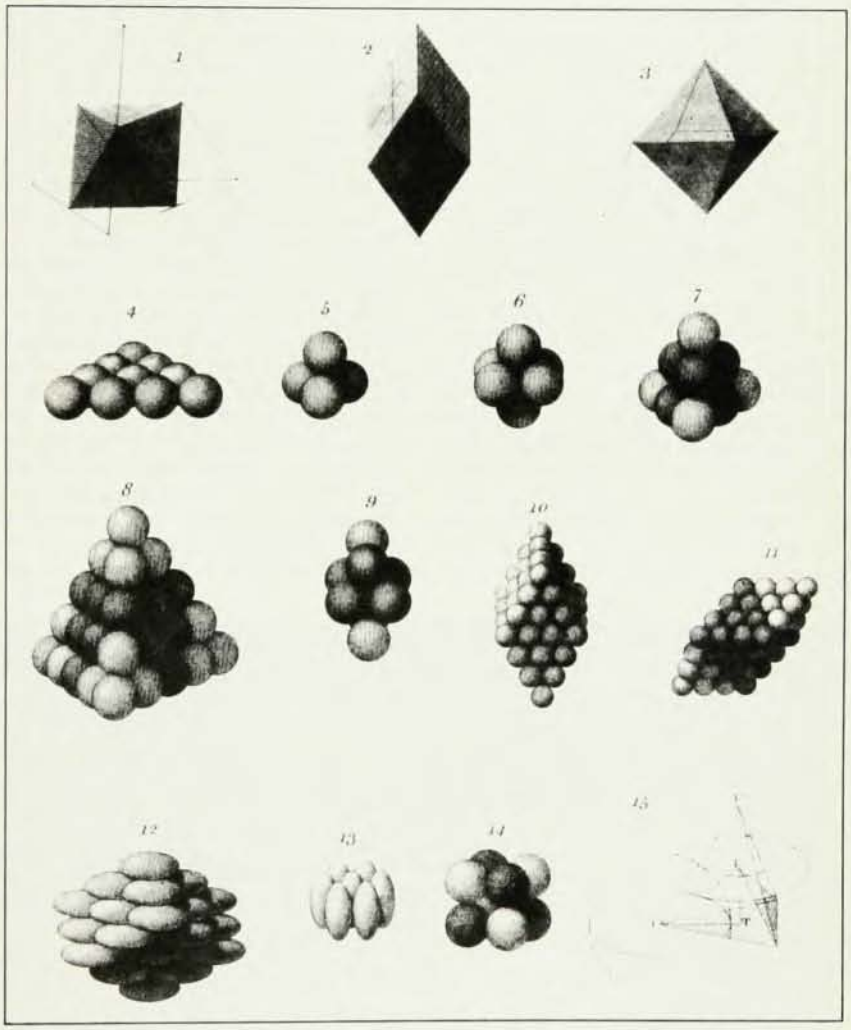
Where Euclid and Einstein meet

Geometrical Methods of Mathematical Physics

B. Schutz
250 pp. Cambridge U.P., New York, 1982.
$39.95 cloth, $16.95 paper
Reviewed by Ann K. Stehney

Geometry has no life of its own in the traditional education of physics students. It exists only as part of analysis (calculus in Euclidean space) or linear algebra (tensors). There is no evidence of the modern view of geometry as the study of manifolds endowed with "geometric" structures (such as connections or fiber bundles), which has been fundamental to recent developments in relativity and gauge theories.

Bernard Schutz seeks to remedy this situation by acquainting students and working physicists with the terminology, results and applications of modern geometry. His book is ambitious in scope and generally both thorough and clear. Assuming a background in multivariable calculus and matrix algebra, he starts with the definition of a differentiable manifold and covers vector fields, tensors, Lie derivatives, differential forms and Lie groups. He provides applications of these to thermodynamics, mechanics, electromagnetism, fluid dynamics and cosmology. In a final chapter of more advanced material on Riemannian connections, he arrives at the gauge theory of electromagnetism. The extensive examples and exercises with hints and solutions make the book suitable for either self-study or a beginning graduate course, although not for most undergraduates in the US. The author provides references for the proofs he omits and points out likely sources of confusion.



Geometry in physics. One of the traditional uses of symmetry appears in crystallography—as shown in this illustration of crystal structures used by William Wollaston in 1812.

A modern treatment of geometry, no matter what its intended audience, should have certain features, including a formulation unified by differential forms, an invariant (coordinate-free) treatment of tensors and the inclusion of global questions of geometry and topology. This book meets these criteria in different degrees. The chapter on differential forms includes a discussion of volumes, the theorems of Stokes and Gauss, and Frobenius' theorem on integrable distributions; it is a major strength of the book.

The second criterion, a goal Schutz sets for himself, he meets more in theory than in practice. He includes both invariant and coordinate (or component) expressions throughout; he defines some important terms (such as an Abelian Lie algebra) with unnecessary reference to a basis. On the other hand, Schutz does acquaint readers with such material as Christoffel symbols, which they need to connect geometrical topics to other physics. He also provides appropriate exercises and hints for manipulating tensors for that purpose.

The main weakness of this book is in topology, which cannot be removed

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from geometry as Schutz would wish. The topology of a space restricts the geometric structures it may support, as illustrated by the fact, known to Carl Frederich Gauss, that the sphere S^2 cannot as a whole be given a flat Riemannian metric. Schutz generally avoids global topological and geometric considerations (like compactness and completeness), and his use of topological terms (such as *Hausdorff* and *foliation*) is imprecise and even incorrect.

As an introduction to geometric methods, this book is valuable in describing the objects of interest and the machinery which physicists use to work with them. Accordingly, it should help to make research articles in theoretical physics accessible to the reader. The book provides less insight into topology and global geometry, and those who would consider them are advised to look elsewhere.

Extragalactic Astronomy

J. Sérsic
245 pp. Reidel (US dist. Kluwer, Boston), 1982. $49.50

Extragalactic astronomy is a youthfully exuberant field of research. Over the past twenty years there has been rapid growth in the quantity and quality of observational data. New data along with equally exciting theoretical developments have frequently brought extragalactic astronomy from the pages of technical journals to newspaper columns. Significant changes in the field now occur on a timescale of a year or even less.

The dynamism of the field makes it extremely difficult to write the much-needed texts. *Extragalactic Astronomy* by José Luis Sérsic fails to meet the challenge to provide a clear, logically developed treatment of some of the fundamental models, observations and problems.

The publisher, the translator, and the editor as well as the author share responsibility for the weaknesses of the book. There is no excuse for the hundreds of misprints in a 250-page book. They appear in the text, in equations and even in running page titles. One figure caption rather charmingly credits "Halo Observatories" (more commonly known as Hale). The translation is often so awkward that sentences are incomprehensible even to those who work in the field. These flaws alone are sufficient to make the book a poor choice for the intended audience of students and working astronomers and physicists.

Sérsic covers selected topics with some emphasis on areas to which he has contributed. In principle, this strategy has merit. However, the overall logical structure of the field should be made clear in a book intended as a text. The physical arguments in this monograph are neither well-developed nor well-motivated. Descriptions of the links between the data and the models are inadequate. The data quoted are often more than ten years old and have frequently been supplanted in the literature by more extensive, higher-quality data. Sérsic overlooks these more recent data and the analyses that accompanied them. For example, the discussion of binary galaxies cites the well-known early (1962) work of Thornton Page but ignores Edwin Turner's equally widely recognized 1976 study; the results of Turner's study depart substantially from those of Page. On the theoretical side, the section on the formation of galaxies and clusters of galaxies contains no mention of the "pancake" picture suggested by Yakov Zel'dovich and Rashid Sunyaev. A student of the field should have at least a passing acquaintance with this very frequently referenced model.

The one strength of this book is the beautiful set of photographs of galaxies and systems of galaxies. These plates are reminiscent of Sérsic's *Atlas de Galaxias Australes*, the *Hubble Atlas* of the Southern Hemisphere.

There is still no single book from which one can learn the elements of extragalactic astronomy. P. James E. Peebles' book, *Physical Cosmology*, though more than ten years old, remains a classic in the field. Dimitri Mihalas and James Binney's *Galactic Astronomy* contains excellent discussions of the structure, kinematics, and stellar and gaseous content of galaxies. These books, unlike *Extragalactic Astronomy*, are accessible to students and to physicists without prior training in astronomical jargon.

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The galaxy NGC 5128 shows a complex optical structure that suggests recurrent activity has taken place in it. (Copyright by AURA, this photo appears in *Extragalactic Astronomy*.)

Mathematical Theory of Entropy

N. F. G. Martin, J. W. England
257 pp. Addison-Wesley, Reading, Mass., 1981. $29.50

Mathematical Theory of Entropy is carefully—even lovingly—written, but few physicists will find it easy reading. The authors presuppose a familiarity with measure theory at a mathematician's first-year graduate level, appropriate, of course, for a volume in the series *Encyclopedia of Mathematics and its Applications*. Nonetheless, most physicists, even after working their way through chapter one, "Topics from Probability Theory," which provides a minimal background, will find the book tough sledding.

The heart of the book is chapter two. There the authors define the entropy function, generalize it to conditional probabilities, and establish some properties. The introduction to this chapter, a heuristic discussion of infor-