electrical resistance thermometry, thermocouples, optical and radiation pyrometry, and expansion thermometers. In each of these chapters the respective measuring instruments are described in sufficient detail, the measuring procedures are given (including the basic equations) and the possible errors as well as the reduction of errors are discussed.

Then comes the chapter on calibration of the instruments, where the triple point of water, the ice point, the boiling point of water and sulphur, the boiling point of oxygen, the freezing points of metals and the standard devices necessary for calibration are reviewed.

The last chapter deals with temperature measurement in practice and gives much useful advice, for instance that the temperature of the sensing element of a thermometer should be brought to the same temperature as that of the item of which the temperature is required, which is very often not at all easy. Also, that it is absurd to speak of measuring or controlling the temperature of a room, for instance to 0.2 °C. This is frequently disregarded, and not only by students. Finally, measurement of surface temperature and the thermometric lag are discussed.

At the end of each chapter there are references for further study and exercises in some chapters. The book concludes with an author and subject index. The small book is warmly recommended to all who are interested in temperature measurement.

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Not for pedestrians

LIE GROUPS FOR PHYSICISTS. By Robert Hermann. 193 pp. Benjamin, New York, 1966. $12.50

by Lawrence C. Biedenharn

The "mathematization" of theoretical physics—as for example in axiomatic field theory—is an inevitable (though not unanimously welcomed!) development; in elementary-particle physics the application of group-theoretic techniques follows this trend, and many texts, at various levels, have appeared on this theme in the past few years. The book by Robert Hermann, a mathematical physicist at Stanford, is rather different than this genre despite its title. For it assumes the reader to be already familiar with Lie groups, and aims instead at introducing to physicists the powerful, relatively recent, geometric techniques used by mathematicians in the theory of symmetric spaces.

The theory of symmetric spaces, as is true of most topics in Lie-group theory, was begun by Elie Cartan. The basic ideas, very briefly put, are these: the Lie algebra **G** belonging to a semisimple Lie group G can always be split by a *Cartan decomposition* into the subsets: $\mathbf{G} = \mathbf{K} + \mathbf{P}$, where $[\mathbf{K}, \mathbf{K}] \subset \mathbf{K}$; $[\mathbf{K}, \mathbf{P}] \subset \mathbf{P}$; $[\mathbf{P}, \mathbf{P}] \subset \mathbf{K}$. In addition, there always exists an automorphism s for which $s(\mathbf{K}) = \mathbf{K}$, $s(\mathbf{P}) \equiv -\mathbf{P}$.

Consider now the (finite) elements of G obtained from **P** by exponentiation; that is, $P = \exp \mathbf{P}$; this set of elements plays an additional role as a carrier space, called a *symmetric* space. For if $p \in P$ one has for *every* $g \in G$ an associated transformation in the space P: $p \rightarrow p' \equiv gps(g^{-1})$. This exhibits the Lie group G as a *transformation group* on the symmetric space P; one can show: (1) that P is a *homogenous* space (given p_1 and p_2, then there is a g such that $p_1 = gp_2$), (2) that the isotropy group at $g = e$ (the elements of G which leave e fixed) is $K = \exp \mathbf{K}$, and (3) that the elements $g \in P$ induce *transvections* (symmetries of the space P). Lie-group theory is in this way united with geometry.

The theory of homogeneous spaces is very natural to physics; for example, the Poincaré group has for its homogeneous space Minkowski space (identified here as the space of cosets of the Lorentz group).

The plan of Hermann's book may be sketched as follows: the first eight chapters treat standard Lie-group theory from Hermann's special point of view. Among the topics treated are: compact and noncompact Lie algebras, the Cartan decomposition, conjugacy of Cartan subalgebras, dual symmetric spaces, and the Iwasawa decomposition. The ideas and concepts treated here are very important—though even familiar results appear a bit forbidding in the "language" Hermann employs.

The next two chapters present the most important, and basically new, geometrical ideas with which Hermann is concerned: the concept of *vector bundles over homogeneous spaces.* This is the key point of the book and it is best to let Hermann speak here: ". . . many of the complications one finds in the physics literature, due, for example, to spin, are clarified in a vector-bundle context, and the theory can be strongly recommended to physicists as an appropriate mathematical language with which to understand the true nature of the relation between symmetries and fields. Certainly it can be quite dogmatically asserted that the machinery is absolutely necessary to organize the existing results on infinite-dimensional representations of noncompact groups in a semicoherent framework. (Unfortunately, even many mathematicians who work on this subject have only realized this in the last few years.)"

These concepts are applied in the final eight chapters, which alternate between mathematics (group-theoretic version of the Fourier transform, compactification of homogeneous spaces, representations of noncompact groups) and physics (contractions of Lie groups, groups in quantum mechanics and particle physics).

The task of making available to theoretical physicists the many fundamental and powerful ideas being developed by mathematicians is an essential and continuing one, and Hermann has much to offer. How well does he succeed in his task? Unfortunately not very well. He has set himself a large task, and covered much ground; of necessity many discussions are so condensed as to be indigestible—but this is only to be expected. Throughout, though, there are many valuable insights, clearly presented, as well as indications of currently unsolved problems.

The chief failure could, however,

have been avoided: the author has deliberately chosen (and so states) to use a language unfamiliar to physicists; perhaps this is really for the best, but one badly needs an occasional translation here and there! The second failing has no justification: the book is incredibly sloppily put together. Subscripts, symbols, words, equations, references, index, titles, tables—all are garbled far too frequently! (Even theorems are not immune: we have the ludicrous example of a "nonparameter subgroup.") The sloppiness is primarily typographical garbling, but not always: for example many key concepts are never defined, products of groups are not distinguished notationally from product of sets, etc. One long calculation is presented, in laborious detail—but the concluding, and essential, steps are inexplicably omitted. This unnecessary carelessness greatly limits the book's usefulness.

Hermann's occasional views on physics should not go unchallenged either. Consider this astonishing remark (page 134, repeated on page 137): "In general, quantum mechanics has a formal structure parallel to that of classical mechanics, but *in principle, having nothing to do with it.*" (The italics are mine.)

Despite these criticisms, which may be taken as forewarnings, the book *does* contain a great deal of very valuable information, much more accessible than can be found elsewhere; it can definitely be recommended to theoretical physicists with a good knowledge of group theory. The material is so important, in fact, that it is hoped that a second edition be considered, or even that other mathematicians be encouraged to try to do better.

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Of skeletons and electron flows

ELECTRON DYNAMICS OF DIODE REGIONS. By Charles K. Birdsall, William B. Bridges. 270 pp. Academic Press, New York, 1966. $10.00

by J. Arol Simpson

Every family has skeletons in their closets and the family of electron physicists is no exception. The fact that our knowledge of the details of time-dependent electron flows is restricted to one dimensional model calculations is something most of us would like to forget. The authors of this book are engineers, and facing the hard facts of the real world, they cannot forget and do us a real favor by casting light into this dark corner, "telling it like it is."

They lead us from the general concepts of time dependent flow down the dusty corridors of linear space-charge theory until we are brought face to face with the terrors of nonlinear onsets of instability, nonuniform field distributions, crossed-field gaps, and multivelocity streams. The only cheerful note I personally can find is that they demonstrate that the solid-state people also face these horrors.

The authors never lose heart and present their material in calm, direct prose, and although the work is mathematical in nature they are not afraid to use words when they serve