such as Charles Mason and Jeremiah Dixon's surveying work in North America and James Cook's voyage to the South Pacific in 1769. Joseph Banks, a gentleman botanist from Lincolnshire who took part in Cook's voyage as a naturalist, became an instant celebrity on his return and was elected president of the Royal Society in 1778; he served until 1820. It was Banks, more than anyone, who helped to develop the society's role in public life and the advisory functions it still exercises today.

Tinniswood's account of the society's history from about 1800 to the present, including Banks's transformative presidency, is rather perfunctory, focusing on a couple of episodes only. He offers a useful retelling of the society's drawn-out efforts to exclude women until the election of Kathleen Lonsdale and Marjory Stephenson as the first women fellows in 1945, but his account of the debates in the 1930s about the social responsibilities of science and scientists could have been extended. Within the constraints imposed by brevity, however, Tinniswood's book is an entertaining and remarkably balanced account of a fascinating institution.

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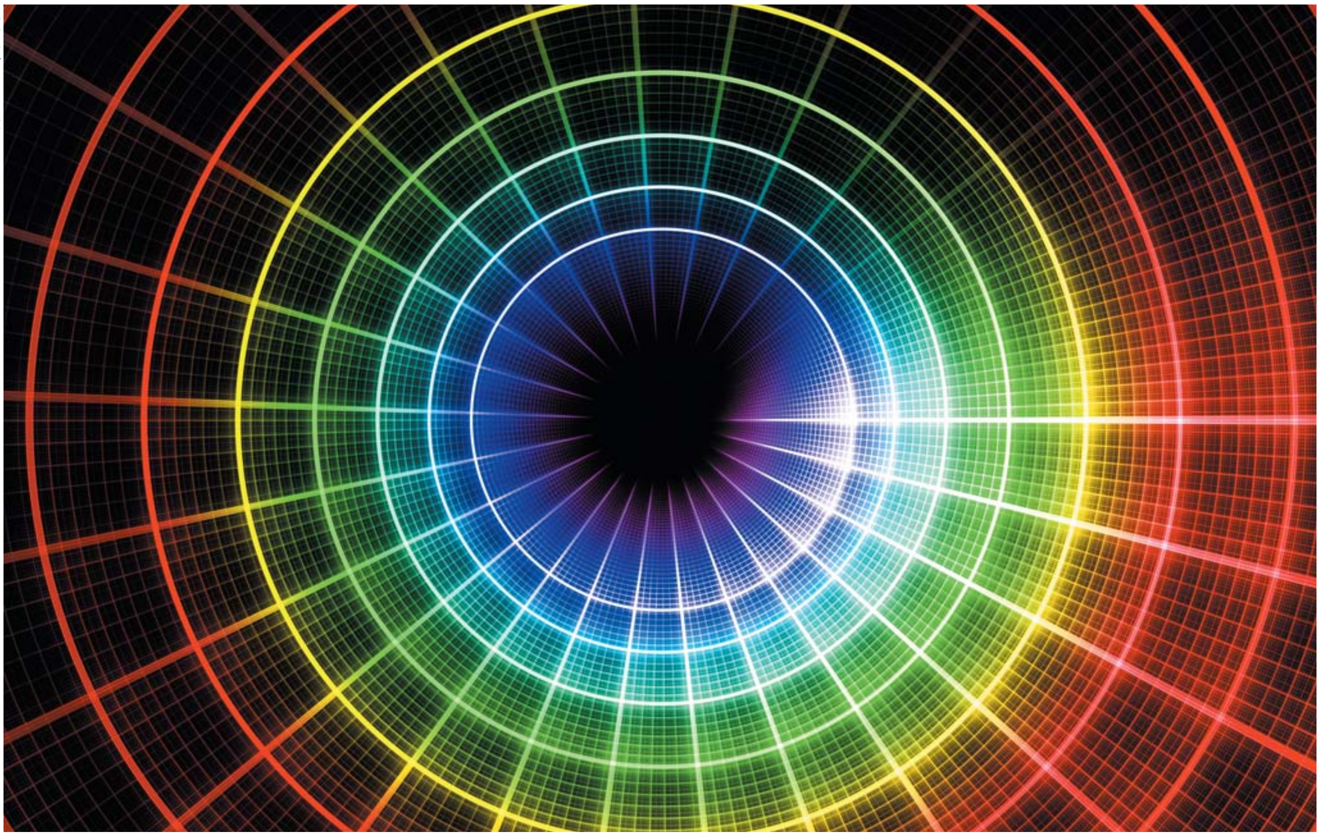

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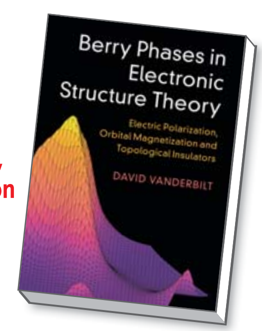
The mathematics and physics of electronic structure theory

Berry Phases in Electronic Structure Theory
Electric Polarization, Orbital Magnetization and Topological Insulators
David Vanderbilt
Cambridge U. Press, 2018. $79.99



The theory of electric polarization underwent a genuine revolution in the early 1990s. In the wake of that revolution, some long-established views about other observables have been superseded, the most notable being orbital magnetization. The geometry of the electronic ground state provides the formal mathematical expression for those observables, and the archetype for all of them is the geometric phase in quantum mechanics, discovered by Michael Berry in 1984.

Berry Phases in Electronic Structure Theory: Electric Polarization, Orbital Magnetization and Topological Insulators provides a comprehensive pedagogical account of several breakthrough developments in electronic structure theory associated with geometric phases. Its author, Rutgers University physicist David Vanderbilt, is eminently qualified for the task: He is the senior author of a large part of the research at the book's core. That literature is now fundamental knowledge for any scientist working on modern electronic structure. Some of the methods presented in Vanderbilt's book have such wide-ranging impact and use that they are now standard options in many open-source computer codes for electronic structure in solids.

The book's presentation combines mathematical rigor with illuminating discussions and examples. It clearly connects the underlying mathematics with the physics of the phenomena addressed. Although several review papers over the years have covered some of the same topics, Vanderbilt's book is the first to present them systematically and comprehensively at the textbook level.

Berry Phases in Electronic Structure Theory is primarily aimed at graduate students, and it looks like the ideal textbook for any special-topics course that broadly covers geometry and topology in electronic structure. It comes at a time when such courses are becoming more and more popular worldwide. The book is also aimed at both theorists and experimentalists who want to become familiar with geometric or topologic observables and, more generally, with the most basic concepts in electronic structure that have been unveiled in the past three decades.

Electric polarization and orbital magnetization, two of the observables Vanderbilt mentions, are basic undergraduate-level concepts that unfortunately often receive severely flawed accounts in other textbooks. General literacy about those topics beyond the community of electronic-structure specialists is poor. Vanderbilt's comprehensive treatment of electric polarization and orbital magnetization will hopefully improve the situation. The book also addresses other, less popular, observables and concepts, all based on the geometry and topology of the electronic ground state in solids.

The book's first three chapters are devoted to introductory or formal topics. After a semiquantitative overview of phenomena that have a geometrical or topological character, the book starts at an elementary level and provides the fundamentals of electronic structure theory. I have noticed that a large part of the geometrical–topological literature often overemphasizes tight binding. Vanderbilt, however, begins with first principles and then progresses to the tight-binding level, an approach that I prefer and that is more appropriate to a textbook.

After that review, the book addresses "Berryology,"—Vanderbilt's neologism for geometry in electronic structure—first in a very general way and then in terms of crystal momentum and in relationship with band-structure theory. The Wannier functions in their modern formulation, pioneered by the author in the late 1990s, are a key part of that section. The last three chapters of the book are devoted to the geometrical or topological observables, namely electric polarization, quantum anomalous Hall conductivity, the nature of the topological insulating state, orbital magnetization, and the so-called axion term in magnetoelectric coupling.

Every chapter includes traditional paper-and-pencil examples and exercises along with computational ones based on an open-source package developed by the author in Python. Thus the book encourages students and researchers alike to take a hands-on approach to the many fundamental properties of electrons in solids.

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