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Symmetry, Broken Symmetry, and Topology in Modern Physics: A First Course. By Mike Guidry and Yang Sun. Cambridge University Press, 2022. Hardback, pp. xv + 810. ISBN 9781316518618. Price USD 79.99.

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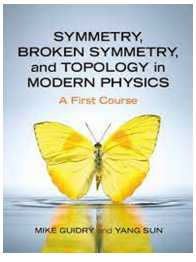
One of the many things that bring mathematicians, crystallographers and physicists together is the search for symmetry. The fact remains that a profound understanding of what symmetry is calls for a reasonable command of mathematical jargon and knowledge of mathematical toolboxes. Crystallographers and physicists are thus required to equip themselves with the knowledge of geometry, topology and, more importantly, group theory which is essentially the study of symmetries (Zee, 2015; Mala, 2022) (Figs. 1, 2).

Symmetry, Broken Symmetry, and Topology in Modern Physics by Mike Guidry and Yang Sun is written for use in teaching and self-study and is intended to provide a comprehensive and pedagogical introduction to groups, algebras, geometry and topology. The emphasis is on providing a wide range of modern applications including Lorentz and Poincaré invariance (Hsu & Zhang, 2001), spacetime symmetry, coherent states, quantum phase transitions, the quantum Hall effect, topological matter and Chern numbers, among many others. From the word go, the authors have exercised great caution in making sure that an example-based approach, in addition to the use of information boxes, is adopted to facilitate a profound understanding of key concepts. The book has 344 problems and comes with two supplementary manuals, the Instructor Solutions Manual and the Student Solutions Manual. Half the total number of problems, that is 172 problems, are fully solved for students in the Student Solutions Manual. The Instructor Solutions Manual contains solutions to all the problems in the book.

The book has been divided into four parts.

Part I, *Symmetry Groups and Algebras*, consists of the first 16 chapters of the book. It sets the tone for the entire book and subtly takes care of all the preliminaries, thereby attempting to make the book self-contained. Theoretical physics is based on symmetries, and so is our general picture of the universe. This book is about such symmetries and their many manifestations in nature. It aims to equip students with a theoretical and empirical understanding of the rudimentary fundamental properties of the universe. This part of the book lays the foundation of the key concepts in group theory – groups, their examples, their types, some of the basic properties of groups, and some special groups such as the permutation groups. According to the famous Cayley's theorem, all groups are essentially permutation groups. From the symmetries of a triangle to that of a Rubik's cube, groups are everywhere (Fig. 3).

It then goes on to discuss more advanced topics such as Lie groups, continuous groups with elements labeled by a finite number of parameters and a multiplication law depending smoothly on those parameters.



Part II, *Broken Symmetry*, is primarily about broken symmetry, a phenomenon where a disordered but symmetric state collapses into an ordered but less symmetric state (Gross, 1996). Symmetry breaking takes on two distinct meanings – the symmetry may be broken in essence or it may only appear to be so. The latter may more appropriately be termed hidden symmetry rather than broken symmetry. Modern or current-day theories of symmetry breaking may be classified into one of five – the Wigner mode, the Nambu–Goldstone mode or spontaneous symmetry breaking, the Higgs mode, dynamical symmetry, and anomalous symmetry breaking. Each of these have been detailed.

Part III, *Topology and Geometry*, consists of six chapters. Its primary concern is topology, topological spaces, differentiable manifolds, metrics and metric spaces. The

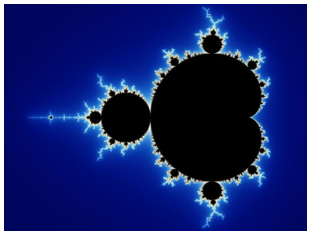


Figure 1
The Mandelbrot set. Created by Wolfgang Beyer with the program *Ultra Fractal 3*, CC BY-SA 3.0 https://creativecommons.org/licenses/by-sa/3.0/, via Wikimedia Commons.

Euclidean or the Minkowski space has a host of physical problems that possess properties not determined by local symmetries. This makes the study of topology all the more important. Continuity, smoothness and distance are the central concepts of this part of the book.

Part IV, *A Variety of Physical Applications*, is a compendium of some applications of the content of the book and includes treatments of angular momentum recoupling, nuclear fermion dynamical symmetry, superconductivity and superfluidity, and current algebra.

What sets this book apart from the majority of popular books covering similar subject matter is its remarkable combination of in-depth theory and practical applications. It covers a wide range of special topics, including electrons on periodic lattices, harmonic oscillators, the Lorentz group, the Higgs mechanism and quantum phase transitions, ensuring its appeal to both mathematicians and physicists. This book is highly esteemed for its pedagogical approach.

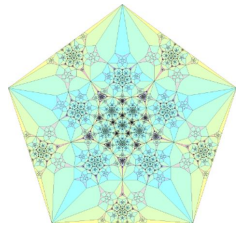


Figure 2
A fractal-like shape. Brirush, CC BY-SA 3.0 https://creativecommons.org/licenses/by-sa/3.0, via Wikimedia Commons.

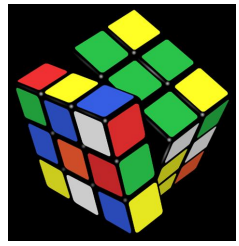


Figure 3
The Rubik's cube. Booyabazooka, CC BY-SA 3.0 https://creativecommons.org/licenses/by-sa/3.0/, via Wikimedia Commons.

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