absorption or attenuation of photons and charged particles. Molecular biophysics is not treated in depth.

The book is soundly designed as both a text and a reference book. The notation is consistent from chapter to chapter; the illustrations are helpful; references and mathematical symbols are listed at the end of each chapter; the appendices are useful; and the Pascal computer programs should help readers who wish to explore some models in more detail. And a separate solutions manual is available.

The second edition is an improvement upon an already excellent text: Important material has been added; several key derivations are more polished; and there are twice as many problems, many of which are drawn from the literature. There is a slight unevenness in the level of sophistication among the chapters, but this is less true of the second edition than of the first. For example, ion diffusion is covered with much more detail and rigor than is the electrocardiogram—but then transport phenomena have much broader applicability. The writing style is uniformly enjoyable and the derivations are easy to follow. So much material is presented that an instructor can select the material best suited for a particular class, whether it covers one, two or three semesters. The book can be intimidating, particularly to undergraduates not familiar with the ways of physics, but an instructor should be able to calm the anxious student by showing how well physics works on what are often, and erroneously, thought of as nonphysical systems.

This book is worthy of careful examination by any physicist curious about the life sciences. It could easily become the basis of a variety of courses that demonstrate to physicists and nonphysicists alike the elegance and universality of physics. In this perspective, it is appropriate to modify the classic statement "A good way to prepare for the Graduate Record Examination in physics is to master everything in David Halliday's and Robert Resnick's *Physics*" to read "A good way to become a medical physicist or biophysicist is to master everything in Hobbie's *Intermediate Physics for Medicine and Biology*."

Galileo Heretic

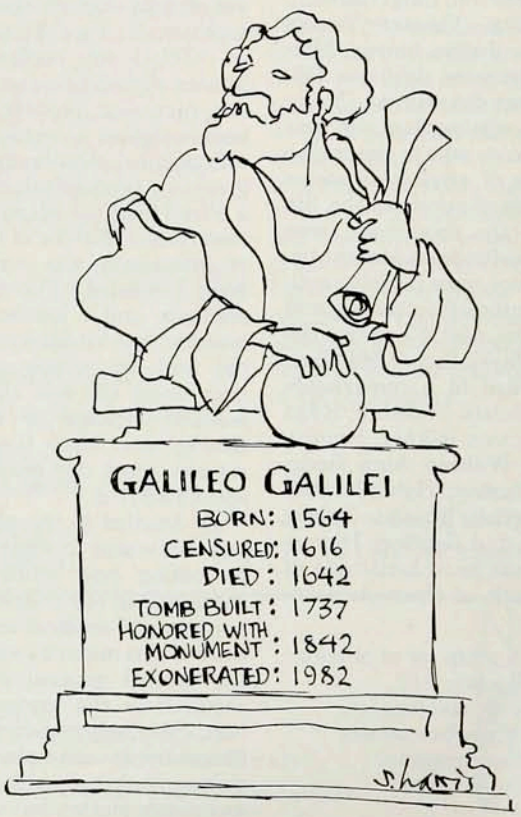
Pietro Redondi
Princeton U. P., Princeton, N. J., 1987. 356 pp. $29.95 hc
ISBN 0-691-08451-3

In 1623 Galileo published *The Assayer*, a slashing attack on a work called *The Astronomical and Philosophical Balance* that had appeared a few years before under a pseudonym, but was known to be the work of Orazio Grassi, S. J., a member of the faculty at the prestigious Jesuit Collegio Romano. Their disagreement had begun as a debate about the nature of comets. Grassi held them to be something like planetary bodies; Galileo maintained that they were no more than optical effects in the upper atmosphere. The dispute had by then enlarged to include the physics of heat, light and color.

Galileo's book was an instant success with the general public. Its biting irony, its witty sallies and the elegance of its literary style commended it to a much larger audience than a work in natural philosophy could ordinarily count on. The newly elected Pope, Urban VIII, an admirer of Galileo, had it read to him at table. But professionals were much less enthusiastic, though respectful of the achievements of the talented Florentine. Astronomers had, over the previous half-century, accumulated sufficient data on the motions and parallaxes of comets to make Galileo's arguments in support of the traditional Aristotelian view (that they were sublunar) appear suspect and, indeed, quite puzzling. In particular, his criticisms of Tycho Brahe were seen as unfair; even the mild Johannes Kepler felt called on to point out that Galileo's flat dismissal of Tycho's compromise alternative to the two chief world systems of Ptolemy-Aristotle and Nicolaus Copernicus rested on some bad arguments.

Pietro Redondi's new book takes *The Assayer* as its starting point, and has had a reception in some ways remarkably similar to the earlier work's. It has been accorded enthusiastic notices in literary reviews and the general press; it has been adopted by book clubs and ranked on best-seller lists. It has been praised for its style and for the feel it gives for the "theater of shadows" (the author's phrase) that was 17th-century ecclesiastical Rome. But the professionals (in this case historians) have on the whole been quite critical. They acknowledge the scholarship and the energy that have gone into the making of the book, but find its arguments unpersuasive and its main thesis quite incredible.

The book reads almost like a thriller. The author cuts back and forward between the 17th century and the 20th, from Galileo enmeshed in the Roman politics of his day to Redondi, the sleuth, searching for clues in ancient files as to what *really* happened back then. The central episode of the book, that around which the



entire plot hinges, is Redondi's discovery on the morning of 11 June 1982 of an unsigned denunciation of Galileo in the archives of the Holy Office, a document that had escaped the eagle eye of the editor of the National Edition of Galileo's works, Antonio Favaro.

Redondi was looking for something quite different. In a letter to Galileo in 1625, Mario Guiducci mentioned that a complaint had been made to the Holy Office about *The Assayer*'s defense of Copernicanism; a theologian familiar with astronomy, Giovanni di Guevara, was consulted and found nothing condemnable about "that doctrine of motion." Redondi was (rightly) puzzled: *The Assayer* does not deal with the Copernican issue at all, and a theologian could hardly exonerate the Copernican belief in the Earth's motion, which only a few years before (1616) had been proscribed by the Congregation of the Index. So he set out to find, if possible, di Guevara's report for the Holy Office.

What was actually brought to him in the archives, however, was not di Guevara's defense of Galileo but, on the contrary, a denunciation of *The Assayer* for the atomism it purveys, incompatible as it is (the document's author urges) with the Catholic doctrine of the Eucharist. This previously unremarked letter, which Redondi has dubbed "G3," was bound in a miscellaneous collection of 17th-century documents, and was listed (under "Galileo"!) in a card file compiled since Favaro's day.

Galileo was denounced to the Holy Office many times in his career. And the Holy Office files are full of denunciations like G3. It was of interest to uncover a new document in a case that has been so thoroughly investigated by so many for so long. But of itself, it did not seem especially significant. Unless.... All of a sudden Redondi saw a way to make it the key to an entirely novel reinterpretation of the Galileo trial. Suppose, just suppose, the *real* case against Galileo dated back to this denunciation of *The Assayer*. Suppose the Church's objection to his work was not his defense of Copernican astronomy but the destructive implications of his atomism for Catholic theology. Would this not stand the usual account of the Galileo trial on its head? Indeed it would. So Redondi proceeded to seek for clues, for "new scenery" in place of the "traditional stage-setting" (he is very fond of theatrical metaphor). His procedure, he tells us, is to ignore the obvious readings of the evidence; are we not, after all, dealing with a world where dissimulation and stratagem were the rule? We must, then, penetrate behind the appearances and invent motivations, plots and counterplots in an effort to bring all into a new coherence.

His scenario is an ingenious one. The author of the denunciation—he suggests—was none other than Grassi, the butt of so much savage satire in *The Assayer*. A challenge to the Eucharist, the touchstone of Catholic belief, was far more serious than a mere matter of astronomy. (The real presence of Christ in the Eucharist was defined at the Council of Trent in terms of "transubstantiation": The appearances of bread and wine miraculously remain, but the substance is now that of Christ. The substitution of atoms for Aristotelian substance, according to the critics, made it impossible to see how Christ could *really* be present in the Eucharist.) In early 1632, Galileo's *Dialogue on Two Chief World Systems* appeared. Its publication obeyed all the rules. And yet, almost immediately, violent opposition to it showed itself in Rome. "We know," Redondi says, that the problem "could not be Copernicus's theory, which he had unofficially been authorized to broach." So what was it? Well, the only other likely candidate was the charge of heresy in regard to the Eucharist. Even though atomism nowhere figures in the *Dialogue*, Galileo's Jesuit critics would not have allowed the charge to die.

The Pope wanted to protect his old friend Galileo—so Redondi's scenario continues—and did his best to prevent the matter's coming to trial. But he was himself in the midst of a political crisis: The Spanish cardinals were charging him with insufficient zeal for the Catholic (to them the Hapsburg) cause. He could not allow his "official scientist" (in Redondi's words) to be tried at this sensitive time for a serious heresy, but he also could not at this point avoid a trial of some sort. So "in order to cover up a more serious scandal," a face-saving "farce" was worked out within the Holy Office at the Pope's instigation. Galileo was tried for the lesser charge, the "venial crime" of Copernicanism, and in fact received the minimum penalty. This clever compromise more or less satisfied everyone, even the defendant. Many of the original protagonists, both Galileo's critics and his supporters, were exiled from Rome; Grassi was not heard from again, and as for di Guevara, "the Galileo affair shattered his ecclesiastical career."

How about it? Every single compo-

nent in this construction can be challenged. There is no real evidence that Grassi was the author of G3; the handwriting samples reproduced in the book do not support the claim, nor is there any other halfway convincing argument. Atomism is only a quite minor theme in *The Assayer*; in no sense can that work be construed as a defense of it. Galileo took over a view that had become widespread among natural philosophers and used it for his own purposes without any particular emphasis. There is not the slightest evidence that this issue was ever so much as *mentioned* in the course of the debates that followed the appearance of the *Dialogue*. The evidence that the Pope was violently angry with Galileo is overwhelming. Far from attempting to protect the scientist, the Pope's evident feeling of betrayal led him to carry on the vendetta against his former friend even into Galileo's last years at Arcetri, and indeed even beyond the grave.

The likely reasons have often been laid out. Galileo had promised to treat Copernicanism "hypothetically," that is, as a calculational fiction. (This was how Urban used the term "hypothetical.") But the *Dialogue* claimed that the offending doctrine could be *proved*. The issue was no "venial crime." It was not a matter of astronomy nor of displacing man from the center of the universe. It was a matter of the authority of Scripture, in an age where this issue (even more than the Eucharistic doctrine) was at the foreground of theological debate between Protestant and Catholic. There is no evidence that the charge against Galileo was seen as the lesser of two alternatives, none that Galileo was satisfied with the outcome, nor any that di Guevara and Grassi were "exiled" because of their roles in the affair.

In short, we have here an engaging "theater of shadows" to match the Rome that Redondi so eloquently invokes. The book is an altogether impressive example of what sheer erudition and a powerful historical imagination can do to transform shadow into highly readable substance.

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Introductory Nuclear Physics

Kenneth S. Krane
Wiley, New York, 1987. 845 pp. $54.90 hc ISBN 0-471-80553-X

In the past decade and a half, many new nuclear phenomena have been observed. In addition, nuclear physics is now increasingly relevant to astrophysics, the recent naked-eye supernova being only the most strikingly obvious example. Nuclear experimental techniques have also been adapted to solve problems in medicine and other disciplines. Someone teaching the subject would surely like to address many of these issues within an introductory undergraduate nuclear physics course. Until recently, however, the only available texts were ones written in the late 1960s or early 1970s and few have been revised since. New texts are clearly needed. *Introductory Nuclear Physics* by Kenneth Krane is a welcome addition to the literature; it discusses many of the new phenomena and has many attractive features that lead me to strongly recommend it for an undergraduate course.

The book is divided into four sections, covering nuclear structure, radioactive decay, nuclear reactions, and advanced topics and applications. The section devoted to nuclear structure discusses the nucleon–nucleon interaction, the masses and radii of stable nuclei, and the shell and collective model descriptions of the low-lying nuclear levels. The section on radioactivity deals with weak, strong and electromagnetic decay modes of the nucleus; it also contains a chapter on detection techniques. In the section on nuclear reactions, there are separate chapters on accelerators, fusion and fission. The latter two chapters include descriptions of solar fusion, nuclear reactors and nuclear weapons. The final section, on advanced topics and applications, includes chapters devoted to meson physics, particle physics, nuclear astrophysics, and applications of nuclear physics to other disciplines such as medicine.

The text emphasizes experimental observations, not the formal development of nuclear theory. In most cases, theoretical concepts are discussed at a level comparable to that of Walter Meyerhof's undergraduate text *Elements of Nuclear Physics* (McGraw–Hill, New York, 1967), but sometimes at a simpler level than found in Bernard Cohen's text *Concepts of Nuclear Physics* (McGraw–Hill, New York, 1971) or in W. E. Burcham's text *Elements of Nuclear Physics* (Longman, London, 1979). Formulas that require a nontrivial understanding of the quantum theories of angular momentum or many-body systems are usually motivated by simple and often classical arguments. Even in this simplified approach, some prior familarity with three-dimensional quantum mechanics is necessary, and a review chapter on the subject is included in the text. Beginning students will find the resulting text easy to read. Despite the book's considerable length (about 800 pages), an instructor can construct even a short, 10-week introductory course using this text, without a loss in continuity.

I recommend this text strongly. It covers an impressively large scope of topics and includes a number of interesting recent developments in nuclear physics and related topics. For example, spontaneous C^{14} emission, the natural fission reactor in Gabon in Africa, rotational backbending, hypernuclei, *CP* violation and grand unification theories are all briefly discussed. Krane has also taken special efforts to illustrate even the more traditional topics, such as β decay, with examples from the recent literature and to relate these measurements to issues beyond the domain of nuclear physics. With respect to β decay, for example, one finds discussions of β-delayed nucleon emission; experimental measurements of double β decay and their relationship to lepton number conservation; recent neutrino mass measurements and their relationships to the closure of the universe, lepton number mixing and the solar neutrino problem; and also a discussion of the measurement of the solar neutrino flux by Raymond Davis. As other examples, the chapter on electromagnetic decay contains a description of measurements of the gravitational redshift via the Mössbauer effect, and the chapter on neutron-induced reactions contains descriptions of the low-energy neutron interference measurements that demonstrated the phase shift of the neutron wavefunction caused by the gravitational potential. These and other inclusions of modern topics and examples really help interest the student and communicate the liveliness of the scientific endeavor.

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Collider Physics

Vernon D. Barger and Roger J. N. Phillips
Addison–Wesley, Redwood City, Calif., 1987. 592 pp. $44.95 hc ISBN 0-201-05876-6

A major achievement by particle physicists in recent years is the discovery that the strong, weak and electromagnetic forces can be described by gauge theories in what has come to be known as the "standard model." *Collider Physics* covers the