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Book Reviews

Tenbin no Majutsushi: Arukimedesu no Sūgaku (Sorcerer of the Scales: Archimedes' Mathematics)

By Eiji Hayashi and Ken Saito. Tokyo (Kyōritsu Shuppan). 2009. ISBN 978-4-320-01910-2. x + 249 pp. + 8 clr. plates. ¥ 3300.

林栄治・斎藤憲『天秤の魔術師 アルキメデスの数学』共立出版, 2009.

Hayashi and Saito have produced a detailed and valuable study of Archimedes' enigmatic treatise the *Method*. In this treatise, Archimedes discusses the use of a mechanical conception of geometric objects that he claims he used to discover many of his published results, and which he shows can also be used to find new results. The book itself can be understood as an extended argument that it is possible to read the *Method* as the description of a set of mechanical techniques that Archimedes really did use to make many of the discoveries concerning the measurement of geometric objects for which he is so famous. It is intended for a broad audience, and, as such, it contains short sections confirming Archimedes' results using integral calculus and the mechanical concept of moment as well as longer arguments following Archimedes' own style, but which may seem unwieldy to readers not immersed in Greek mathematics. Nevertheless, it also contains a number of discussions that will be of interest to specialists, including a number of new readings, based on the Archimedes Palimpsest, and new reconstructions following Archimedes' methods (ex. pp. 57, 94–97, 119–127, 214–216).

Although they consider a number of possibilities, Hayashi and Saito are inclined to the belief that the *Method* was written by Archimedes in his old age and sent to Eratosthenes in the earnest hope that the techniques it reveals might be put to further use after he had passed away (pp. 157–158, 217–222). As the authors explain, Archimedes' approach relies on the use of a conceptual device that allows one to apply the law of the lever to balance sections of solids or plane figures, and which they call a *virtual balance* (*kasō-tenbin* 仮想天秤, p. 33). Many of the propositions, however, are accompanied by photographs of physical models that depict the equilibrium in question, and which lend weight to the claim that the results were originally obtained by following a mechanical line of thought. Nevertheless, Hayashi and Saito maintain that the mechanical aspect of the approach was conceptual, not experimental (pp. 32–34), and indeed some of the equilibriums in question cannot be instantiated in a physical model, since more than one object would have to occupy the same physical space (pp. 77, 134). The analysis of the mechanical approach of the *Method* is supported, in the first of four appendixes, by a discussion of Archimedes' previous work on the law of the lever, *Equilibrium of Planes* I 6 and 7. This appendix will be of interest to historians since it argues that there is no fundamental problem with *Equilibrium of Planes* I 7, as previous scholars have claimed, and that any gaps in the transmitted argument can readily be filled by considerations that Archimedes would have regarded as trivial.

After an introductory chapter, dealing with Archimedes' life, the manuscript evidence, Greek mathematical practice, and the mechanical assumptions that will be used in the treatise, the book proceeds to a discussion of *Method* 4 and 5, which treat the volume and center of gravity of a paraboloid. The detailed treatment begins with these two propositions because they are mathematically simpler than the first propositions of the treatise (pp. 34 and 138), and the ideas developed here will appear in later chapters as well. The format of the treatment of most of the propositions is similar: first the overall argument is sketched using the principle of the lever applied to the *virtual balance* and accompanied with photographs of a model showing the equilibrium in question, then the details of the argument are given, using Archimedes' mathematical methods. These are usually accompanied with an insert, using integral calculus to confirm Archimedes' result. For propositions that concern a center of gravity, there is often also a section that treats the problem using the modern concept of moment, proceeding the section on Archimedes' argument. In Chapters 3 and 5, this structure is then applied to explaining *Method* 2, 6, 7 and 9 (a discussion of *Method* 3 is omitted, since the proof is similar to *Method* 2, while *Method* 8 and 10 are merely asserted by Archimedes without proof). Chapter 5 contains a complete reconstruction of the argument for *Method* 11, on the volume and center of gravity of a hyperboloid. There is no physical model for this proposition because two of the figures that must be balanced, a hyperboloid and ellipsoid, are imagined as taking up the same space (p. 134). Chapter 6 then returns to the first proposition of the treatise, which finds the area and center of gravity of the sector of a parabola. This is treated, first, following the mechanical approach of the *Method*, and then, by way of comparison, according to the two geometrical approaches that Archimedes had previously published in his *Quadrature of the Parabola*. The chapter ends with a discussion of the order in which Archimedes wrote his works, dividing them into three types: (1) geometrical, (2) mechanical and (3) computational, including combinatoric.

The last four chapters cover the final propositions of the treatise, *Method* 12–15, in which Archimedes treats objects and derives results not discussed in any of his previous works. Chapter 7 treats the mechanical method for determining the volume of the so-called nail-form, or cylindrical hoof, which is formed by sectioning a semicylinder with a plane passing through the straight line at its base, *Method* 12 and 13, which, following Sato [1990], are regarded as a single proposition. This is covered in the same way as the first few chapters: an overview of the mechanical argument that the nail-form can be balanced with a known rectilinear figure, using a plane balance at a point as well as a linear balance at a fulcrum and accompanied with photos of a physical model, followed by a closer look at Archimedes' actual argument. Chapter 8 then discusses Archimedes' treatment of the same object using concepts similar to Cavalieri's indivisibles and the rigorous double-indirect argument that follows this, *Method* 14 and 15. Hayashi and Saito argue that we can understand these two propositions as Archimedes' way of showing, with an example, how a result that has been discovered through the method of the *virtual balance* can be shown by rigorous geometrical proof (pp. 191–192). Chapter 9 then discusses the mathematical properties of the last object that Archimedes claims to have handled, the intersection of two cylinders of the same diameter. Finally, in Chapter 10, Hayashi and Saito show that the manuscript, as it existed in the 10th century when the palimpsest was made, could not have contained any of the lengthy arguments that previous scholars have proposed and, hence, most likely simply relied on the fact that the intersection of the cylinders is equal to 8 of the nail-forms (pp. 204–215). Chapter 10 ends with a brief discussion of possible reasons why Archimedes may have written the treatise.

One of the outstanding features of this book is the visual aids. There are eight color photographs, including archeological sites and the Archimedes palimpsest in both natural and augmented spectrums. There are also fourteen black and white photographs of models that demonstrate the equilibrium of all of those sets of objects that can actually be balanced in the way that Archimedes envisions (see above). Finally, there are over a hundred technical illustrations of the geometric objects, in both the plane configurations that Archimedes produced and in the solid configurations implied by the mathematical discussion. These solid figures are a great help to the reader, and make clear, once again, the strength of Archimedes' geometric intuition.

This book will be of value to anyone interested in Greek mathematics and in the use of mechanical modes of thought to produce mathematical knowledge and is deserving of a broad readership.

Reference

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"L'opere stupende dell'arti più ingegnose." La recezione degli *Pneumatiká* di Erone Alessandrino nella cultura italiana del Cinquecento

By Oreste Trabucco. Firenze (Olschki). 2010. ISBN 978-8-822-25990-5. 184 pp. 20 €.

Oreste Trabucco's study explores the diffusion of Hero's *Pneumatics* in 16th and 17th century Italy, focusing on the social and cultural reception of Hero's work. It is a work along the lines of Paul Lawrence's *The Italian Renaissance of Mathematics* [Lawrence, 1975] and Mauro Biagioli's "The Social Status of Italian Mathematicians (1450–1600)" [Biagioli, 1989]. Although Trabucco's book provides the reader with interesting information and many details about the reception of the *Pneumatics* in 16th and 17th century Italy, it does not provide a general assessment of the role of the *Pneumatics* in Renaissance Italy.

The book is in four chapters. The first chapter compares Giorgio Valla's and Federico Commandino's approach to the translation of the *Pneumatics* in Latin. While Commandino undertook the translation of the Pneumatics within the context of a program of translation into Latin of a large number of Greek scientific texts, Valla largely quoted the *Pneumatics* in his *De spiritalibus* which was contained in *De expetendis et fugiendis rebus.* According to Trabucco, Commandino's philological practice followed that of Valla. The author stresses, however, that Valla's translation was sometimes undermined by an ignorance of scientific issues which led to a misunderstanding of some technical terms which were then inadequately rendered into Latin.