PREFACE

A two-month program on Nanoscale Material Interfaces: Experiment, Theory and Simulation was held at the Institute for Mathematical Sciences (IMS) at the National University of Singapore (NUS) from November 2004 to January 2005. The goals of this program were to: (i) review the recent development in the research on materials surfaces and interfaces, from experiment to theory to simulation; (ii) identify critical scientific issues in the understanding of the fundamental principles and basic mechanisms of interfacial dynamics in different kinds of materials systems, particularly those that are characterized by fluctuation, multiscale, and non-equilibrium; and (iii) accelerate the interaction of applied mathematics and computational science with physics and material science, and promote the highly interdisciplinary research on new material interface problems with emerging applications.

As part of the program, tutorials were conducted by leading experts in the fields. These tutorials covered dynamics in models of coarsening, coagulation, condensation and quantization as well as complex fluids and were meant for graduate students and researchers who would like to prepare themselves for original research in the fields. The current volume collects four expanded lecture notes with each self-contained tutorials. In the following, we give a brief introduction to these tutorials here:

Part I. Lectures on dynamics in models of coarsening and coagulation by Robert Pego: It starts with a hierarchy of different domain coarsening models in one space dimension, explores different models to domain coarsening in two and three dimensions, derives rigorous power-law bounds on coarsening rates by using the Kohn-Otto method, and studies the Smolushowski's coagulation equations and dynamics on the scaling attractors.

Part II. Quantized vortices in superfluids – a mathematical and computational study by Qiang Du: It provides a concise description of

the physical background, several relevant mathematical models, and the numerical methods developed for the study of the motion and interaction of quantized vortices in the celebrated Ginzburg-Landau models of superconductivity and the mean field Gross-Pitaevskii equations of superfluidity.

Part III. The nonlinear Schrödinger equation and applications in Bose-Einstein condensation and plasma physics by Weizhu Bao: It begins with the derivation of the nonlinear Schrödinger equation (NLS) from wave propagation and Bose-Einstein condensation (BEC); reviews variational formulation, plane and solitary wave solutions, existence/blowup results, WKB expansion and quantum hydrodynamics, Wigner transform and semiclassical limit of NLS; presents different numerical methods for computing ground states and dynamics of Gross-Pitaevskii equation with applications in BEC. Derivation of the Zakharov system with application in plasma physics is provided and different numerical methods are proposed for efficient computation.

Part IV. Introduction to constitutive modeling of macromolecular fluids by Qi Wang: It gives a crash course on the basics needed to model the complex fluids in fundamental thermodynamics, statistic mechanics, polymer physics and continuum mechanics, surveys the existing models for various polymeric liquids and explores a systematic approach for flexible polymers and liquid crystal polymers within the framework of the kinetic theory.

Besides us, the other members of the Organizing Committee are Gan-Moog Chow (Material Sciences Department, NUS), Weinan E (Princeton University), Yuanping Feng (Physics Departmnet, NUS), Bo Li (University of California at San Diego and Co-Chairman), Ping Lin (Mathematics Department, NUS and Co-Chairman), Chun Lu (Institute of High Performance Computing, NUS), Xingbin Pan (East China Normal University), Chang Shu (Mechanical Engineering Department, NUS), Eitan Tadmor (University of Maryland), Xuesen Wang (Physics Department, NUS), Kaiyang Zeng (Institute of Materials Research Engineering, NUS), Yongwei Zhang (Material Sciences Department, NUS). We are very much grateful to their invaluable services. Thanks also to all the participants of this program for their support and stimulating interactions during the two months!

We would like to take this opportunity to thank Professor Louis Chen, Director of IMS, for his leadership in creating an exciting environment for

mathematical research in IMS and for his guidance throughout our program. The expertise and dedication of all IMS staff contributed essentially to the success of this program. Last but not least, we would like to acknowledge IMS for providing financial support to the program.

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