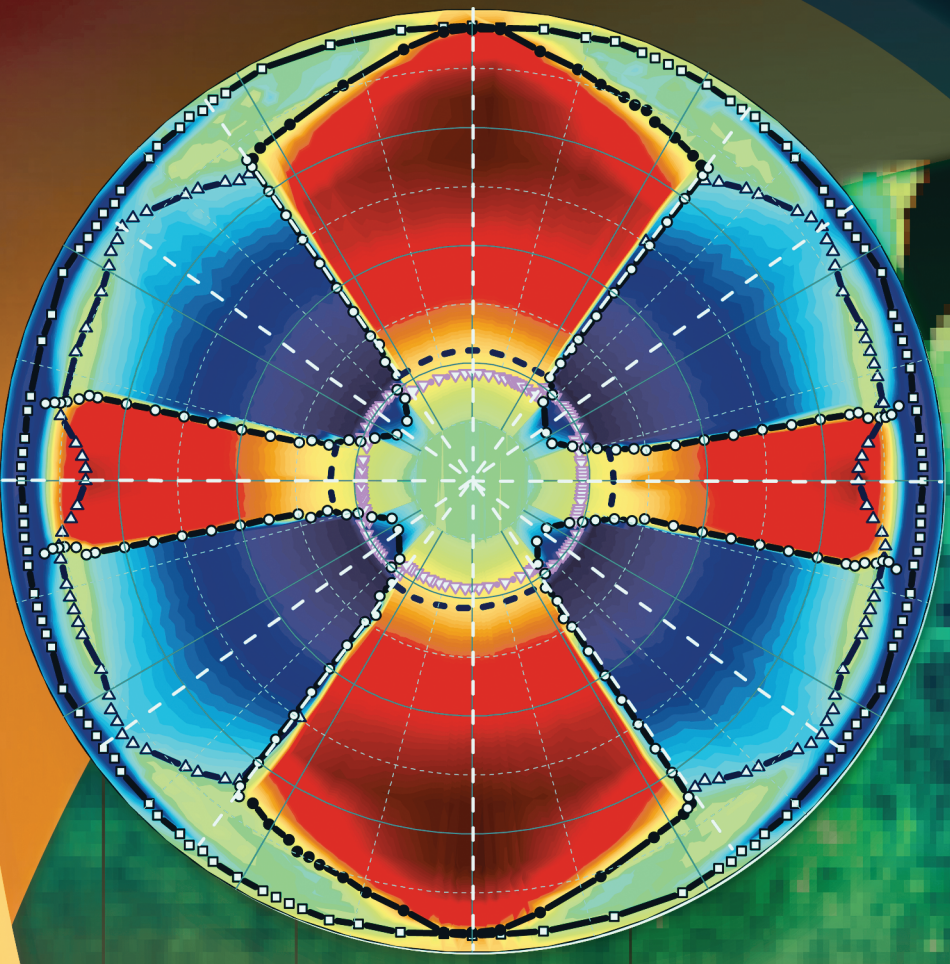

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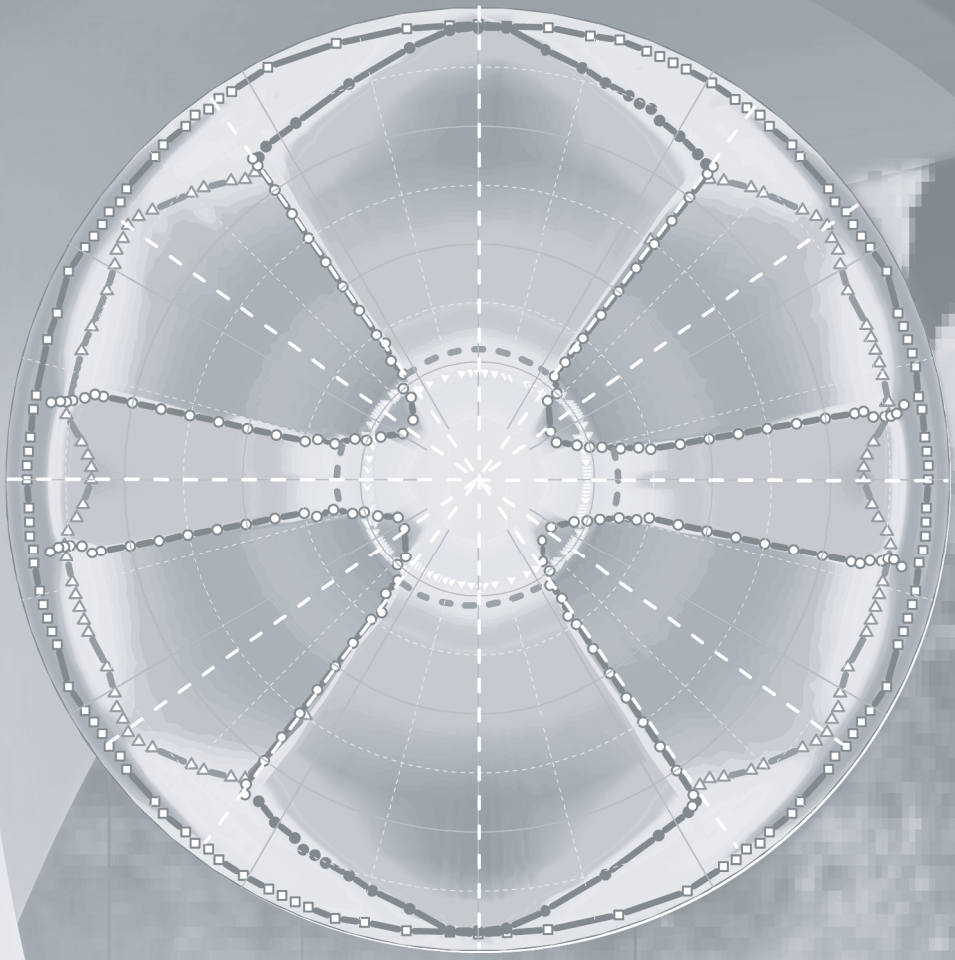

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Preface

This book deals with the multifarious family of binary crystalline compounds formed between the rare-earth elements and boron. Most of these compounds are not at all new, as the history of rare-earth borides extends over almost a century. Many excellent reviews about their crystal chemistry and physical properties have already been published. So why would one need another book on the subject?

This review volume is motivated by a recent surge of interest in rare-earth borides across various seemingly unrelated areas of condensed-matter physics, which has intensified considerably in the past two decades. Research on the topics of magnetic frustration in the Shastry–Sutherland lattice of tetraborides, topological electronic properties in the Kondo insulators SmB_6 and YbB_{12}, and the multipolar "hidden-order" phases in CeB_6 remains at the forefront of the most actively pursued areas in the physics of correlated electron systems, for both experiment and theory. The burgeoning interest in rare-earth borides has also motivated a meticulous re-examination of their structural and electronic properties, revealing a number of delicate and exciting phenomena such as the boron isotope effect on the local lattice symmetry, structural and electronic instabilities, and an extreme sensitivity of the physical properties to crystalline defects or impurities. Our advances in understanding these subtle effects go hand in hand with the progress in crystal-growth technology and the development of modern physical characterization methods.

This book is intended for researchers and advanced undergraduate and graduate students interested in the physics of rare-earth compounds, in particular solid-state chemists, crystallographers, and both experimental and theoretical physicists. It consists of 11

chapters, which are cross-referenced but can be otherwise seen as independent reviews. Every chapter begins with a short but comprehensive overview of the early research in the field before moving on to the main emphasis of the more recent developments that are discussed from the personal viewpoints of the authors.

Chapters 1 and 2 are concerned with the material aspects of rare-earth borides in the form of single crystals and thin films, respectively. High-quality samples are an important prerequisite of any modern experiment, and therefore much attention is paid to the importance of sample quality characterization and the optimization of growth methods in order to achieve the desired physical properties. Chapter 3 focuses on crystallographic aspects of the lattice structure of dodecaborides and, in particular, subtle effects related to the symmetry-lowering distortions of the lattice, whereas the influence of such structural and electronic instabilities on the physical properties is discussed in detail in Chapter 4. The lattice dynamics of metal borides are discussed both in Chapter 5 from the perspective of Raman scattering and in Chapter 6 from the viewpoint of neutron spectroscopy. Chapter 6 also describes the role of neutron scattering in understanding the magnetic excitations and magnetovibration interactions in hexa- and dodecaborides. Applications of modern x-ray spectroscopy to the analysis of competing low-temperature ordered phases in hexa- and tetraborides are discussed in Chapter 7, with an emphasis on "hidden-order" phases with multipolar order parameters. The theoretical approach to treat such multipolar order in rare-earth boride Kondo systems and to calculate the associated magnetic excitations is developed in Chapter 8, followed by the experimental Chapter 9, where these predictions are verified on one of the most studied hidden-order compounds, CeB_6, using inelastic neutron scattering (INS). In particular, neutron-spectroscopy results in magnetic fields with varying orientations to the crystal lattice are presented, which bear a close relationship to the electron spin resonance (ESR) in CeB_6. The interpretation of both INS and ESR data in strongly correlated electron systems is far from straightforward, and the corresponding theory for CeB_6 is introduced in Chapter 10. Finally, Chapter 11 is devoted to the bulk and surface properties of SmB_6, which attracted

much attention in recent years after it was predicted to be a strongly correlated topological Kondo insulator.

In closing this preface, I would like to thank all the authors of this volume for their contributions and for very detailed, friendly, and constructive discussions. I am especially thankful to Nikolay Sluchanko and Natalya Shitsevalova for first introducing me to the exciting physics of borides during the ICM'09 conference in Karlsruhe more than a decade ago. I am grateful to Alistair Cameron, Darren Peets, Sahana Rößler, and Marein Rahn for their help in proofreading and improving some of the chapters, as well as to Anas Shahab and Mubashir Ali for the technical assistance with typesetting the book in LaTeX.

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