Studying photon interactions with atoms and molecules

Photoabsorption, Photoionization, and Photoelectron Spectroscopy

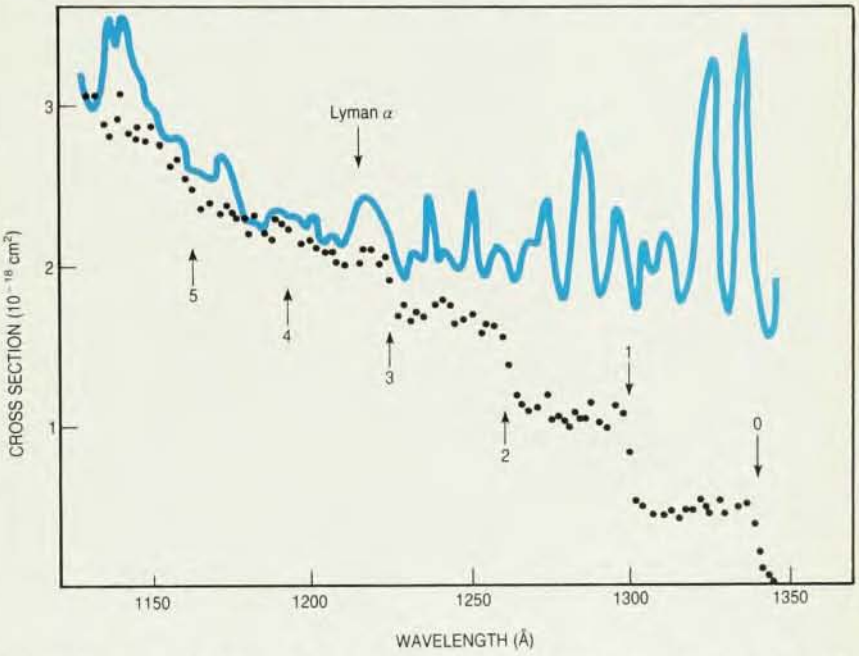
J. Berkowitz
486 pp., Academic, New York, 1979. $39.50

Reviewed by Steven T. Manson

The study of the interaction of electromagnetic radiation with atoms and molecules has a long and distinguished history dating back to the last century. After the pioneering work, which extended to the 1930's, activity in this field dropped off considerably. The past two decades have seen a remarkable resurgence owing to various experimental (and theoretical) advances.

There are at least three conceptually distinct ways of studying the $h\nu + X$ process; photoabsorption spectroscopy, which is concerned with the attenuation of the photon beam; photoionization spectroscopy, where the resulting ions are detected and analyzed, and photoelectron spectroscopy, in which the ejected electrons are scrutinized. Each of these spectroscopies yields information on various (and overlapping) aspects of the fundamental interaction process. The author of *Photoabsorption, Photoionization, and Photoelectron Spectroscopy*, Joseph Berkowitz, has been a major contributor to the areas of photoionization and photoelectron spectroscopy for almost two decades. In this book he attempts to synthesize the information derived from the various spectroscopies and to present the total and partial cross sections and photoelectron angular distributions in a unified way for a number of free atoms and molecules. In my view, the attempt is successful.

But this book is not just a synthesis. The author has also critically reviewed essentially all of the extant data for six atoms (the noble gases plus mercury) and eighteen molecules (H_2, O_2, N_2, CO, NO, H_2O, CO_2, N_2O, NH_3, SF_6, and a number of simple organics) and has presented excellent composite curves and tables of these data. He has analyzed the photoabsorption data by intercomparison as well as by using three separate sum rules to check consistency of the oscillator strength distribution and to make inferences concerning unmeasured regions of the spectrum. In this connection, the author has also presented in each case the contributions to the various sums in each spectral region.



Photoabsorption (solid line) and photoionization (dots) cross sections of NO in the region of the ionization threshold. Note the contrast between the peaked structure in photoabsorption and the apparent steplike structure in photoionization. From *Photoabsorption, Photoionization, and Photoelectron Spectroscopy*, by Joseph Berkowitz.

In a chapter that makes up almost half of the book, Berkowitz has addressed the question of the partial cross sections, that is, the probabilities of the photoabsorption process leading to the various alternative final states. For atoms this is fairly simple, but for molecules many more possibilities exist such as dissociative ionization and vibrational excitation. The author has brought a tremendous amount of data to bear on these problems—120 figures and tables in this chapter, including some of his own previously unpublished work and an extensive table titled "Wavelength Dependent Photoion Yield Curves for Molecular Species not Encompassed in this Monograph."

The angular distributions of photoelectrons, which contain a wealth of information on atomic and molecular dynamics, suffer from a relative paucity of experimental data, as compared with total or partial cross sections. The author discusses these matters emphasizing on the theoretical formulation, and here the data presented are indicative rather than exhaustive.

Berkowitz also discusses experimental techniques, both light sources and detectors, and analyzers. Although he does not go into very great technical detail, virtually all of the important pieces of equipment in this field are treated and their strong points and limitations enumerated. This summary should prove quite useful to workers entering the field.

The book is well written and clear. If it suffers from any defect, it is that the very volume of material Berkowitz presents can overwhelm the reader. I would, however, strongly recommend this book to all physicists, chemists and

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biologists whose work involves the interaction of electromagnetic radiation with matter as well as to graduate students preparing to work in this field.

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Steven T. Manson is a professor of physics at Georgia State University. He has been an active worker in the field of theoretical atomic physics, with particular emphasis on photoionization and photoelectron angular distributions, since the late 1960's.

Physics of High Temperature Plasmas (Second Edition)

G. Schmidt
418 pp. Academic, New York, 1979. (first ed., 1966). $29.50

This book is designed for graduate students who have already had some exposure to plasma physics. As is well known by readers of PHYSICS TODAY, this field has seen an explosive rise in activity between the publication of the first edition (1966) and the latest edition (1979). Fusion research is obviously the major part of this effort, and George Schmidt has oriented this text in that direction. Students of low-temperature plasma physics could benefit much more from other textbooks.

Schmidt, a renowned theorist and educator, has attempted to provide a broad background of fusion-oriented plasma physics in which he relates the theory to experiments. I particularly enjoyed his chapters on MHD, hydromagnetic stability, steady-state plasmas and collisions. He uses phase-space trajectories to explain particle motion and waves, but unfortunately neglects its connection to magnetic topology. By contrast, the author includes a well-developed section on nonlinear waves with an especially welcome treatment of solitons. He has provided answers to many questions often asked by students.

That Schmidt has retained his fine pedagogical style is clearly evident in the chapter on hydromagnetic stability. The energy principle, in particular, is presented well. His chapter on bounded plasmas concentrates a bit too much on flute instabilities, leading him to neglect mentioning other important instabilities such as ballooning modes. It must be pointed out that the section on collisions does a good job of introducing both heat and mass transport. A brief section on the applications of these quantities to various fusion geometries is also included.

There are many uses for this text beyond the classroom level. I have found that the first edition often supplied quite detailed explanations of the basis for assumptions utilized in other texts or papers.

Since Schmidt's closest interaction with experimentalists have been in the mirror and cusp geometries, it is expected that these would occupy a sig-

Nollet's experiment performed in Japan. One of the most spectacular electrical experiments of the mid-eighteenth century consisted of discharging a "battery" of Leyden jars through hundreds of soldiers and monks who formed a human chain. The shock of the discharge caused the participants to jump simultaneously. Reproduced from *Album of Science: From Leonardo to Lavoisier*. I. B. Cohen. Scribner's, New York, 1980. $37.50.