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RESEARCH PROGRAM

Gersonides’ *Astronomy*: Scientific Realism and Empiricism in a 14th-century Treatise. An Annotated Critical Edition of the Text

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By

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Levi ben Gershom (Gersonides, 1288–1344), the eminent scientist-philosopher, was unquestionably the most original Jewish astronomer of the Middle Ages. For him, an astronomical theory that enables one to determine the position of the planets at any given time was insufficient. He was a realist who sought to discover the true structure of the universe, aspiring to establish an astronomical theory compatible with natural science and cohering with empirical evidence. Accordingly, he believed that astronomical investigation “can only be undertaken in its perfection by one who is at once a mathematician, a natural scientist, and a philosopher.” Therefore, one should not be surprised to find that Gersonides’ main astronomical work – known as *Astronomy* – is not a standalone composition, but rather forms an integral part of his great philosophical work, *Milḥamot ha-šem* (*The Wars of the Lord*, book V part 1). Moreover, it is replete with interactions between mathematical astronomy, philosophy, and natural science. The *Astronomy* incorporates innovative astronomical models; criticism directed against many of the most respected scientific authorities of its time; reports on no less than 82 astronomical observations made by Gersonides; and descriptions of observational instruments, some of which were designed by the author himself. Gersonides takes an empiricist stance, which is reflected not only in his reports on actual observations, but also in his recurring and explicit statements on the essential role of sense experience in testing scientific hypotheses. In this regard, the *Astronomy* also deals with meta-science, as it contains discussions on scientific methodologies and reasoning. This monumental work was translated into Latin by Petrus de Alexandria in collaboration with Gersonides, and in 1342 Gersonides dedicated a revised version of chapters 4-11 of the Latin translation to Pope Clement VI.

The *Astronomy*, which has been described by one scholar as “one of the most original texts on the subject [of astronomy]” in the Middle Ages, has received considerable scholarly attention in recent years. Nevertheless, and despite the interconnections between its content and Gersonides’ other fields of study (including natural science and Biblical exegesis), only some of its 136 chapters have been published, as the text was omitted from all printed editions of *Milḥamot ha-šem* (probably due to its mathematical character and its length: it fills more than 250 folios in its extant manuscripts). The main goal of my project is to produce the first complete critical edition of the *Astronomy*, based on the extant Hebrew manuscripts, accompanied by an introduction, commentary, and a glossary of technical terms. In addition to a close study of the *Astronomy*’s content, the project will shed new light on Gersonides’ scientific sources, his use of textual sources, his mathematical, astronomical and philosophical terminology, and the reception of the text among later generations. The contribution of the study will not be limited to those interested in the thought of Gersonides nor to historians of Jewish thought, as the study will also advance our knowledge in other fields of research, such as the history of mathematical astronomy, philosophy of science, the role of socio-culture in knowledge transfer, the history of empirical science, the development of Hebrew scientific terminology, Biblical exegesis, medieval interreligious scientific collaboration, and the relationship between science and religion in the Middle Ages.

The research will rely on numerous primary sources, some of which have been published while others are still in manuscript form. These sources can be divided into three groups: First and foremost, the research will utilize all available Hebrew manuscripts of the *Astronomy*. The codicological and paleographical features of these manuscripts will be closely examined in order to glean information on the *Astronomy*’s reception, readership and cultural significance. The Hebrew text will be compared with the Latin version of the work. The second group of primary sources includes the scientific material produced by the Hebrew translation movement and original Hebrew scientific treatises, a corpus of works with which Gersonides was well familiar and which he frequently utilized when writing the *Astronomy*. As indicated by the catalogue of Gersonides’ private library, he was acquainted with specific scientific works from the 12th and 13th centuries, such as the astronomical works of Abraham Bar Ḥiyya; a few astrological works by Abraham Ibn Ezra; Hebrew treatises on the astrolabe; Jacob Anatoli’s translations of astronomical texts including Ptolemy’s *Almagest* and Al-Farghānī’s *Elements*; and the Hebrew translation of Pseudo-Avicenna’s *De caelo* *et Mundo* and Ibn al-Haytham’s *On the Configuration of the World* – all of which I had the pleasure of examining during my masters and doctoral studies (I also intend to analyze another 13th-century astronomical treatise at the Bavarian Academy of Sciences and Humanities in Munich during summer 2021). Since Gersonides holds a critical attitude towards some astronomical notions about which there was broad agreement, and since he learned about these notions from the material produced by the Hebrew translation movement, we must examine his ideas in light of the Hebrew translations and ask whether various aspects of these translations had somehow stimulated his critical approach. Considering that the *Astronomy* is not an independent work but rather an essential part of Gersonides’ greater project, the third group of primary sources that will be used is Gersonides’ complete oeuvre, most notably the philosophical sections of his *Milḥamot ha-šem*, his Biblical commentaries, and his supercommentaries on Averroes. As recent studies have shown, various scientific notions explained in the *Astronomy* were integrated in other contexts, including into Gersonides’ Biblical exegesis. One example is Gersonides’ notion of a “body that does not preserve its shape.” The scientific characteristics of this ‘body’ are discussed at length in the *Astronomy*, but it also plays an essential role in Gersonides’ commentary on the ‘account of Creation,’ as well as in his philosophical discussions. The *Astronomy* also sheds light on theologico-philosophical features in Gersonides’ thought, as I demonstrate in a forthcoming article (in *Aleph: Historical Studies in Science and Judaism*) which, *inter alia,* illustrates the dissimilarities between Gersonides’ and Levi ben Abraham’s respective naturalistic accounts of providence.

In addition to these primary sources, the research will make extensive use of the secondary literature devoted to medieval mathematical astronomy, to Gersonides’ oeuvre in general, and to his *Astronomy* in particular. Most notably, the project will closely address the research conducted by a group of prominent scholars in the field, including Bernard R. Goldstein, José Luis Mancha, José Chabás, Ruth Glasner, Gad Freudenthal, Seymour Feldman, Shlomo Sela, Tzvi Langermann, Sara Klein-Braslavy, and Ofer Elior, among many others. These scholars’ contributions to our understanding of Gersonides’ scientific approach are invaluable, and the conclusions drawn on the basis of their research will be reflected in the edition. I am in regular contact with many of the above-mentioned scholars, and some of them have generously offered their support during the project. In particular, during my research I will be in very close contact with Ofer Elior, who recently published a critical edition of books I-IV of *Milḥamot ha-šem*, and is now working on an edition of the remainder of the work – except for the *Astronomy*. My project will also engage with prior studies on the historical development of medieval scientific terminology, and it will utilize the terminological database PESHAT (Premodern Philosophic and Scientific Hebrew Terminology in Context), produced in recent years by scholars at the University of Hamburg and the Hebrew University in Jerusalem.

The project will be executed in stages. The first will be devoted to a preliminary examination of the available manuscripts, focusing on strategic parts of the text (the most problematic ones). This examination will reveal whether the manuscripts can be divided into families. Digital scans of some of the manuscripts are available online, while the rest of the manuscripts will be examined at the Institute for Microfilmed Hebrew Manuscripts at the National Library of Israel in Jerusalem. The conclusions reached during this initial step will determine the editorial methodology to be employed (my initial review of the manuscripts suggests that the edition will likely be eclectic). While examining the manuscripts, I will also use my knowledge in Hebrew codicology and paleography to determine where and when the manuscripts were produced, and to glean information about their readers. In the second stage, I will select a few manuscripts that will be used for the production of an initial transcription. The manuscripts will be selected on the basis of the following criteria: (i) copies that are representative of distinct manuscript families; (ii) the oldest, most legible, and most complete manuscripts. In this stage I will identify Gersonides’ sources, study his use of sources, detect all cross-references embedded in the text, and produce a first draft of a glossary that will ultimately include all scientific and technical Hebrew terms employed in the *Astronomy*. Following this, I will collate other copies, thereby obtaining a final Hebrew version alongside a critical apparatus that records all textual variations. In this stage I will draw a comparison between the Hebrew and Latin variants. Finally, the critical edition will receive a commentary, notes, and introduction.

Besides the standard challenges one faces when taking on any project that aims to produce a critical edition of a medieval text, this project includes two unique difficulties. First, Gersonides thoroughly revised his work time and again, changing his opinions, adding new chapters, and refining his models. In fact, Gersonides worked on the *Astronomy* for almost two decades, and the preserved manuscripts leave the impression of a work in progress (11 chapters are missing from both the Hebrew and Latin versions, and it is possible that these chapters were never written). Relying on the secondary literature devoted to the subject, alongside a close examination of Gersonides’ reports, wording and terminology, the edition will aim to reveal the different stages of the treatise’s composition, distinguishing between earlier and later passages, thereby also shedding light on the development that took place in Gersonides’ thought. A second challenge is related to the fact that the Latin version of the *Astronomy* was produced in collaboration with Gersonides himself. This fact obliges us to take the Latin version into consideration, and to compare it with the Hebrew original. Substantial differences between the two versions will be reported and examined in depth.

The first annotated critical edition of the entire text of the *Astronomy* will not only provide an original contribution to our understanding of Gersonides’ scientific thought and to the fields of medieval astronomy and Jewish history; it will also advance our knowledge in other fields of study, such as the history of mathematics, medieval philosophy, the history of empirical science, philosophy of science, the reception of scientific ideas in Latin Europe and its Jewish communities, interactions between science and religion, Biblical exegesis, the development of scientific terminology, and interactions between Christian and Jewish scientists in the Latin West. Indeed, in recent years there has been increasing interest in Gersonides’ scientific and philosophical thought, as well as in the reception of Gersonides’ oeuvre, not only among experts in Jewish thought, but also among scholars from related fields. The first complete annotated critical edition of the *Astronomy*, accompanied by an introduction and a glossary of technical terms, will thus represent an enormous contribution to the scholarly community, and will certainly serve academic scholars from varied fields of study.