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Meta-mathematical rhetoric: Hero and Ptolemy against the philosophers

Jacqueline Feke

Society of Fellows in the Liberal Arts and Humanities Collegiate Division, The University of Chicago, 5845 S. Ellis Ave., Gates-Blake 408, Chicago, IL 60637, USA

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Abstract

Bringing the meta-mathematics of Hero of Alexandria and Claudius Ptolemy into conversation for the first time, I argue that they employ identical rhetorical strategies in the introductions to Hero's *Belopoeica*, *Pneumatica*, *Metrica* and Ptolemy's *Almagest*. They each adopt a paradigmatic argument, in which they criticize the discourses of philosophers and declare epistemological supremacy for mathematics by asserting that geometrical demonstration is indisputable. The rarity of this claim—in conjunction with the paradigmatic argument—indicates that Hero and Ptolemy participated in a single meta-mathematical tradition, which made available to them rhetoric designed to introduce, justify, and bolster the value of mathematics.

Riassunto

Mettendo in relazione per la prima volta la meta-matematica di Erone di Alessandria con quella di Claudio Tolomeo, sostengo che questi due autori hanno impiegato strategie retoriche identiche nelle introduzioni alla Belopoeica, Pneumatica, Metrica e nell'Almagesto. Entrambi adottano un argomento paradigmatico, nel quale essi criticano i discorsi dei filosofi e dichiarano la supremazia epistemologica della matematica, asserendo che la dimostrazione geometrica è indisputabile. La rarità di questa affermazione – unita alla natura paradigmatica dell'argomento in questione – indicano che Erone e Tolomeo partecipavano ad un'unica tradizione meta-matematica che metteva a loro disposizione risorse retoriche volte a introdurre, giustificare, e promuovere il valore delle matematiche.

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In addition to pursuing the more technical aspects of mathematics—making calculations, constructing mathematical proofs, and modeling natural phenomena, to name only a few—what intellectual practices, if

E-mail address: jfeke@uchicago.edu.

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any, distinguished Greco-Roman mathematicians? This paper begins to address this question by means of a case study, bringing the texts of Hero of Alexandria and Claudius Ptolemy into conversation for the first time.[1] At first glance, it is surprising that no scholar has undertaken this task, as Hero and Ptolemy lived within a hundred years of one another. Hero lived in the late first century CE, Ptolemy in the second century CE, and it is likely that they lived in or around Alexandria. Hero's toponym indicates some connection with Alexandria, as does Ptolemy's identification of Alexandria as the location of his observations.[2] With regard to their subjects of study, Hero and Ptolemy's extant mathematical contributions fall within the domain of what we today call 'applied' rather than 'pure' mathematics. Nevertheless, the types of mathematics examined are for the most part heterogeneous. Hero's extant contributions include mechanics, catoptrics, pneumatics, artillery and catapult construction, mensuration geometry, and automatic theaters. Ptolemy's extant mathematical contributions include studies in astronomy, optics, and harmonics.[3]

Yet, some prospects for intellectual convergence remain. The tenth-century *Suda*'s description of Ptolemy ascribes to him a text on mechanics in three books, but the lack of any other attestation to a mechanical text of Ptolemy puts its composition into doubt.[4] Hero's *Dioptra* and text on the astrolabe, on the other hand, suggest that he was conversant in astronomy, and his commentary on Euclid's *Elements* indicates that he was well versed in geometry. Therefore, it is possible that Ptolemy read Hero's texts when studying astronomy and geometry. Moreover, the mechanical and astronomical traditions in which Hero and Ptolemy participated may have shared a close association. James Evans and Christián Carlos Carman recently have argued that *sphairopoiia*—the art devoted to building models of the cosmos—might have influenced the invention of the eccentric and epicyclic hypotheses around 200 BCE. The relationship of astronomy and mechanics, they posit, was not a unidirectional path of influence but one of conversation.[5] That Ptolemy was familiar with *sphairopoiia* is evident from his reference to the craft in the *Planetary Hypotheses*, and it is possible that in his time mechanics and astronomy retained this conversational relationship.[6] Although Ptolemy rejected a mechanistic cosmology—in the *Planetary Hypotheses* he explains the heavens' movements animistically—it is possible that he admitted a correspondence between the mechanical and astronomical textual traditions such that he read mechanical texts as part of his education. An even stronger case can be made for Ptolemy's study of Hero's work given the similarity in their mathematical methods, styles of argumentation, and, in some cases, content. For instance, both Hero and Ptolemy—in *Dioptra* 35 and *Analemma*, respectively—use the analemma to solve spherical problems by means of geometrical constructions.[7]

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[1] That is not to say that other scholars have not discussed Hero and Ptolemy's texts in proximity. See, for instance, Cuomo (2001, pp. 205–206). No one, however, has brought their texts into dialogue.

[2] It is, of course, possible that Hero never resided in Alexandria, despite his toponym. Concerning when he lived, Hero discusses a lunar eclipse visible in both Rome and Alexandria in *Dioptra* 35. Otto Neugebauer dates the eclipse to 62 CE and argues that Hero personally observed it: Neugebauer (1938, p. 23). Nathan Sidoli argues that 62 CE may be taken at most as a *terminus post quem* for Hero's activity: Sidoli (2010). In the *Almagest*, Ptolemy includes thirty-six astronomical observations which he reports as his own. The earliest is from 127 CE and the latest is from 141 CE. Another unaccredited observation from 125 CE may also be his. See Pedersen (2011, pp. 408–422). Ptolemy recorded an early summary of his astronomical system in the *Canobic Inscription*, dated 146/147 CE.

[3] The types of mathematics Hero's texts examine fall within the domain of so-called 'practical' mathematics, and Ptolemy's within 'theoretical' mathematics. This distinction, however, is not impermeable. Practical mathematics has theoretical aspects, and theoretical mathematics has practical aspects. Concerning the theoretical aspects of Hero's mathematics, see Tybjerg (2000, 2003, 2005). On the relationship between mechanics and philosophy in antiquity, see Berryman (2009). Concerning the practical aspects of Ptolemy's mathematics, see Bernard (2010).

[4] *Suda* π.3033.

[5] Evans and Carman (2013).

[6] Ptolemy *Planetary Hypotheses* 1.1, 70 Heiberg. On *sphairopoiia* in the *Planetary Hypotheses*, see Hamm (2011).

[7] See Acerbi (2011, p. 133).