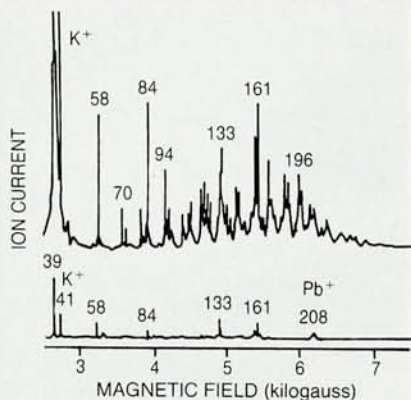




Analysis of an air sample from a room in which one cigarette has been smoked compared with normal room air. The scales are the same. The mass-84 and 161 peaks are nicotine and the level is 20 ppb. The measurement was made with a 3-inch-radius 90° magnet sector mass spectrometer with a mass resolution of 115. Surface ionization was employed using a heated Re ribbon on which a jet of room air impinged. (From W. D. Davis, *Environ. Sci. Technol.* **11**, 543, 1977; adapted from *Mass Spectrometry* by permission of the publisher.)

geochronology; atmospheric, lunar and planetary measurements; and biomedicine, toxicology and forensic science. But all the sections are eminently readable and informative. The illustrations are superb throughout.

Although mass spectrometry is almost 100 years old, many of its technical developments and applications have emerged only recently. One of the newest is accelerator mass spectrometry, which in fact celebrated its tenth anniversary in 1987 at the symposium alluded to above. However, even those of us working in this newest branch of the science may be astonished at the power and diversity of conventional low-energy (tens of keV) mass spectrometry, so ably illuminated in the book.

That mass spectrometry is a vital and growing field is demonstrated by the number and variety of new developments, such as accelerator mass spectrometry, secondary ion mass spectrometry, ion microprobes, depth profiling and molecular analysis. AMS is probably the most potentially valuable new addition to the mass spectrometry arsenal, and a whole chapter in the book could well have been devoted exclusively to it. The new developments in general are reasonably well covered, although somewhat disjointedly. Only a few subjects of importance are omitted or given short shrift. The use of AMS for measuring Cl^{36} to obtain ground wa-

ter ages (among other important applications) and for measuring certain important nuclear half-lives and cross sections is one such topic. There is also little discussion of the relative merits of negative and positive ion production in ion sources. There is no discussion of the importance of AMS for radiocarbon dating or of why no conventional low-energy mass spectrometry technique will work. These are relatively minor flaws in what is otherwise an important and timely compendium of the current status of mass spectrometry and its diverse applications.

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Quantum Theory of Collective Phenomena

G. L. Sewell

Clarendon, Oxford, 1986.

229 pp. \$55.00 hc

ISBN 0-19-851371-2

A continuing theoretical and experimental challenge is understanding our macroscopic world on the basis of its microscopic constituents—atoms and molecules governed by the laws of quantum mechanics. In its own way, mathematical physics has also struggled with this problem: What is the proper mathematical framework for the quantum mechanics of systems with very many—eventually an infinite number of—degrees of freedom? Is the dynamics of an infinitely extended system well defined? Does the system approach, in the course of time, a state of thermal equilibrium? How are equilibrium states singled out from other time-invariant states? Why is matter stable? In what sense are the laws of macroscopic physics (for example, thermodynamics, hydrodynamics or elasticity theory) a consequence of quantum dynamics?

Only a few publications address some of these questions: Gérard G. Emch, *Algebraic Methods in Statistical Mechanics and Quantum Field Theory* (Wiley, New York, 1972); Daniel A. Dubin, *Solvable Models in Algebraic Statistical Mechanics* (Clarendon, Oxford, 1974); Elliot H. Lieb's article in *Reviews of Modern Physics* **48**, 553 (1976); Phillippe A. Martin, *Modèles en Mécanique Statistique des Processus Irréversibles* (Springer-Verlag, New York, 1979); Ola Bratteli and Derek W. Robinson, *Operator Algebras and Quantum Statistical Mechanics* (Springer-Verlag, New York, 1979); and Walter Thirring, *Quantum Mechanics of Large Systems* (Springer-Verlag, New York, 1980). The

book by Geoffrey Sewell is a most welcome enrichment of the list. In fact, it has rather limited overlap with the books cited.

Sewell provides the necessary physical background while trying to keep the prerequisites at the level of graduate courses in quantum mechanics and statistical mechanics. The mathematics is as simple as possible without sacrificing rigor. For these reasons the book serves as an excellent and competent introduction to the field. The book also is a source of information for the expert.

The selection of topics necessarily reflects which collective phenomena can be studied up to the standards of mathematical physics. The static ones are phase transitions, spontaneous symmetry breaking and long-range order. The dynamic ones are mean field models with transitions far from equilibrium. The book also includes an interesting chapter on metastability. Particularly nice is the presentation of the role of the Kubo–Martin–Schwinger condition, including its connection to stability conditions.

It is easy to criticize omissions: for example, symmetry breaking for quantum ground states. But given the amount of space available, the selection of material is well balanced.

Quantum Theory of Collective Phenomena will be of interest to students and researchers in mathematical physics, theoretical physics and applied mathematics.

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Treatise on Heavy-Ion Science, Volume 5: High-Energy Atomic Physics

Edited by D. Allan Bromley

Plenum, New York, 1985.

498 pp. \$79.50 hc

ISBN 0-306-41575-5

Physics of Highly Charged Ions

R. K. Janev,

L. P. Presnyakov and

V. P. Shevelko

Springer-Verlag, New York,

1985. 330 pp. \$62.00 hc

ISBN 0-387-12559-0

Until recently, the particle beams used in atomic collision physics were usually composed of electrons or ions of lighter atoms. The more highly ionized heavier atomic species (and

their spectroscopy) were of great interest to astrophysics, but controlled, systematic exploration of the interaction between projectiles of highly charged ions and complex target atoms has become a rewarding research area only in the last two decades.

Volume 5 of the seven-volume *Treatise on Heavy-Ion Science* is devoted to the physics of collisions involving ions with energies in the region of a few MeV per atomic mass unit. The use of particle accelerators (mostly single-ended and tandem Van de Graaffs and linacs) designed for use in light-ion and heavy-ion nuclear physics defines the field operationally. Although the term "high-energy atomic physics" in the book's title may startle particle physicists, it is intended only in reference to the atomic eV scale. In this regime the ion velocity is often less, and rarely greater, than the velocity of the strongly bound atomic electrons.

The aim of the experiments and theoretical calculations described in this volume is to clarify what happens to target or projectile electrons in a violent encounter between ion-atom collision partners. If high- Z nuclei are involved, very strong electromagnetic forces come into play, but the interactions are qualitatively the same as those governing the structure of atoms and molecules. Some traditional concepts from quantum chemistry have been profitably transferred to this field, but the challenge lies in disentangling the dynamics of two-center atomic systems under extreme conditions and in answering such questions as:

- ▷ What happens to the tightly bound inner-shell electrons during and as a result of the collision? Where do they go, and how does the atom from which they come adjust to the vacancy or vacancies? When and how do electrons get transferred between the collision partners during the impact?
- ▷ How do slow and nearly adiabatic collisions differ from those in which the projectile velocity is comparable to the speed of the atomic electrons?
- ▷ How different are head-on collisions from the gentler distant collisions?

These and many other questions are confronted, if not always answered, in two chapters that make up the bulk of this volume of the *Treatise on Heavy-Ion Science*. Joachim Reinhardt and Walter Greiner from the Institute of Theoretical Physics in Frankfurt have written on the theoretical aspects of energetic ion-atom collisions, summarizing the semiclassical description, which assumes that

the nuclei move on classical trajectories past one another and that the dynamical problem to be solved is the evolution of the quantum states of one or more electrons in the time-varying strong fields of the two collision partners. If the nuclei have high Z , their near-coalescence during the collision simulates fleetingly the attractive force exerted by a superheavy nucleus (with Z around 165 or more). This intriguing circumstance has motivated much of the work reviewed in this volume. The high nuclear charge calls for the use of relativistic quantum mechanics for the electron in the presence of two centers of force, and the relativistic increase of the probability density near the nucleus is responsible for new physical effects. The idea that positrons can be produced in the strong nuclear fields during heavy-ion-atom collisions has been a persistent research theme of the Frankfurt group and has inspired much experimental work, mostly at the GSI accelerator facility in Darmstadt. Reinhardt and Greiner provide a good, but poorly copy-edited, introduction to this subject, including a brief updating of the story in a note added in proof at the end of the volume.

The second chapter in the volume, by Jack S. Greenberg (Yale) and Paul Vincent (Brookhaven National Laboratory), contains a far more detailed account (almost a hundred pages) of the long and arduous effort by experimenters to detect the positrons and understand their properties. In essence, the authors—themselves experimenters—have written a comprehensive and self-contained monograph on high-energy atomic physics. The emphasis is less on the collision mechanisms than on the photon, electron and positron spectroscopy arising from such collisions. The physical picture of transient quasimolecule formation is used as the guiding principle, and the discussion of the physics that one can learn from the observations is thorough, illuminating and critical. Greenberg and Vincent have produced a much needed, informative and detailed review of the experimental research in this area, replete with figures showing experimental arrangements and reproducing observed spectra. Not the least virtue of this chapter is its delightful readability.

The tale ends with the puzzling sharp line features that have recently been observed in positron spectra. (See the figure accompanying this review.) Since 1984, when Greenberg and Vincent completed this chapter, the observation of electron peaks in



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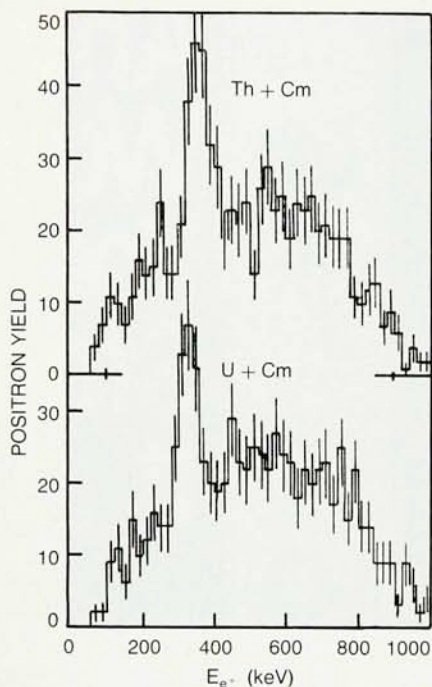
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Mysterious positron peaks around 300 keV rising above a broad continuum are seen in many different collisions of heavy ions with heavy atoms. The collision energy for the spectrum shown was about 6 MeV per atomic mass unit. (Adapted from *Treatise on Heavy-Ion Science, Volume 5*, by permission of the publisher.)

apparent coincidence with the positron lines has deepened the mystery of the origin of these pairs. Despite such subsequent discoveries, this splendid review, with its full documentation, will remain useful to orient anyone who wants to study the fundamentals of heavy-ion-atom collision physics.

The volume concludes with a pedagogic review of beam-foil spectroscopy by one of its practitioners, Indrek Martinson, now at the University of Lund (Sweden), but formerly at the University of Arizona, where much of the development of this elegant spectroscopic tool was done. Martinson provides an overview of the method and its applications. He does not hide the limitations of beam-foil spectroscopy and sometimes seems overly modest about its accomplishments. The chapter's bibliography is extensive, up to 1980.

Physics of Highly Charged Ions, by one Yugoslav (Janev) and two Soviet physicists (Presnyakov and Shevelko), is a fine, carefully organized monograph on the theory of ion-atom collisions, especially at the lower energies that are relevant to controlled fusion plasma physics and astrophysics. It is an excellent modern sequel to M. R. C. McDowell and J. P. Coleman's *Introduction to the Theory of*

Ion-Atom Collisions (North Holland, New York, 1970). Experimental results are cited only to illustrate the theory, which is covered in sufficient detail to make this a textbook for graduate students. It is remarkable that a book written by a collaboration of three authors can present the subject in such a unified, systematic and consistent manner.

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Carrier Scattering in Metals and Semiconductors

V. F. Gantmakher and
Y. B. Levinson
North Holland, New York,
1987. 459 pp. \$136.75 hc
ISBN 0-444-87025-3

The ultimate purpose of any investigation of carrier scattering is to determine its influence on the transport characteristics of an electron gas. Therefore, solutions of the kinetic equation and of the scattering problem traditionally accompany each other in monographs and textbooks.

The present monograph, written by two well-known Russian theorists, is quite different in that the authors do not even consider the problem of finding nonequilibrium electron distribution functions. Instead they restrict themselves to estimates of the energy and momentum loss rates for a test electron—averaged over an equilibrium electron distribution. On the other hand, they describe the microscopic relaxation times in such detail that interested readers can find in this book the "techniques" for frontier investigations of their own.

This approach is justified by the fact that in many instances, especially in metals, no practical solution of the kinetic equation exists anyway because of the complicated Fermi surfaces and the unknown dispersion laws. In these cases one has to be satisfied with the averaged characteristics: Knowing them, at least, helps one have a qualitative understanding of transport processes.

The monograph begins with an introductory chapter containing a general description of the band picture of an ideal crystal, a lucid introduction to the quasiparticle concept, and a pedagogically excellent discussion of the basic band structure properties of cubic semiconductors, including the well-known Kane model. Several chapters are devoted to such traditional topics in carrier scattering

as the mechanisms of electron interaction with various types of phonons and with charged or neutral impurity centers; the authors calculate the energy and momentum relaxation times in detail both for simple bands and for bands with multiple valleys or a degenerate spectrum. Throughout, the authors support the quantitative results with original qualitative analyses that many a reader will find highly instructive. (Especially happy will be those readers who do not wish to be bothered by the mathematical detail.)

Particularly noteworthy is the authors' description of diffusion in k space—a very useful approximation that allows one to determine the momentum relaxation time of electrons interacting with acoustic phonons in a metal with a complicated Fermi surface. The book gives an exhaustive analysis of the role of electron-electron interaction in the establishment of a nonequilibrium form of the electron distribution function. Considerable attention is paid also to the role of *umklapp* processes in electron scattering—a question rarely discussed in textbooks.

Among other topics description of which is hard to find in monographs, but extensively discussed in the present book, are the influence of a magnetic field on the elementary act of scattering and various effects leading to spin relaxation in the electron gases of semiconductors and metals. In addition to the paramagnetic resonance effects where manifestations of the electron spin relaxation have been known for a long time, the book describes optical spin polarization of the electron gas in semiconductors, an effect that was fully developed (both experimentally and theoretically) only relatively recently.

Like most other books in the North Holland *Modern Problems in Condensed Matter Science* series, this one has a lavish appearance and costs a fortune. There is a fly in the ointment, though (or, as Russians would say, a spoonful of tar in a keg of honey). There are generally two types of bad scientific translations from Russian. One is done by scientists (like ourselves) whose mother tongue is not English. Their writing is often stilted; for example, the book editor of *PHYSICS TODAY* tells us that the present review was much improved by his red pencil (however hard this may be to believe). The other type is produced by perfectly literate English speakers who do not know the subject; such translators are likely to call an anomalous effect an "extraordinary" one or to put in a