Sci & Educ (2011) 20:83–87
DOI 10.1007/s11191-010-9244-0

BOOK REVIEW

Alan Hirshfeld, *Eureka Man: The Life and Legacy of Archimedes*

Walker & Company, New York, 2009, ISBN: 978-0-8027-1618-7, 242 pp, price: U.S. $26.00

A. K. T. Assis

Published online: 19 March 2010
© Springer Science+Business Media B.V. 2010

Alan Hirshfeld is a professor of physics at the University of Massachusetts Dartmouth. He conducts research in the history of physics and astronomy. He is an Associate of the Harvard College Observatory and is the director of the UMass Dartmouth Observatory. He obtained his B.A. in astrophysics from Princeton University in 1973, his M.S. in astronomy from Yale in 1975, and his Ph.D. in astronomy also from Yale in 1978.

Hirshfeld previously published *Parallax: The Race to Measure the Cosmos*, (Henry Holt & Co., 2002); *The Electric Life of Michael Faraday*, (Walker & Co., 2006); and the *Astronomy Activity and Laboratory Manual*, (Jones & Bartlett Publishers, 2008). He is also the lead author of two reference books in astronomy: *Sky Catalogue 2000.0*, Vol. 1: *Stars to Magnitude 8.0* (Cambridge U.P. and Sky Publishing Corp., 1982 and 1991); and *Sky Catalogue 2000.0*, Vol. 2: *Double Stars, Variable Stars and Nonstellar Objects* (Cambridge U.P. and Sky Publishing Corp., 1985).

Apart from books, he has written articles on the history of astrophysics, on ancient Greek measurements of the solar system, and biographies of astronomers like James Bradley.

This book is divided into two parts: Master of Thought (six Chapters), and A Palimpsest's Tale (eight Chapters).

In Chapter One, titled 'The Essential Archimedes,' Hirshfeld tells some famous stories: That of "Eureka!" and the crown, "Give me a place to stand and I will move the Earth," (related to the use of levers and pulleys), etc. He also presents general information about Archimedes, comparing him with Newton and Gauss. He tries to separate the man from the myth, which is a difficult task. He makes a good job, quoting reliable sources and presenting reasonable information.

Chapter Two, 'The Stormy Sea,' presents the world in which Archimedes lived. He goes back to the beginning of the story of Syracuse in 733 B.C. He follows it up to Archimedes' time, when Hieron II ascended to power. He also mentions that nowhere in Archimedes' writings is there acknowledgment of any God. This is a hallmark of Greek science and mathematics, their strict secularity.

A. K. T. Assis (✉)
University of Campinas, Campinas, Brazil
e-mail: assis@ifi.unicamp.br

Chapter Three, 'Euclidean Fantasies,' lists Archimedes' treatises which have reached us: *On the Sphere and Cylinder*, *Measurement of a Circle*, *The Sand-Reckoner*, *On Conoids and Spheroids*, *On Spirals*, *On the Equilibrium of Planes*, *Quadrature of the Parabola*, *On Floating Bodies*, and the *Method of Mechanical Theorems*. Hirshfeld discusses some aspects of Euclid's *Elements*, and the writing and reading of numbers in the ancient Greek system. He presents in more detail Archimedes' *Measurement of a Circle*. This is equivalent to the determination of the numerical constant π. Archimedes utilized 96-sided inscribed and circumscribed polygons. His conclusion can be expressed nowadays by saying that π must be between 3.1408 and 3.1429, a remarkable achievement. He also discusses *On the Sphere and Cylinder*. In modern notation the main results of this work are the surface area of any sphere of radius R as given by $4\pi R^2$, and its volume as given by $(4/3)\pi R^3$. In order to obtain these results Archimedes utilized Eudoxo's technique, now known as the method of exhaustion.

In Chapter Four, 'Number Games,' he discusses *The Sand-Reckoner*. This treatise presents Archimedes' numerical system for handling large numbers. But it is also important for being the oldest and most reliable source we have of Aristarchus's heliocentric theory, as his own treatise has not reached us. In this Chapter Hirschfeld also discusses other treatises by Archimedes related to mathematical puzzles. One of them is now known as *The Cattle Problem*. The other one is the *Stomachion*, of which we know only fragments. The puzzle resembles a tangram game, but with fourteen pieces. Apparently one of the goals of this treatise was to calculate the number of possibilities to form a square.

Chapter Five, 'Eureka Man,' presents the basics of hydrostatics as set down in Archimedes' treatise *On Floating Bodies*. He also discusses Archimedes' work *On the Equilibrium of Planes*. This is presented on pages 77–85 of the book. In this treatise Archimedes presented a mathematical deduction of the law of the lever, namely, that two magnitudes balance at distances reciprocally proportional to the weights. Hirshfeld presented a good qualification of the center of gravity, namely: "Suspended from this point, an object would remain motionless in any orientation." He tried to show how to derive this law based only on symmetrical conditions: equal weights situated at equal distances from the fulcrum are in equilibrium; the center of gravity of two equal weights lies at the midpoint of the line connecting their individual centers of gravity; and that the overall center of gravity of an entire system of even weights spaced uniformly along a lever lies at the midpoint of the line connecting the centers of gravity of the innermost pair of weights. However, from symmetrical propositions it is not possible to deduce the general law of the lever. There are only two alternatives. The first one has been pointed out by Ernst Mach (1960) in his book *The Science of Mechanics*, namely, that Archimedes utilized the law of the lever in his own deduction of this law, a vicious circle. The second alternative, which we prefer, has been discussed by Dijksterhuis (1987) in his book *Archimedes*. According to this second approach, Archimedes' proof is correct and is based not only on symmetrical propositions, but also on his sixth postulate, namely: If magnitudes at certain distances be in equilibrium, other magnitudes equal to them will also be in equilibrium at the same distances. According to Dijksterhuis, assuming that by "magnitudes at the same distances" Archimedes understood "magnitudes the centers of gravity of which lie at the same distances from the fulcrum," we confer a reasonable meaning on this postulate. In this way it is possible to avoid the vicious circle pointed out by Mach.

In Chapter Six, 'The Science of Fear,' the Roman attack on Syracuse and the war machines invented by Archimedes are discussed. It is based on information supplied by the historians Polybius, Plutarch and Livy.

The second part of the book is essentially devoted to the discovery of the palimpsest containing the only known copy of the treatise *The Method of Mechanical Theorems*. It was discovered in 1906 by the philologist of Copenhagen Johan Ludvig Heiberg (1854–1928). It is a fascinating history and goes up to present times. The content of this treatise is discussed on pages 171–175.

In Chapter Seven, 'The Voice Beneath the Page,' describes how the manuscript criss-crossed the Byzantine Empire, its journey from a monastic library in the Holy Land to the Metochion-"daughter-house"-of Jerusalem's Church of the Holy Sepulchre, in Constantinople, where Heiberg studied it in 1906 and 1908. The codex had 177 leaves with a liturgical document from the late twelfth century. At right angles to this text, beneath it, there was Archimedes' works, which had not been completely scraped. That is, it was a palimpsest, a manuscript containing two texts superimposed. Heiberg was able to decipher it with his naked eyes and taking photographs. Beyond Archimedes' texts already known, it contained three treasures: (I) fragments of the *Stomachion*, (II) the Greek text of the work *On Floating Bodies*, and (III) the lost work *The Method*. Until 1906 it was believed that *On Floating Bodies* have survived only in the Latin translation made by Willem von Moerbeke in 1269 from a Greek manuscript which is now believed to be lost. In 1907 Heiberg published the Greek text of *The Method*, and a German translation with commentary by Zeuthen. Since then many translations have been published in English, French, Italian, etc. Heiberg (1880–1881) had published the complete works of Archimedes in 3 volumes between 1880 and 1881. It was entirely superseded by the second edition which he published also in 3 volumes between 1910 and 1915. As mentioned by Hirshfeld (page 111): "The fragile codex marked the very pinnacle of Heiberg's career as a classicist. In a way, his decades of single-minded devotion to the study of antiquity had been prelude to his culminating work on the palimpsest. Arguably, there was no one else in the world at the time who could have done it as well."

Chapter 8, 'A Bridge Across Time,' describes the importance of writing for the historical record of civilizations. He discusses the cuneiform characters inscribed in the tablets of Mesopotamia and the hieroplyphics written in the papyrus scrolls of Egypt. He also mentions the alphabet developed in the Middle East before 1000 B.C. The Greeks utilized an alphabetic writing system inherited from Phoenician in the eighth century B.C.

In Chapter 9, 'The Parchment Brothers,' the way the parchment made of animal's skins took the place of papyrus around the second century B.C. is presented. The codex or small book was introduced around the second century A.D. The Chapter describes the transformation of scrolls to codices and the several centers of book production: Athens, Alexandria, Rome and Byzantium (later Constantinople). The three main compilations of Archimedes' works were generated in Byzantium in the ninth and tenth centuries. All his works known to us derive from these codices. Two of them disappeared in the thirteenth and sixteenth century, but copies of them from the fifteenth and sixteenth centuries are still extant. They did not contain *The Method*. The third codex is the famous one discovered by Heiberg in 1906.

Chapter 10, 'Leo's Library,' discusses the Library of Alexandria and the commentaries to some of Archimedes' treatises prepared by the sixth-century mathematician Eutocius. It also mentions the three main compilations of Archimedes' works which were prepared in Constantinople around the ninth-century. Archimedes' treatises were copied into three parchment codices. It is supposed that at least one codex was prepared under the direction of Leo the Mathematician. All subsequent copies and translations of Archimedes' works were based on the first two codices until the beginning of the XXth century, when Heiberg discovered the third one, the Archimedes' palimpsest.

In Chapter 11, 'Resurrection and Light,' tells how the first two codices left Constantinople in the thirteenth century and their fate afterward. They were translated into Latin by William of Moerbeke around 1269. A new Latin translation of the first codex was prepared by Jacobus Cremonensis in the fifteenth century. Archimedes' works begin to disseminate.

Chapter 12, 'Gentleman and Scoundrel,' describes what happened with Archimedes' palimpsest after leaving Constantinople, going to Mar Saba's Monastery in the Dead Sea in the sixteenth century, going to Jerusalem's Church of the Holy Sepulchre around 1840, and back to Constantinople in the library of the Metochion, daughter-house, of this Church, where Heiberg located it in 1906. This Chapter also describes briefly the contents of *The Method* of Archimedes (2002), addressed to Eratosthenes. It utilizes the law of the lever in order to obtain the values of areas, volumes and centers of gravity of some geometric figures (parabola, sphere, a paraboloid of revolution, etc.).

It is worth quoting here from the Introduction of this Treatise with Archimedes writing to Eratosthenes, in Heath's translation: "I thought fit to write out for you and explain in detail in the same book the peculiarity of a certain method, by which it will be possible for you to get a start to enable you to investigate some of the problems in mathematics by means of mechanics. This procedure is, I am persuaded, no less useful even for the proof of the theorems themselves; for certain things first became clear to me by a mechanical method, although they had to be demonstrated by geometry afterwards because their investigation by the said method did not furnish an actual demonstration. But it is of course easier, when we have previously acquired, by the method, some knowledge of the questions, to supply the proof than it is to find it without any previous knowledge."

In Chapter 13, 'The French Connection,' describes what little is known about the palimpsest after 1908. Somehow it left Constantinople, appeared in a private collection in Paris around 1930, disappeared again, resurfaced in the 1990s, arriving at Christie's in New York in 1998. The auction took place on October 29, 1998. It was bought by an anonymous private collector, being sold for US$ 2 million. On page 187 the author quotes the German magazine *Der Spiegel* reporting that the owner is likely the founder of Amazon, Jeff Bezos.

Chapter 14, 'Sweetest Sustenance of Souls,' describes how the anonymous owner of the palimpsest not only consented to lend it to the Walters Art Museum in Baltimore, but also agreed to fund a modern research of the manuscript. It has been now completely digitalized and the result can be found at http://www.archimedespalimpsest.org/. The curator of manuscripts of Waters' is William Noel. The Museum is now responsible for its conservation and imaging. The scholar Reviel Netz, professor of ancient science at Stanford University, has studied the palimpsest and is preparing a complete English translation and commentary of Archimedes' works. The first part of this three-volume project has appeared in 2004, *The Two Books on Sphere and Cylinder*.

The book contains a map of Syracuse showing the original Greek settlement, a picture of the ruins of modern Syracuse, a possible design of the Archimedes' claw used by the Syracusans during the Roman siege, a photograph of Heiberg around 1918, a painting of Mar Saba monastery which housed Archimedes' palimpsest by the sixteenth century, a painting by Benjamin West representing Cicero discovering the tomb of Archimedes, the Archimedes palimpsest as it appeared in 1999, and two photographs of folios 16 and 17 from the Archimedes palimpsest.

The beautiful photograph of Heiberg is preceded by a very interesting paragraph on pages 103–104: "In this leg of its long, peripatetic existence, the manuscript journeyed from a monastic library in the Holy Land to the Metochion–"daughter-house"—of Jerusalem's Church of the Holy Sepulchre, in Constantinople. And there, during the summer of

1906, it fell open under the gaze of Professor Johan Ludvig Heiberg, the world's foremost philologist, who had traveled in haste from Copenhagen to read the aged document. With his biblical beard and riveting gaze, Heiberg's very presence cast the library into a confluence of the ancient and modern worlds."

It was a pleasure to read this non-technical book. There are many quotations distributed throughout the work, with their sources collected in the Notes at the end of the manuscript. It contains also a large Bibliography with old and modern references. This book is a nice introduction to the life and works of Archimedes, the "Master of Thought."

References

Archimedes. (2002). The method of Archimedes. In T. L. Heath (Eds.), *The works of Archimedes* (pp. 1–51; T. L. Heath, Trans.). (Supplement). New York: Dover.

Archimedes. (2004). With a critical edition of the diagrams and a translation of Eutocius' commentaries. In *The sphere and the cylinder* (Vol I, R. Netz, Trans.). Cambridge: Cambridge University Press.

Dijksterhuis, E. J. (1987). *Archimedes*. Princeton: Princeton University Press.

Heiberg, J. L. (1880–1881). *Archimedis opera* (1st ed., Vol 3). Leipzig: Teubner.

Heiberg J. L. (1910–1915). *Archimedis opera* (2nd ed., Vol 3). Leipzig: Teubner (Reprinted 1972 Stuttgart).

Mach, E. (1960). *The science of mechanics* (6th ed.). La Salle: Open Court.