

Preface

This book is based on advanced fluid mechanics course taught by the author at Southern Methodist University, primarily for graduate students in applied mathematics and mechanical engineering. The main focus of the course has been on fluid mechanics of microscale systems with liquid–gas, liquid–liquid, and liquid–solid interfaces. An introductory graduate-level fluid mechanics course was a pre-requisite, so students were expected to be familiar with the fundamentals of fluid mechanics of single-phase systems. The focus of the present book is on mathematical modeling of interfacial flows rather than on various sophisticated experimental techniques devised to investigate these flows on the microscale. The author’s objective is to provide detailed descriptions of mathematical techniques and working numerical codes and thus make it easier for an applied math or engineering graduate student to start their research work in the field of interfacial fluid mechanics.

The interest in interfacial phenomena has been motivated by a number of practical applications of fluid mechanics in microscale systems. Remarkable examples of such systems include portable “lab-on-a-chip” devices for conducting blood tests using a small droplet of blood or identification of a virus by specific genetic sequences in a small sample containing a roughly purified DNA. Excellent discussions of these and many other applications can be found in several recently published books mentioned in the end of Chap. 1. By choosing a certain set of topics for this introductory book on the subject, the author does not attempt to state that these represent the most important problems in microscale fluid mechanics. Instead, the choice is often guided by how suitable a certain physical problem is for illustrating a mathematical method with a wide range of applicability. In some cases, the choices were also biased by the author’s own research interests. Sections which contain advanced material are marked by asterisks (*). Several topics from interfacial fluid mechanics, most notably theories of interfacial instabilities, are covered in standard graduate textbooks on fluid mechanics and therefore received relatively little attention in the present book.

Many parts of the book benefited from numerous illuminating discussions with my scientific mentors, Professors S.H. Davis and G.M. Homsy, and with a number of wonderful collaborators from all over the globe, especially D. Brutin, T. Gambaryan-Roisman, E.Ya. Gatapova, O.A. Kabov, P. Stephan, L. Tadrist, and O.I. Vinogradova. I would also like to acknowledge many stimulating discussions of numerical methods of applied mathematics with my colleagues at SMU, especially I. Gladwell and J. Tausch. I am deeply grateful to several colleagues who took time to read various parts of the book. They are Steffen Hardt, Bud Homsy, Rouslan Krechetnikov, David Willis, and several anonymous referees. Many current and former SMU graduate students, especially Jill Klentzman and Christiaan Ketelaar, provided useful feedback on the manuscript.

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