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Introduction to Graphene-Based Nanomaterials. From Electronic Structure to Quantum Transport. 2nd edition. By Luis E. F. Foa Torres, Stephan Roche and Jean-Christophe Charlier. Cambridge University Press, 2020. Hardback, 476 pp. Price GBP 74.99. ISBN 978-1-108-47699-7

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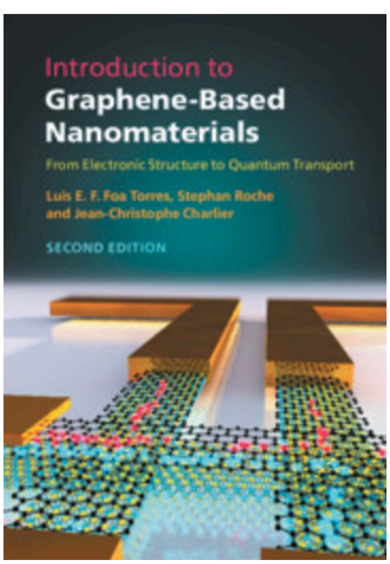
Five years after the publication of their book entitled *Introduction to Graphene-Based Nanomaterials: From Electronic Structure to Quantum Transport*, Luis E. F. Foa Torres, Stephan Roche and Jean-Christophe Charlier provide us with a second edition. During this time much has happened in the field of the so-called two-dimensional materials [a widespread yet incorrect expression for single-layer materials (Nespolo, 2019)], which is still growing extremely rapidly and, therefore, a new edition of this book is very timely. Since I have already reviewed (Lebègue, 2014) the first edition of the book, here I will mostly concentrate on the novelties and updates present in the second edition.

This new edition contains ten chapters, instead of eight for the first edition, and consequently the book has gained about 50 pages. The first chapter, entitled *Introduction to carbon-based nanostructures*, is a short introduction to carbon chemistry, and is essentially kept identical to the first version of the book. Only the guide to the book, which is the third part of this chapter, has been updated to reflect the changes made in this version. The second chapter, *Electronic properties of carbon-based nanostructures*, deals with some basics related to the electronic structure of graphene, nanoribbons and nanotubes. This chapter is identical to the corresponding one in the previous version, except that the parts 'Spin-orbit coupling in graphene' and 'Magnetic field effects in low-dimensional graphene-related materials' have been removed.

The next chapter, with the title *The new family of two-dimensional materials and van der Waals heterostructures*, is new to this edition, and presents in 20 pages 'two-dimensional' compounds which are usually designed as being 'beyond graphene'. Since new two-dimensional (*i.e.* layered) materials are discovered almost on a daily basis, keeping an up to date list of them is an almost impossible task, and therefore the authors have chosen to focus on the structural and electronic properties of a single layer of hexagonal boron nitride, transition metal dichalcogenides in the form of monolayers, phosphorene, borophene, silicene, germanene, stanene and MXenes. Then the chapter continues with a description of van der Waals heterostructures, which are stacks of layers. Several examples and applications are presented, and the fact that their properties are not simply the sum of the properties of the constituting blocks is clearly highlighted. The authors conclude the chapter by mentioning the possibility of finding new 'two-dimensional' materials through a computational search. Sadly, they did not cite the first study of this kind for these types of materials (Lebègue *et al.*, 2013).

The fourth chapter, which is identical to chapter three of the first edition, presents some general concepts on quantum transport, such as Landauer–Büttiker theory or the Kubo formula. The next chapter, with the title *Klein tunneling and ballistic transport in graphene and related materials*, presents several notions about electronic transport that are specific to carbon-based materials. This chapter corresponds to the fourth chapter of the first edition. Chapter 6, *Quantum transport in disordered graphene-based materials*, has the same title as the fifth chapter of the first edition, although it has been considerably shortened: the parts 'Quantum Hall effect in graphene', 'Amorphous graphene' and 'Phonon transport in graphene-related materials' have been removed.



Chapter 7, *Quantum Hall effects in graphene*, is new to this edition and can be seen as an extended version of the paragraph with the same title that was removed from the previous chapter. The concept of Berry phase is introduced and its observation in graphene is presented. Some other notions are detailed in this chapter as well, such as the Aharonov–Bohm gap opening, the orbital degeneracy splitting in carbon nanotubes and Landau levels in graphene. Then the quantum Hall effect in graphene is presented in detail and the chapter is closed by an introduction to the Haldane model.

The following chapter, entitled *Spin-related phenomena*, is also new to this book. It contains a section about spin-orbit coupling in graphene (which was already in the first edition but put in the second chapter), followed by a discussion about spin lifetime and how to measure it. The next section of this chapter entitled ‘Spin dynamics and relaxation mechanisms’ discusses the Elliot–Yafet and Dyakonov–Perel mechanisms in graphene. A subsequent section presents how to manipulate spins in two-dimensional materials, which is quite important in view of possible applications in spintronics. Then a section about the spin Hall effect follows, where it is introduced and a discussion about its possible enhancement in graphene is conducted. Then the chapter is closed by presenting the spin transport formalism and a computationally amenable methodology.

The ninth chapter, *Quantum transport beyond DC*, is identical to the sixth chapter of the first edition, while the tenth chapter, *Ab initio and multiscale quantum transport in graphene-based materials*, corresponds to the seventh chapter of the first edition. The eighth (and last) chapter of the previous edition about various applications of two-dimensional materials is not present in this new edition, which is not shocking since this book primary focuses on fundamental physics. The four appendices about density functional theory, many-body perturbation theory, Landauer–Büttiker formalism and recursion methods are unchanged in comparison with the first edition.

Overall this second edition reflects well the new directions that have been followed by researchers in this field over the last past five years. The chapter about materials not based on carbon (Chapter 3) could have been more developed, and the reader who is interested by more detail on them will have to search for a more complete source of information, which is fine since the book title contains the words ‘graphene-based nanomaterials’ and not ‘two-dimensional materials’ in general. So, I can only repeat the recommendation that I made in the review of the first edition: whether you are a student or an experienced researcher, this book will certainly act as a useful source of information if you decide to buy it.

References

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