordinator, scientific mentorship, support and mentoring activities addressed to students, lectures intended to promote science among students, the research group created to support young students eager to contribute to science and technology.

The last chapter presents the main research directions in terms of fluid transport driven by capillarity, the interfacial phenomena in which mass transfer is achieved via fragmentation, the discovery of new physical manifestations of fluid bodies, and the exploration of new configurations with potential applications in engineering and technology. The chapter presents several ongoing studies aimed at implementing original ideas and unexplored experimental and theoretical scientific configurations, which belong to interfacial phenomena as a subdomain of fluid mechanics, an essential component in energy engineering. The paper concludes with a series of future development actions. These include improving the teaching process and scientific mentoring for students, disseminating research results to the international scientific community, creating tailored laboratory papers for students, and securing research grants to maintain and expand the research group.