

Aperiodic crystals: from modulated phases to quasicrystals. By T. Janssen, G. Chapuis, and M. de Boissieu. *IUCr Monographs on Crystallography*, No. 20. Oxford: IUCr/Oxford University Press, 2007. Pp. 466. Price GBP 75.00. ISBN 978-0-19-856777-6.

The discovery of solids with long-range ordered structure but without translational invariance has led to a fascinating new field of research which extends from mathematics *via* physics and chemistry to material science as well as crystallography. Although it has now reached a certain level of maturity, few textbooks are available for this field. The present volume closes this gap as far as the theoretical foundation regarding structure determination and structural properties are concerned. It also covers dynamical and electronic properties of the aperiodic solids. In contrast to more specialized approaches, in this book the different aperiodic crystal classes, namely modulated structures, incommensurate composites and quasicrystals, are described from a unifying point of view.

Only a basic knowledge of the main concepts of solid-state physics and crystallography is required. Wherever needed, more advanced concepts are introduced in a clear way, so that the book is easily understandable for a newcomer to the field. On the other hand, important aspects are covered in a thorough way which makes the presentation profitable also for specialists in the field. The book is certainly recommendable for everybody interested in one or more kinds of aperiodic crystal.

The introduction begins with a historic perspective, starting with periodic crystals. Believing that I could quickly glance over it, I was immediately stopped by an interesting detail, namely the extremely long periodic structure of so-called Nowotny phases with their modulated structure within the large unit cell. Of course, now it is only a small step from these crystals to modulated phases of aperiodic crystals, and from these phases to quasicrystals. Here again I found the historic description intriguing. One example is the reproduction of a page from Shechtman's notebook regarding the discovery of the icosahedral quasicrystals.

It is surprising how the authors succeed in introducing abstract concepts like the six-dimensional superspace in this context in an easily comprehensible way. Of course, the large number of figures helps the reader to understand the concepts and, for example, to distinguish between the different types of quasiperiodic structures. However, a grain of salt needs to be mentioned here: although the quality of most figures is high, there are some plots which could be improved. For example, the lower part of Fig. 1.15 is very poor in comparison with the upper picture. Or in Fig. 2.22, the scaled tiling is very difficult to identify.

The superspace concept allows the application of standard crystallographic techniques for the structure characterization. This is clearly described in the second chapter. The corresponding higher-dimensional space groups are discussed in the Appendix, where also the character tables important for quasiperiodic crystals are given. This is certainly a helpful list for all those who want to perform investigations of the structure of aperiodic systems

Aperiodic tilings are the topic of the third chapter. These tilings are models for the physical systems, here they are discussed from a mathematical point of view. The different methods to construct quasiperiodic tilings are illustrated, and also the theory of random tilings is briefly mentioned, as are their applications to the stability and the thermodynamic properties. Although I have done research in this area, I found a lot of interesting information in this chapter, too.

The structure determination by diffraction techniques is extensively treated in the next chapter. This is of course necessary to obtain information about the long-range ordering of the materials. In a short detour, the experimental techniques which are commonly utilized to derive the structure are mentioned. The various difficulties in obtaining the solution of the structure are discussed in detail. Practical aspects concerning the refinement and the validation of the structure are given adequate consideration. Also recent *ab initio* methods are covered, although in a relatively short section. The advantage of the superspace formulation is demonstrated for various aspects, *e.g.* for the structure determination of different phases

Then typical examples of modulated phases and composites are illustrated and here I appreciated that the authors restrict their presentation to a few examples and do not try to cover the whole collection of the complex structures. The structural determination of one-dimensional quasicrystals as a toy model is particularly illustrative. This is very helpful for the subsequent description of the structure determination of quasicrystals, where again representative examples of quasicrystalline structures are selected. Even with these restrictions the respective sections are rather lengthy but do remain interesting. Some concepts which were left out in previous chapters are introduced here, for example, the Mackay cluster.

But at the end of this chapter I missed the summary. Such a summary is given for most other chapters and I found it very useful that authors had added those concluding statements. I was all the more disappointed when the section about structure ended without a summary.

The different physical mechanisms for creating aperiodicity are presented in the fifth chapter and resulting phase diagrams are shown. The necessary introduction to the phenomenological Landau theory of phase transitions is provided. Then the important semi-microscopic models are applied to describe phase transitions and the kinetics in modulated phases. The subsequent discussion of the electronic instabilities is too short for my taste. Likewise, I would have appreciated a more extensive coverage of the numerical modelling of aperiodic crystals.

On first sight, it may appear surprising that the discussion of the physical properties in Chapter 6 begins with some tensor gymnastics. But it soon becomes clear that this is quite useful for the description of the phonons. Of course, the absence of a Brillouin zone makes the investigation of phonons and electronic states in aperiodic crystals much more complicated as compared to crystals with translational symmetry. Nevertheless, I think that the discussion of the simple models in one-dimensional systems is unnecessary lengthy. Much more

interesting is the investigation of the phasons, because these additional degrees of freedom which appear in the aperiodic crystals are unusual. Of course, the electronic states are important for a variety of physical properties. It may be a matter of personal taste, but again I found the presentation concerning the electronic states and the electronic properties too short.

The interesting morphology of aperiodic crystals is covered in the final chapter and the structure of the surfaces is also nicely illustrated here. The very short subsection about magnetic quasiperiodic systems is supplemented by a more detailed Appendix. Arguably, the topic might have deserved a chapter of its own.

I believe that my review has made it clear that from my point of view this book gives a very useful overview of the theory of the structure and the determination of the structure of aperiodic crystals. A comprehensive list of references helps the interested reader to find more detailed information. Not surprisingly, this list is somewhat biased with considerable weight on the papers published by the authors. But as these

authors are very active researchers and recognized specialists, this bias is not too incongruous.

What is inadequate, however, is the index of the book. Many important keywords are missing, and for the given keywords often the list of page numbers is by no means sufficient. The usage of the book would be much easier if the index were significantly enhanced. Likewise, a list of figures and a list of tables would be very helpful. Finally, in the preface symbols are introduced to indicate paragraphs which can be easily skipped. Unfortunately, these symbols are used only very rarely. But these criticisms cannot destroy the very positive impression which I got from this book, which in conclusion I recommend to everybody interested in this fascinating class of materials, called aperiodic crystals.

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