books

Making the best of the *gruppenpest*

Group Theory

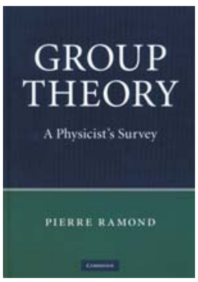
A Physicist's Survey

Pierre Ramond
Cambridge U. Press, New York, 2010. $70.00 (310 pp.).
ISBN 978-0-521-89603-0

Reviewed by Robert Gilmore

In 1928 Paul Dirac gave a seminar at Princeton University. In the discussion that followed, Hermann Weyl protested Dirac's assertion that he would derive his results without using group theory. Dirac replied, "I said I would obtain the results without previous knowledge of group theory." His response was priceless, but not timeless.

The ensuing years saw diminishing returns on efforts by some physicists to slay the *gruppenpest* created by Weyl and Eugene Wigner. Those efforts were effectively laid to rest in the 1960s by numerous successful applications of group theory to particle physics. During that period, and especially following, there has been a deluge of books on group theory: by mathematicians for mathematicians, by mathematicians for physicists, and by physicists for physicists. Most books in the third category attempt to summarize the applications of group theory in one or a few corners of the field, for example, spectral and structural details in atomic and molecular physics, nuclear physics, condensed-matter physics, and particle physics. So it would be fair to assume that theoretical physicist Pierre Ramond's *Group Theory: A Physicist's Survey* would lay out the group-theoretical foundations of the standard model, to which he has made significant contributions. It does not, nor was that his intent.



The book's construction is straightforward. It first introduces a mathematical description of some physical problem—for example, the isotropic harmonic oscillator, the Bohr atom, the Elliott model, the Eightfold Way, or the standard model. Next it provides a brief indication of how group theory has been useful in understanding the underlying physics and points out computations that could be carried out without overburdening the reader. The latter discussion is used as a jumping-off point to introduce material that should, or could, be useful in models yet to come.

Not surprisingly, the most extensive presentation devoted to a single area of physics is Ramond's chapter on the standard model. But it is not a chapter to turn to for instruction in carrying out anything but the most elementary computations. Rather, it gives prescriptions for constructing models that go beyond the standard model but remain within the constraints of various prescribed symmetries and their breakings. Those prescriptions inch inexorably toward ever more exceptional or exotic groups: E_6, E_7, E_8, $E_8 \times E_8$, and finite subgroups of $SO(3)$ and $SU(2)$. In fact, the closing chapter is given over entirely to the presentation of exceptional structures, which are poorly known to physicists. As a result of that emphasis, Ramond's book is not directly comparable to any "Group Theory and (fill in the details) Physics" text.

Group Theory: A Physicist's Survey contains a few small disappointments. Irreducible representations of the simple Lie groups are labeled in various ways, but never through Young partitions. That omission makes it difficult to compare results developed in the book with those available in most research papers. The other disappointment is in the correspondence between infinitesimal generators of some Lie groups with creation and annihilation operators. Ramond describes the Hilbert spaces generated by k independent fermion operators; those spaces are of use in constructing antisymmetric representations of many groups. But there is no mention of the extension to many-boson modes, which is relevant to the symmetric representations. In particular, missing is the restriction to two-boson modes and bilinear products that involve one creation and one annihilation operator; that scheme was introduced in a beautiful way by Julian Schwinger to provide a simple and direct description of the properties of both the angular momentum algebra and the $SU(2)$ representations.

Despite those minor disappointments, and an index far too small, *Group Theory: A Physicist's Survey* successfully introduces physics model builders to the most likely tools of choice for future constructions. Ramond's underlying belief is that any future fundamental theory will be beautiful and exceptionally elegant. The trouble is that we don't yet know what kind of mathematics it will involve. Lie groups? Supergroups? Kac–Moody algebras? Finite groups over fields unfamiliar to physicists? Each case has regularities and exceptions, and there are some regularities among the exceptions. Many particle theorists, including Ramond, share the prejudice that when the dust settles and we have a "final theory," it will be understood through the facet of some exceptional structure. After all, isn't the universe in which we live itself exceptional?

Robert Gilmore is a professor of physics at Drexel University in Philadelphia. He is the author of several books, including *Lie Groups, Physics, and Geometry: An Introduction for Physicists, Engineers and Chemists* (Cambridge University Press, 2008) and, with Christophe Letellier, *The Symmetry of Chaos* (Oxford University Press, 2007). He contributed to the paper that first described how to construct atomic coherent states and has developed the most general framework for the construction of coherent states for Lie groups.

Dark Energy

Theory and Observations

Luca Amendola and Shinji Tsujikawa
Cambridge U. Press, New York, 2010. $75.00 (491 pp.).
ISBN 978-0-521-51600-6

Dark Energy

Yun Wang
Wiley-VCH, Weinheim, Germany, 2010. $79.00 (244 pp.).
ISBN 978-3-527-40941-9

Two teams of astronomers studying distant type Ia supernovae presented