Book Reviews

Readings of Galileo

Galileo and His Sources. The Heritage of the Collegio Romano in Galileo's Science. WILLIAM A. WALLACE. Princeton University, Princeton, N.J., 1985. xiv, 372 pp. $42.50.

Galileo is one of the few scientists whose works and correspondence have been published in full, and this has enabled scholars to study his thought in greater detail than is possible for most pioneers of the Scientific Revolution. The 20 volumes of the National Edition of his writings, edited by Antonio Favaro between 1890 and 1909, have withstood the test of time. In recent years, however, two shortcomings have become apparent. The first concerns manuscript notes related to the *Two New Sciences*, the masterpiece in which Galileo laid the foundations of mechanics. Favaro had found these notes so fragmentary and incomplete that he gave only a sample of them. In the last 15 years they have been the object of intensive research, and they were published in the probable order of their composition by Stillman Drake in 1979. The second shortcoming concerns three Latin notebooks that Favaro took to be scholastic exercises and ascribed to the period 1581–1585, when Galileo, then between 17 and 20 years of age, was still a student at the University of Pisa. Favaro published only the second, which contains discussions of topics raised in Aristotle's *On the Heavens* and *On Generation and Corruption*, and the third, which consists of drafts of a dialogue and an incomplete treatise on motion. The first notebook, which deals with logical questions in Aristotle's *Posterior Analytics*, was effectively excluded, Favaro contenting himself with giving a few excerpts as examples of Galileo's undergraduate notes. These three notebooks, all in Galileo's handwriting and now in the National Library in Florence, are the subject of this volume by William Wallace, who has devoted several years to their study. He is responsible, along with Alistair C. Crombie in England and Adriano Carugo in Italy, for identifying these sources as works of professors at the Collegio Romano, the most prestigious institution of the Jesuits. Although Crombie, Carugo, and Wallace are not always in agreement over the particular text that Galileo summarized, there can no longer be any doubt that he attached great importance to Jesuit teaching in natural philosophy.

Wallace is able to establish that Galileo did not write these notebooks as an undergraduate, as Favaro claimed, but during the tenure of his first university appointment at Pisa, between 1589 and 1592. Like many young professors faced with the task of lecturing for the first time, Galileo cast around for the best available textbooks. It was natural that he should turn to the Collegio Romano, then at the forefront of learning in Catholic countries. As a young mathematician, he had called on Christoph Clavius (1537–1612), the professor of mathematics and astronomy, had been warmly received, and had even obtained a letter of recommendation that helped him secure his post at the University of Pisa. Galileo used Clavius's *Commentary on the Sphere of Sacroboscus* (published in 1581) in compiling the section on astronomy in his second Latin notebook. It is here that we find the earliest appearance in Galileo's hand of the name of Copernicus, whose location of the earth in an orbit around the sun is rejected in favor of traditional geocentrism.

The other section of the second notebook, dealing with the theory of elements and qualities put forward by Aristotle, is considered by Crombie and Carugo to derive from the textbook of two other professors of philosophy at the Collegio Romano, both Spaniards: Benito Pereira (around 1535–1610) and Francisco de Toledo, or Toletus (1532–1596), who became a cardinal. Similarities between passages in these textbooks and Galileo's essays cannot be denied, but Wallace argues that the lecture notes of four other Jesuit professors show even more striking parallels and coincidences with the words actually used by Galileo. These professors, who lectured on physics at the Collegio Romano between 1577 and 1591, are Antonion Menu, Paul Valla, Muzio Vitelleschi, and Ludovico Ruggiero.

The source of the first notebook on logical questions raises an even more interesting question. In 1975 Carugo discovered that the first part of this notebook corresponds to a section in a treatise by Ludovico Carbone published as a supplement to a work by Toletus. The date of publication, 1597, startled the world of Galilean scholarship. Could Galileo have been copying scholastic texts as late as 1597, when he was in his 33rd year? It is one of the great merits of Wallace's book that it shows Carbone's text to be a plagiarism and to rest on a course that Paul Valla gave at the Collegio Romano in 1587–1588. Carbone was not a Jesuit, but he had studied at the Collegio Romano, where the professors frequently made their notes available to their students. Wallace conjectures that Galileo was given the notes that Carbone later published under his own name, and perhaps other lecture notes by other professors, when he visited Clavius in Rome late in 1587. Whether he got the notes at this time or shortly thereafter, he was anxious to prepare himself for his first teaching appointment by mastering the works of the men who were at the vanguard of the revival of Catholic learning.

Thanks to Crombie, Carugo, and Wallace, we now know that Galileo read the notes and textbooks of Clavius and his colleagues. The three Latin notebooks are a faithful mirror of the best scholastic treatises of the latter half of the 16th century. They comprise closely reasoned arguments, making often fine distinctions between opposing opinions. Apart from Aristotle, cited continuously, the highest rates of citation are scored by his commentator Averroes, followed by Aquinas and his disciples. The theory of truly scientific demonstration expounded by Aristotle in the *Posterior Analytics* was a model on which everyone in Galileo's time had been educated and which was widely accepted as the ultimate goal of knowledge. Wallace argues that Galileo remained, from a methodological point of view, a true Aristotelian to his dying day. After surveying the development of Galileo's science, he concludes: "A more puzzling aspect of the thesis presented in the foregoing pages is that Galileo emerges from them as an Aristotelian *malgré lui*" (p. 348). One would not wish to deny that a great attraction for Galileo of his argument from the tides to the earth's motion was that here he had a truly scientific demonstration by Aristotle's criteria: *this* cause must produce *those* effects, and *those* effects must entail *this* cause *and no other*. I am struck, however, by the radical difference between Galileo's science and the conservative and stale natural philosophy of the Jesuits whose works he pored over in his early 20's. The evidence adduced by Wallace seems to be overwhelming in one sense: if this was Galileo's heritage he was born a pauper! Galileo's greatness is enhanced when we realize how far he had to travel to reach the avenue that was to lead to modern science. Galileo could not but hope to prove his system to the satisfaction of the Aristotelians, but he drew his inspiration from other sources. Niccolo Gherardino, who had known Galileo personally and was one of his first biographers, writes: "He exalted Plato to the skies for his truly golden eloquence, and for his method of writing and composing dialogues, but above everyone else he praised Pythagoras for his way of philosophizing, but in genius he said that Archimedes had surpassed them all, and he called him his master." The omission of Aristotle's name from this role of honors is not insignificant.

It is inevitable that a book of the scope and ambition of this one will be controversial and give rise to objections of the kind put forward here. What ought not be controversial, however, is that Wallace has given us an outstandingly lucid and intelligent account of matters of great interest. This book is the first comprehensive and unified treatment of the influence that the Jesuits exerted on one of the greatest minds of all times, and the nature and extent of that influence are now open for debate.

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Atom-Atom Collisions

Theory of Slow Atomic Collisions. E. E. NIKITIN and S. YA. UMANSKII. Springer-Verlag, New York, 1984. xii, 432 pp., illus. $49. Springer Series in Chemical Physics, 30. Translated from the Russian edition (Moscow, 1979).

The theory of slow atomic collisions plays a fundamental role in the microscopic understanding of a variety of processes in chemical physics and chemical kinetics. The term "slow" means that the velocity of the atoms is substantially smaller than the velocity of the electrons in the atoms, and generally applies to atom-atom collision energies less than 10 electron volts in the center-of-mass frame. Considerable progress has been made on the development of this theory, and the time is ripe for a comprehensive presentation such as is provided by Nikitin and Umanskii. Both authors have been at the forefront of research in this subject and have made seminal contributions to the current form of the theory.

The main focus of the book is on the quasi-classical version of the theory. Most of the formal development has occurred with this version, perhaps because the fully quantum mechanical version is more "well defined" and hence is somewhat more of a computational problem. This is not to say that all aspects of a fully quantum mechanical description are well understood, but the quasi-classical approach allows for more "art" in its execution. Furthermore, it is generally simpler to apply (once the correct formulation is constructed for a given problem), and it often provides a clearer physical picture of the collision process. A theoretical analysis of slow, quasi-classical atomic collisions can be viewed in three stages: calculation of the adiabatic electronic terms and couplings between relevant states; calculation of the probability amplitudes of nonadiabatic transitions between these states, induced by the relative motion of the atoms; and calculation of differential and total cross sections using these probability amplitudes. Though previous books have dealt with selected aspects of the three stages, the present book provides the most balanced and up-to-date treatment of all three aspects.

Since the treatment of electronically nonadiabatic transitions in atomic collisions must include two or more electronic states (and, indeed, most atomic collisions of current research interest are nonadiabatic—the elastic approximation is generally restricted to the collision of two closed-shell atoms, both in ^1S states colliding at low energy, or to nonzero spin states when the electronic orbital angular momenta are zero), the collision theorist has been forced to consider electronic degrees of freedom explicitly. This means that the well-rounded collision theorist must be a good "spectroscopist" in terms of understanding various electronic and nuclear angular momentum coupling schemes. The authors, who are established experts in this regard, have devoted considerable space in the book to this subject. The novice collision theorist is no longer forced to look in many different places in order to gain a unified picture.

The authors have not sacrificed discussions of the cornerstones of basic collision theory, such as elastic scattering and two-state semiclassical models. With respect to the latter, they have tackled the fundamental problems of multiple transition points and the breakdown of the standard JWKB (Jordan-Wentzel-Kramers-Brillouin) approximation, such as occur in nonadiabatic transitions near a turning point.

The book is written in a very readable style. I would be happy to teach a course on modern collision theory based on it. The concepts presented are restricted to atom-atom collisions, and for an up-to-date understanding of atom-molecule collisions, particularly rearrangement processes, one must turn to journals and review articles. The restriction to atom-atom collisions is part of the reason for the success of the book: All three stages of slow, quasi-classical atomic collisions are covered thoroughly, with considerable attention given to many "nasty" details that are usually omitted. The book can be viewed as the first volume of the current theory of atom-molecule collisions.

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Avian Ecology

Shorebirds. Behavior of Marine Animals, vols. 5 and 6. JOANNA BURGER and BORI L. OLLA, Eds. Plenum, New York, 1984. Vol. 5, Breeding Behavior and Populations. xvi, 437 pp., illus. $59.50. Vol. 6, Migration and Foraging Behavior. xiv, 329 pp., illus. $49.50.

The papers in these two volumes document the increased interest in shorebird biology that has developed over the last decade or so. The 15 contributions cover shorebird classification, population dynamics, breeding systems, migratory behavior, foraging and spacing patterns, and conservation and related topics. Most provide useful, interesting, and often provocative blends of literature review and current research that lead to new insight into ecological and evolutionary questions or at the least point out limitations in current knowledge. I was surprised in the review sections at how much of the information on shorebird biology derives either from what might be called anecdotal sources (incidental observations and short-term or topical investigations) or from a relatively few intensive investigations. The latter, in particular, have been concerned with only a handful of species, most of which have been studied by only one investigator at one site over a period of at most a