Pions and Nuclei

Torleif Ericson and Wolfram Weise
Clarendon (Oxford U. P.), New York, 1988. 479 pp. $125.00 hc ISBN 0-19-852008-5

Although Hideki Yukawa predicted the existence of the pion in 1935, not until 1947 was the pion observed. In the ensuing years its various properties—mass, spin, parity and lifetime—were determined. In 1953 Enrico Fermi and his collaborators discovered the Δ resonance, which figures so importantly in pion interactions with nucleons and nuclei. Although pions had been produced using nuclear targets, and the relationship of pions to nuclear forces was understood, it was not until the 1960s that a serious attack on the meson–nucleus interaction began. It was signaled by a conference held at CERN in 1963, organized by Amos de Shalit, Torleif Ericson and Victor Weisskopf. A surge of activity followed the construction of accelerators at LAMPF, SIN and TRIUMF, which provided copious beams of pions that made possible precise studies. *Pions and Nuclei* presents the results of 25 years of experimentation and theory.

The principal thesis motivating the authors' presentation is that the only degrees of freedom important for the pion–nucleon and pion–nucleus interactions (for pions with energy less than 1 GeV) are those of the pion, the nucleon and the Δ. Starting out with the phenomenological description of the pion–nucleon interaction and a meson-based model of nucleon–nucleon forces, the authors demonstrate the validity of this assertion by showing how it provides an explanation of much of the data.

Properties of the deuteron, such as the quadrupole moment and the asymptotic D/S ratio, and the effective range parameters are shown to be dominated by one-pion exchange. The next most complicated system involves pion production in nucleon-nucleon collisions and pion–deuteron scattering. At the other extreme is the physics of the pion and the Δ in nuclear matter, where one studies the influence of the medium on pion and Δ propagation, and the possibility of pion condensation.

Perhaps the most persuasive evidence for the authors' thesis lies in the elastic and inelastic pion–nucleus scattering and in charge-exchange scattering. At low energies an optical model whose parameters are closely related to the potential used to describe pionic atoms provides a good description. For larger energies the Δ plays a dominant role, and one finds that in the nuclear environment it behaves like an excited nucleon. The Δ-hole nuclear state acts as a doorway for the reactions in this energy range.

The electromagnetic field can be used to probe this picture of the pion-nuclear system with nucleonic, pionic and Δ degrees of freedom. The model's quantitative predictions of photoproduction of pions and of the presence of the pionic exchange current, as revealed by neutron or deutron capture and electron scattering from He^3 and H^3, confirm its validity.

Soft pion processes require an understanding of chiral symmetry, which is exact in the limit of massless quarks. The authors explain beautifully the place of chiral symmetry in quantum chromodynamics, providing an understanding of the partially conserved axial current and the Goldberger–Treiman relations.

This is an excellent book. The authors successfully make every effort to put their intuition at the service of the reader. They make analogies with electromagnetic phenomena time and again to introduce and clarify their approach. Their account is coherent, well integrated and persuasive. It is not an "easy read," however; their discussion, in order to highlight the physics, often does not provide the details of the intermediate steps. Summaries of the background formalism are relegated to 16 appendices and will be useful to the well-educated advanced student and research worker. As the authors point out, the number of possible references is enormous, so the major publications they cite are review papers. There is no attempt at completeness. The authors have a particular point of view and a fascinating story to tell, and for the most part they list only those references relevant to that point of view.

I have only two complaints. I would have liked a chapter on future directions for the field. And the cost of this book is exorbitant, a disservice to the authors and to the scientific community.

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The Physics of Laser Plasma Interactions

William L. Kruer
Addison–Wesley, Redwood City, Calif., 1988. 182 pp. $40.95 hc ISBN 0-201-15672-5

This is a timely and important book on recent developments in the theory of the interaction of intense laser light with plasma. Many of the topics discussed apply generally to any problem involving the interaction of intense electromagnetic radiation with an unmagnetized plasma. The field of laser–plasma interactions has developed over the past 20 years in support of work toward achieving inertially confined fusion using lasers. William Kruer, the book's author, has been a leader and a pioneer in efforts to understand the rich and challenging physics that has been discovered as a result.

Many phenomena compete and interact in laser–plasma interactions; one would think that little progress could be made. However, as this book clearly shows—through comparison of predictions with experimental results—a considerable degree of success has been achieved. This success has largely been obtained through numerical modeling of phenomena in combination with analytic treatments of simple physical models incorporating the essential physical processes that show up in the numerical simulations. These results are verified by experiments. The resulting physical understanding has a considerable (though not perfect) predictive capability.

No one is better at explaining the basic physics considerations on which this understanding is based than Kruer. The starting point is a fundamental understanding of the physics of plasmas, which includes kinetic theory, the theory of wave propagation in plasma and an understanding of important nonlinear processes such as those responsible for parametric instabilities, those involved in wave–particle interactions and those involved in nonlinear heat transport. All these and more are discussed in