Book Review

Introduction to Atomic and Nuclear Physics. By Henry Semat and John R. Albright. Holt, Rinehart and Winston, Inc., New York (1972). 721 pp.

Introduction to Atomic and Nuclear Physics is the fifth edition of the book first introduced by Henry Semat and now includes John Albright as junior author. The four previous editions have seen many years of usage. The fifth edition draws on that usage, as well as on the authors' many years of experience teaching atomic and nuclear physics to undergraduates. The book is designed for a one-year course for sophomores and juniors or for use as texts for separate undergraduate courses in atomic and nuclear physics.

Since many have used the previous editions, it is appropriate to mention first the major revisions included in this latest edition. The emphasis is still on the experimental foundations of the two fields, including the historical context in which they have developed. A great deal of the data presented has been updated, and many new problems, references, and mathematical appendixes have been added. In the older chapters, however, the data have not been uniformly upgraded; for example, older decay schemes and NaI(Tl) gamma-ray spectra are kept in Chaps. 15 and 16. Three new chapters on the simple Schrodinger quantum mechanics, molecular and solid-state physics, and particle detection devices and transport systems appear as welcome additions, along with a considerably expanded chapter on the fundamental particles. For the benefit of all, a brief look at the complete book is given.

Each person brings to the teaching of atomic and nuclear physics his own interests and biases in the selection of material to be covered, as this reviewer well knows from his own experience teaching undergraduates these subjects over the last ten years. Any text that would include all of everyone's material would be too unwieldy as well as expensive. My review reflects my own biases, which in many ways are very similar to those of the authors of the text. Overall it is a good text for a one-year course. For use in separate courses, it is stronger in the nuclear and particle sections than in atomic physics. However, this judgment depends on how much molecular and solid-state physics one would like to include in a one-semester atomic physics course. One of the strengths of the book is its good interweaving of the historical material and the development of each topic to its present understanding.

The introductory chapter gives adequate accounts of the work that gave rise to our early understanding of atoms and electrons. There is a lack of material on statistical phenomena and kinetic theory of gases that could be useful. The experimental evidence for radioactive decay and the atomic nucleus is presented in Chap. 3. There are good discussions on the identification of the alpha particle and on Rutherford's scattering work, which is strengthened by an appendix.

Chapter 4 is quite good and includes some valuable material often omitted in such texts. These include sections on radiation from accelerated charges, polarization, pressure, and linear and angular momentum of radiation. The section on black body radiation could have been somewhat more thorough, but this material is found in many texts. This section naturally ties in strongly with the following material on x rays. There are extensive discussions of x-ray scattering, absorption, and the Compton effect.

The chapter on waves and particles is more of a mixed bag. The discussion of de Broglie waves and the velocities is well done, but the electron diffraction experiments of Davidsson and Germer could have been more complete. In the section on the Heisenberg uncertainty principle, the position-momentum expression is thoroughly covered, while the energy-time condition is only briefly mentioned. The latter could have been illustrated with the lifetime of atomic and nuclear levels. There is a nice section on electron microscopes. The problems for Chap. 6 could have been improved.

The next chapters on the elements of quantum mechanics and the hydrogen atom are very good. The concept of selection rules is well handled and illustrated. The problems complement the material nicely. The development of the Bohr theory is treated well, and there is a helpful discussion of the reduced mass of the system, which is often omitted in such texts.

The chapter on optical spectra and electronic structure begins with a good discussion of angular momenta and their coupling. The coupling of the spin and orbital motions to split the electron levels in atoms, however, is not treated as thoroughly as it should have been. The Zeeman effect is well covered, as is the Laser effect. For a one-semester course in atomic physics, one would like some more material on two-electron and multi-electron spectra. The chapter on the theoretical understanding of characteristic x rays follows very naturally. The x-ray spectra of uranium provide a good illustration of the energy levels and their quantum numbers, but the relationship between the levels, quantum numbers, and transitions seen could have been discussed more extensively. Some modern applications of x-ray fluorescence would have added interest. The companion material on molecular spectra follows as one of selected applications of quantum physics and is well done. Again, for a one-semester course one might desire some more material on the band theory of solids (depending on what the instructor chooses to emphasize), but the basic material is there.

The third section of the book turns to nuclear and elementary particle physics. While one might choose to shift Chaps. 12 and 13 on particle accelerators and detecting devices to later in the semester, these chapters are generally well-done valuable additions. One is somewhat surprised to find essentially nothing on sector-focused cyclotrons and heavy ion accelerators. The next chapter is excellent for

high energy particle detectors at this level but is behind the times for low energy electron and gamma-ray detectors. More material is needed on solid-state detectors and multichannel pulse height analysis, which are producing a revolution in the quantity and quality data in nuclear physics.

While the chapter on radioactivity contains all of the essential material, some of the illustrations of nuclear decay schemes and gamma-ray spectra should have been more current. Moreover, one does not get the sense of vigor that is present in this field. The sections on resonant absorption and the Mössbauer effect are well done, including applications of the Mössbauer effect. The chapter on nuclear reactions does an excellent job of letting us see the historical development of this field and the basic reactions. Again, however, the vitality of nuclear reaction physics as a research field today does not come through; it should be noted, however, that this is a common fault of most all textbooks in this area. The chapter on fission and fusion is good and includes some nice surprises, such as the section on transuranic elements. The chapter on nuclear processes covers a variety of important topics, generally well. The section on nuclear models is good, but the discussion of collective effects and nuclear deformations could have been expanded.

The chapter on fundamental particles is up-to-date and includes good discussions of many of the important experiments of the last 15 years. Parity nonconservation in beta decay and its consequences is covered more thoroughly than usual. The sections on elementary particles and the role of symmetry principles are well done.

In conclusion, the authors have provided more than sufficient material for a good one-year course or two one-semester courses in atomic and nuclear physics at the sophomore-junior level, with the latter sections of the nuclear material more suitable for junior or seniors. Those who have used Semat's earlier editions will be pleased by the new edition, which will win some new friends too.

J. H. Hamilton

Vanderbilt University
Department of Physics and Astronomy
Nashville, Tennessee 37203

March 9, 1973

About the Reviewer: Joseph Hamilton is professor of physics at Vanderbilt University, where he has been a faculty member since 1958. Following undergraduate studies at Mississippi College, Dr. Hamilton completed his graduate work at Indiana University. His extensive research interest is in experimental nuclear physics, resulting in his participation in many national and international conferences. He is a Fellow of the American Physical Society.