"Recess at the black Veysey school in Greene County, Georgia, 1941." This photograph "indicate[s] the same pattern of voluntary gender segregation on school playgrounds fifty years ago that researchers document today." [From *Learning Together*; Jack Delano, FSA, Library of Congress]

cess. This is not to suggest, they warn, that schools are or ever have been benign places. Like many other historians whose work they discuss, Tyack and Hansot maintain that American education has never achieved the democratic ideal of serving the needs of all children equally. In practice, they write, the public schools of the 19th century "tended to reflect the values and interests of the white, Anglo-Saxon, Protestant, middle-class males who, by and large, founded and ran them."

But for girls, Tyack and Hansot argue, schools imposed fewer restrictions and provided greater opportunity than society at large. Some critics are sure to challenge Tyack and Hansot on the relativity of their argument. No other institution, they maintain, was as free of gender-specific policies and expectations as public education. They point to the lack of explicit policies that distinguished between boys and girls and give great credence to the relative absence of gender discrimination in the central academic work of the schools. Differentiation occurred only at the periphery, the authors argue, in areas such as vocational education and athletics. It is no surprise, therefore, that these were the first areas of school life to be challenged by sex equity advocates and tested in the courts under Title IX of the 1972 Educational Amendments to the Civil Rights Act of 1964.

It is the generosity and capaciousness of Tyack and Hansot's scholarship that make *Learning Together* so important a book. It pays tribute to a vast amount of research by other historians in the fields of women's history and the history of American education and at the same time incorporates understandings derived from organizational and policy studies. Tyack and Hansot understand that debates about gender policy in the schools have served as a proxy for Americans' attempts to reformulate gender relations in the larger society. And their contribution to this effort is informed by diligence and breadth.

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Nuclear Reactions

Heavy Ion Reactions. Lecture Notes. Vol. 1, The Elementary Processes. Part 1, Elastic and Inelastic Reactions; Part 2, Transfer Reactions. RICARDO A. BROGLIA and AAGE WINTHER. Addison-Wesley, Redwood City, CA, 1990. xx, 504 pp., illus. $49.50. Frontiers in Physics, 84.

Until about two decades ago, the study of nuclear scattering and reactions was dominated by the use of light-ion projectiles (the nuclei of the atoms of helium and lighter particles, namely neutrons, protons, deuterons, tritons, helions, and alpha particles). Then came the advent of "heavy-ion physics" with the widespread availability of accelerated beams of heavier ions. This led to a dramatic explosion in the number and variety of nuclear reactions that could be studied. Essentially any stable nucleus could be used to bombard any other stable nucleus. Currently, even secondary beams of radioactive nuclei initiated by a primary nuclear reaction are being used, and this particular field promises to expand in the near future. The range of bombarding energies has also expanded enormously, now covering energies from close to zero up to 200 GeV per nucleon.

In view of the broad interest in this field, which engages the activities of a considerable fraction of the nuclear physics community, there is something of a dearth of books on the subject. There is, of course, the multivolume *Treatise on Heavy-Ion Science*, edited by D. Allan Bromley, and the subject is touched upon briefly in a number of other texts. We also have the nice introductory book of 1980, *Nuclear Reactions with Heavy Ions* by Reiner Bass. It is not feasible for a single volume to cover in depth all the subjects subsumed under the title *Heavy Ion Reactions*, and that is true also for the present volume. The best we can hope for is a careful treatment of some aspect, and that criterion is certainly met by this work.

There is no well-defined borderline between light- and heavy-ion physics; indeed, I regard alpha particles as prototypical "heavy ions" because reactions with them often display features that are characteristic of much heavier projectiles, and concepts derived from their study have found immediate application to reactions induced by the heavier ions. However, two characteristics are usually associated with heavy-ion collisions: the strong repulsive Coulomb field due to the large charges carried by the projectile and target nuclei, and the large momentum and angular momentum carried by their relative motion because of their large masses. Frequently these two features mean that the quantum uncertainties associated with the positions of the nuclei are reduced sufficiently that it becomes a reasonable approximation to think of their centers of mass as localized to motion along a classical trajectory, primarily that of a Rutherford orbit. Wave-mechanical corrections to this picture can be made using the Wentzel-Kramers-Brillouin (WKB) approximation. The internal motions of each nucleus remain strongly quantal, however, and must be treated by the laws of quantum mechanics. This hybrid approach, called "semiclassical," has been very successful when applied to both atomic and heavy-ion collisions and can provide considerably more insight (most of us being classical creatures) into the physical processes being studied than the more detailed (and more difficult) fully quantal calculations.

This semiclassical approach is also the subject of volume 1 of *Heavy Ion Reactions*. Aage Winther has devoted much of his professional career to the development and application of these semiclassical techniques, and Ricardo Broglia has been associated with much of their use in elucidating heavy-ion collision phenomena. Consequently we could hope for an authoritative treatment from these authors, and that we have. This first volume consists of two parts. Part 1 was originally published 10 years ago, under the same title, by Benjamin Cummings and is reproduced here with only minor corrections. It deals with elastic and inelastic scattering, including Coulomb excitation with which Winther has been associated for four decades, and has become established as a standard reference in its field. The present reviewer has found it invaluable source material. It is devoted primarily to the description of collisions at bombarding energies less than 10 MeV per nucleon. Nowadays these are regarded as "low energies," as accelerators capable of accelerating beams to higher energies, up to about 100 MeV per nucleon, have become available. Although this "low energy" emphasis could be regarded as something of a limitation, much of

heavy-ion physics is still done in this energy domain. Further, the techniques discussed here can be extrapolated to the higher energies; possibly this will be touched upon in the upcoming second volume.

Part 2 consists of new material on transfer reactions. It is nearly as long as part 1 and covers the description of heavy-ion collisions in which one or more nucleons are transferred from one nucleus to the other. Again, the semiclassical approach is used and the energy domain below 10 MeV per nucleon is emphasized. Particular attention is paid to the transfer of two nucleons and the importance for this process of pairing correlations in nuclear structure; again this is a subject to which both authors have contributed significantly for many years.

In summary, anyone expecting from this book a broad coverage of all aspects of heavy-ion reactions will be disappointed. But such expectations will have been unreasonably high. This volume is a valuable and useful contribution to a particular aspect of the field and can be recommended to anyone working in it or interested in the application of semiclassical techniques.

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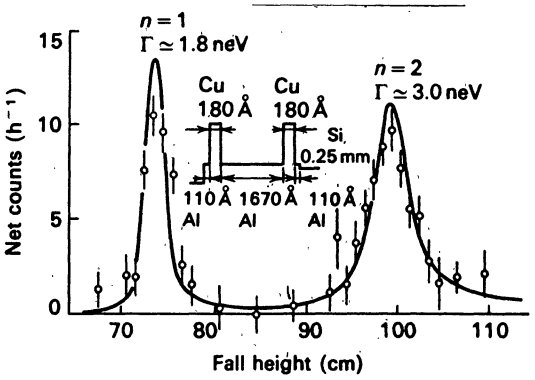
Neutrons in a Bottle

The Physics of Ultracold Neutrons. V. K. IGNATOVICH. Clarendon (Oxford University Press), New York, 1990. xiv, 397 pp., illus. $105. Oxford Series on Neutron Scattering in Condensed Matter, 5. Translated from the Russian edition (1986) by G. B. Pontecorvo.

Ultracold neutrons are neutrons with such low energy that they have velocities less than 10 meters per second; they can climb only a few meters against gravity; they have wave lengths on the order of 100 to 1000 angstroms; they can be collected and stored in material bottles for times comparable to the neutron half-life, 10 minutes. Once captured in bottles, they can be studied or can be used to study material surfaces. In sum, they are unique in their ability to express both quantum and classical characteristics. As such, they are intrinsically interesting to physics.

This book tells the story of ultracold neutrons, from the first experiments in the late 1960s to the present. Though most of the book describes laboratory-based measurements involving ultracold neutrons and the theoretical analysis of these experiments, the author does digress briefly on related topics such as neutron stars and the model of the skyrmion. The study of ultracold neutrons has been confined to a relatively small community of researchers, and the author has included as an appendix an updated bibliography of the papers published on this subject. Hence, to an unusual degree, this book is a complete story, albeit from the Russian perspective, of this very interesting topic.



Results of experiment and theory (solid line) for the relationship between the transmission of ultracold neutrons through a double barrier and the energy of the neutrons as measured by the height from which they have fallen in the gravitational field. The two peaks represent the $n = 1$ and $n = 2$ resonances through this double barrier, which consists of 180 Å of copper separated by 1670 Å. [From *The Physics of Ultracold Neutrons*; after K. A. Steinhauser *et al.*, *Phys. Rev. Lett.* **44**, 1306 (1980)]

The book is organized into a logical series of chapters on the production, detection, transport, and storage of ultracold neutrons in both material and magnetic bottles. Each chapter starts with a readable commentary on the topic followed by a presentation of technical details (both theoretical and experimental). Hence, though the book contains a large amount of technical information that makes it essential to workers in this field, it is written in such a way as to make it easily accessible to the general physicist interested in these novel particles.

A long-term discrepancy between theory and experiment for neutron containment in material bottles is described in some detail: the amount of time that ultracold neutrons can be kept in an enclosed vessel is, in practice, significantly less than that predicted by theory. The basic question is whether there is some fundamental new physics being revealed or the discrepancy is caused by "dirt" (surface hydrogen) on the bottle walls. On balance, the evidence seems to indicate the latter explanation, but the author holds open the possibility that ultracold neutrons may be trying to tell us some new fundamental physics.

For some, perhaps the most interesting chapter will be "The applications of ultracold neutrons," which starts with a description of the use of ultracold neutrons in the search for the electric dipole moment of the neutron (a test of time-reversal symmetry) and then goes on to discuss less well-known applications, such as the search for the gravitational dipole moment, the investigation of the wave properties of the neutron (resonant transmission and reflection from macroscopic targets), the search for neutron-antineutron oscillations, the neutron microscope, and the use of ultracold neutrons to study materials.

In sum, this book provides both an introduction and a review of ultracold neutrons, the only heavy particles that can be obtained with such low energy that their wave length becomes macroscopic. Because these particles dramatically display characteristics that are at the heart of modern physics and because these characteristics are difficult to observe in other systems, the topic of this book will be of interest to a wide audience. Its readability will make it additionally attractive to this audience.

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Cryobiology

Insects at Low Temperature. RICHARD E. LEE, JR., and DAVID L. DENLINGER, Eds. Chapman and Hall, New York, 1991. x, 513 pp., illus. $99.50.

Whether to freeze, vitrify, or supercool is the question faced by insects that overwinter in alpine and polar climates. This volume addresses the diversity of adaptations from the biochemical, cellular, ecological, and ultimately population levels that combine to permit the winter survival of insects. The book is a collection of 20 chapters grouped in four sections of nearly equal length. The initial chapter is appropriately a tribute to the many contributions of Reginald W. Salt (including a complete bibliography of his published work), who first classified overwintering insects into the two currently recognized broad groups: freeze-tolerant (species that can survive some degree of extracellular, and perhaps intracellular, ice formation) and freeze-susceptible (species that do not survive freezing and instead overwinter in either a supercooled or a vitrified state).

The first section, in addition to defining basic concepts and terminology, describes