A fruitful meeting ground for physicists and chemists

Atom—Molecule Collision Theory: A Guide for the Experimentalist

R. B. Bernstein, ed.
799 pp. Plenum, New York, 1979 $57.50

Reviewed by Benjamin Bederson

The growth of modern beams chemistry has been one of the most intellectually satisfying developments of recent years in the physical sciences. It has to a considerable extent captured center stage of the action in modern chemistry, and has also served as a fruitful meeting ground for the molecular-beams physicist and the laser spectroscopist, not to mention the chemical physicist. The experimental chemist can now perform a true state-to-state collision experiment, that is, an experiment in which the reactants are initially prepared in selected rotational, vibrational and electronic states, and are similarly analyzed after the interaction. Couple these dramatic advances in beams technology with the parallel advances in basic theoretical methods and computational techniques. As a result we are witnessing in chemistry what has traditionally been the hallmark of physics—a very close relation between theory and experiment.

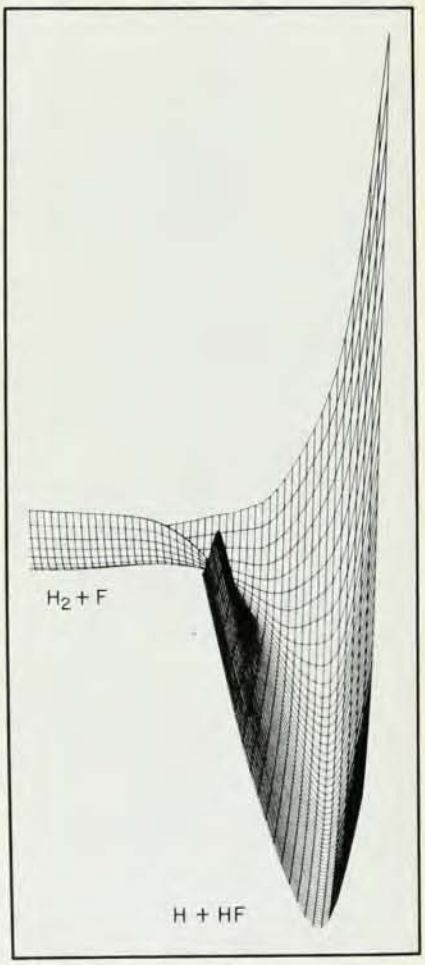
If such is the state of beams chemistry, the ambitious undertaking of Richard B. Bernstein in producing the present monograph is a perfectly timed and finely conceived project. Bernstein's aim was to develop a multi-authored volume devoted to the central current problem of the new chemistry: obtaining the interatomic molecular potential surface from crossed beams (or beam–gas) cross-section measurements, or vice-versa. Physicists should find these dual objectives very familiar. The chemistry interactions do of course possess their own characteristic features. Perhaps the most significant one, from the standpoint of developing a collision theory, is that the energy domain is generally sufficiently low, except near level crossings, so that an adiabatic theory is applicable. Then one can proceed, at least in principle, in a most logical fashion along a well-marked highway of ever more complex interactions, all of them relating to the intermolecular potential. And Bernstein, himself a pioneer beams chemist, as well as a distinguished theorist, was the ideal person to undertake this project.

After an introductory chapter by Bernstein, in which the motivation is clearly presented, two chapters, by Henry F. Schaefer III and by P. J. Kuntz, discuss the general subject of interatomic potentials, from both a "fundamental" (that is, *ab initio*) viewpoint, and semi-empirically. These are followed by two chapters written by representatives of two of the most productive laboratories in the field: H. Pauly (Göttingen) and S. Stolte and J. Reuss (Nijmegen). The former is concerned with scattering experiments that deal with isotropic potentials (primarily atom–atom) and the latter with non-central potentials (primarily atom–diatomic molecules). These chapters are models of clarity and brevity, and present a maximum of information.

We are then led into what is the main feature of the book, a series of carefully graded theory articles, each dealing with a somewhat more complicated situation than that which precedes it. There are chapters by John C. Light and by Donald Jack Kouri on general scattering theory, the former a presentation of formal theory, and the latter a discussion of approximation techniques. This sequence is followed throughout the book, for chapters on rotational excitation (by Don Secrest and Kouri), classical methods (Merle D. Pattengill), vibrational excitation from a quantal viewpoint (Secrest), and classically and semi-classically (W. Ronald Gentry), non-adiabatic electronic transitions (M. S. Childs), and reactive scattering—general, approximate treatments and quasi and semiclassical methods. Several chapters are then devoted to "direct mode" reactions (reactions that occur in a single pass of the incoming constituents) and "compound mode" reactions (those which occur via the formation of temporary compound state). The final topic, which deals with single reactions, is concerned with the still rather embryonic theory of dissociation reactions of the type

$$A + BC \rightarrow A + B + C$$

However, there still follows a rather compact review, by Bernstein, of the recently developing information-theoretic approach to the description of the methodology of chemical reactions.



Potential energy surface including electron correlation for $F + H_2 \rightarrow FH + H$ (after C. F. Bender, S. V. O'Neil, P. K. Pearson and H. F. Schaefer).

As with any multi-authored monograph, the various contributors are not of equal merit; the overall quality however, is exceptionally high. A few minor, but significant features (both plus and minus) could be singled out as worth noting. First, Bernstein has prevailed on authors (and publisher) to list references by title. This is extraordinarily helpful. On the

other hand, the inadequate subject indexing is not very helpful at all. Certain basic material is covered several times, particularly in the formal scattering theory chapters; notations are quite varied (is it possible for the editor of such a volume to order his authors to use a standard set of notations?) Only Stolte and Reuss take the trouble to present a glossary of the many abbreviations that tend to be used in the chemistry literature. Despite these minor deficiencies, in my opinion this is one of the most successful such volumes produced in years. It is sure to find its way onto the bookshelf of any beams chemist or collision physicist, and of many a theorist as well.

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Optical Image Formation and Processing

M. Françon
231 pp. Academic, New York, 1979 (French ed., Masson, Paris, 1972). $19.50

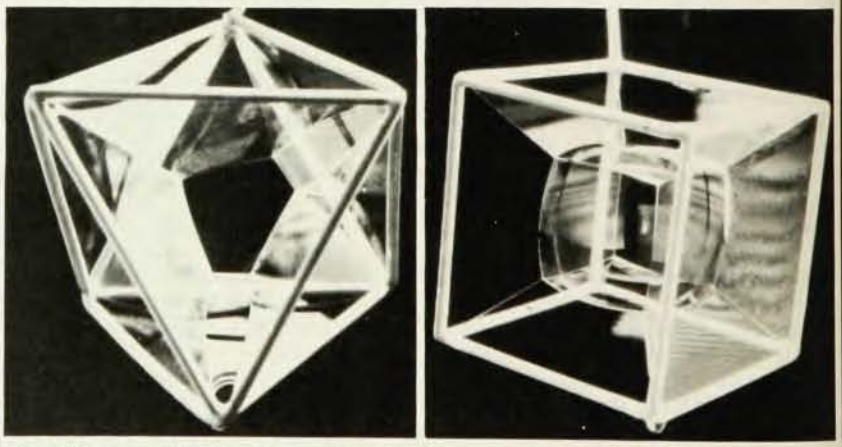
This book by Maurice Françon of the Optics Laboratory at the University of Paris is a translation and expansion (60 pages longer) of the French original *Optique: formation et traitement des images*. The translated title erroneously emphasizes image formation; in fact the first six chapters are similar to many books on optics point sources, interference, diffraction, gratings, coherence and polarization.

The goals of the book can be summarized from the Preface: ". . . it seems very desirable to present the basic facts and the recent developments in a form which is both precise and concise." The Preface also states that the book develops "optics in terms of a conceptual background." The concepts are presented rather well. It is also concise, but too much so in some respects. The book will serve well those persons who have backgrounds in optics, and who wish to learn more of what has been called modern optics. It could also be used as an introductory book, if supplemented, for it has no problems and only six references. The lack of references will be, I suspect, a source of frustration to those readers interested in the derivation of stated results and to those who would like to learn more of the topic.

The author is especially effective in the discussion of blazed gratings, interference effects in which anisotropic materials are used, multiple image storage in holography, and the general description of imaging. The chapter on holography is an excellent introduction. It starts with Gabor (in line) holography of a point. Françon extends the concepts from these to Leith-Upatnieks (off axis) holography of a point. Then, the holography of a general object is analyzed by considering it to be made up of points. A good description of Lohmann-type computer-generated holograms follows. Again it is unfortunate that there are no references.

A minor objection is that the notation is neither uniform nor standard. For example, the y–z plane is the "Fourier transform plane" in coherent systems and is the "image plan" in incoherent systems. The variable R and T are used to denote reflected and transmitted energy on one page and are used to represent amplitudes

Soap Films and Bubbles



Soap films on octahedral (left) and cubic (right) frameworks. The preceding photographs are from Cyril Isenberg's *The Science of Soap Films and Soap Bubbles* (Tieto, Clevedon, Avon, UK $20.00). The book describes the molecular and macroscopic properties of soap films and bubbles, emphasizing their application to the solution of physical problems.