HIGH-TEMPERATURE LEVITATED MATERIALS

One of the major experimental difficulties in studying materials at extreme temperatures is unwanted contamination of the sample through contact with the container. This can be avoided by suspending the sample through levitation. This technique also makes metastable states of matter accessible, opening up new avenues of scientific enquiry, as well as possible new materials for technological applications.

This book describes several methods of levitation, the most important being aerodynamic, electromagnetic and electrostatic. It summarizes the state of the art of the measurement of structural, dynamic and physical properties with levitation techniques, the considerable progress made in this field in the past two decades and prospects for the future. It also explores the concepts behind the experiments and associated theoretical ideas.

Aimed at researchers in physics, physical chemistry and materials science, the book is also of interest to professionals working in high-temperature materials processing and the aerospace industry.

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For Gordon Squires

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Preface

The origins of this monograph can be found in a game of bridge played one evening at the 1994 Gordon Conference on High-Temperature Chemistry in Meriden, USA, the participants being Jimmie Edwards of the University of Toledo, Shankar Krishnan, then at Containerless Research Inc. (CRI), and Marie-Louise Saboungi and myself, then at Argonne National Laboratory (ANL). The outcome of the game is best left unrecorded, but a more fortunate consequence of the evening's proceedings was the inauguration of a CRI–ANL collaboration on structural studies of aerodynamically levitated liquids, first with neutrons at the Intense Pulsed Neutron Source at Argonne and subsequently with X-rays at the National Synchrotron Light Source at Brookhaven, supported by a Small Business Innovative Research Grant from the US Department of Energy. Many interesting experiments ensued, some of which are described in this work. A few years later, Marie-Louise Saboungi and I were invited by Jean-Pierre Coutures, Director of the Center for Research on Materials at High-Temperature (CRMHT), Orléans, France, for a three-month visit. This led to an eventual move to Orléans, with occasional breaks at places like Trinity College, Cambridge, where the idea of writing a book for Cambridge University Press came up.

The monograph that resulted aims to summarize the state of the art of the measurement of structural, dynamic and physical properties with levitation techniques, the considerable progress made in the past two decades and the prospects for the future. In addition to exploring for the benefit of scientists in other fields the various levitation and heating techniques currently in use, I have tried to explain the concepts behind the experiments and the associated theoretical ideas, so as to familiarize a student reader with a considerable section of modern condensed matter physics and materials science.

The book is aimed primarily at research students, scientists and faculty in physics, physical chemistry and materials science. While the overall style is

appropriate for an academic audience, I hope that it will also be of interest in the industrial community – especially regarding high-temperature materials processing and the aerospace industry.

I should like to take the opportunity to express my appreciation to my Ph.D. supervisor Gordon Squires, who played a key role in the conception of the work, collaborators at ANL, CRI – especially Shankar Krishnan, already mentioned – and CRMHT – especially Louis Hennet. Finally, I am most indebted to Marie-Louise Saboungi who came up with most of the creative ideas in this and many other projects in which we have worked together.

I am grateful to the Master, Lord Rees, and the Fellows of Trinity College for the Visiting Fellow Commoner award during which this work was initiated. I also wish to thank the anonymous reviewers for excellent suggestions.