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Plenary Agenda Report for Research Group D-III-3

Mechanics

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Abstract: *a) Topics and goals.* The aim of group D-III-3 »Mechanics« is to investigate the Aristotelian *Mechanica* as a mathematical discipline in the context of Aristotle's natural philosophy. Especially relevant for the group's research is the question of how geometric discourse, spatial models, and diagrammatic representation are employed in these different but intimately correlated scientific areas. The textual tradition of the *Mechanica* is receiving a thorough philological analysis, including the first systematic examination of the diagrams contained in the manuscripts of this treatise. Moreover, the mechanical knowledge presented in this text is being investigated in the context of its reception in antiquity, the medieval world, and the Renaissance. Not only are the insights gained through this research contributing to our understanding of the history of the text, but are also telling for our knowledge of ancient mechanics.

b) Methods. The basic philological research of the group, which is being conducted at the Aristoteles-Archiv of the Freie Universität Berlin, benefits from the extensive microfilm collection and paleographical and codicological materials of this institution. In addition to the philological analysis of the transmission of the *Mechanica*, the contents of the text will be interpreted in the broader context of natural philosophy, ancient mathematics, and the history of science.

c) State of the discussion. The initial approach to the Aristotelian *Mechanica* was primarily philological; planned for the future, however, is an increased emphasis on the text's philosophical and mathematical aspects. The research of the group involves exchanges with several projects in areas D-II-1, »The Ontology of Space,« and D-II-2, »Place, Space, and Motion,« which focus on the mathematical aspects of Aristotle's general theory of motion. Mechanical concepts are also highly relevant to Aristotle's theory of animal locomotion as expounded in *De Motu Animalium* and *De Anima*.

Projects:

- »The tradition of the Aristotelian *Mechanica*: Text and Diagrams« (Joyce van Leeuwen; dissertation project)
- »An Inventory of Diagrams in Greek Manuscripts of Aristotle's Natural Philosophy« (Dieter Harlfinger, Lutz Koch. Student Assistant: Christina Prapa)

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1 Results

The research aim of Group D-III-3 »Mechanics« is to investigate the Aristotelian *Mechanica* as a mathematical discipline in the context of Aristotle's natural philosophy. A main focus to the group is the question of how geometric discourse, spatial models, and diagrammatic representation are employed in these different but intimately correlated scientific areas. Moreover, the mechanical knowledge presented in this text will be examined in the context of its reception in antiquity, the medieval world, and the Renaissance in order to make a substantial contribution to our understanding of the development of mechanical knowledge in antiquity.

The research of the group begins with an investigation of the manuscript tradition of the *Mechanica*. In the context of this philological basic research, which is being conducted by Joyce van Leeuwen at the Aristoteles-Archiv of the Freie Universität Berlin, all 31 extant manuscripts of the treatise have been exhaustively collated, the results of these collations analysed, and subsequently a stemma codicum established. The analysis of the textual tradition is described in detail in a paper by van Leeuwen, which has been submitted for publication. In this project, a new critical edition of the *Mechanica* will be prepared which will supersede the relatively recent but unreliable edition of the treatise by Maria Elisabetta Bottecchia (1982).

The treatise was edited three times in the nineteenth century, namely by Johannes van Cappelle (1812), Immanuel Bekker (1831), and Otto Apelt (1888); the most recent edition was produced in the twentieth century by Bottecchia (1982). (The latest editions by Albert Presas i Puig/Joan Vaqué Jordi [2006] and Maria Fernanda Ferrini [2010] highlight current interest in the Aristotelian *Mechanica*. These publications, however, do not contribute to our understanding of the textual tradition of the treatise, since they reprint the texts of Bottecchia and Bekker.) Whereas the other editors of the *Mechanica* examined only a small portion of the textual tradition, Bottecchia consulted nearly the entire manuscript material for her critical edition. At the beginning of this project, therefore, we did not expect to arrive at significant new results of the kind that would necessitate a completely new critical edition of the text.

However, it soon became clear that Bottecchia's edition contains numerous errors. For example, Bottecchia identifies affiliations between manuscripts which are impossible from a chronological point of view. Even more important is her failure to recognize the influence exerted on the textual tradition by Georgios Pachymeres, parts of whose Byzantine paraphrase of the *Mechanica* were incorporated into some manuscripts of the text. Bottecchia regards *Mut.* 76, which is an apograph of Pachymeres's paraphrase, as an authentic Aristotelian manuscript and includes readings of this paraphrase in her critical edition of the text. A new examination of the manuscripts of the *Mechanica* is therefore necessary, and will yield a different perspective on the textual transmission of the treatise.

Altogether 31 manuscripts of the *Mechanica* have been handed down to us. The textual transmission starts fairly late; the oldest manuscripts date from the beginning of the fourteenth century. The dating of the oldest preserved manuscript, *Marc.gr.* 214, has been the subject of much controversy in recent decades. Some years ago, however, Marwan Rashed (2001) convincingly argued for a date around 1300. A transmission that starts that late entails many difficulties, since it is hard to assess the earlier phases of the textual

tradition with reasonable certainty. The situation is further complicated by the presence of an independent branch of the tradition, that of the paraphrase by Pachymeres, which in turn influenced some of the manuscripts and the previous editions of the treatise.

By means of different readings, the writings were divided into three manuscript families, namely *a*, *b*, and *c*. The independent tradition of the paraphrase by Pachymeres derives from the same hyparchetype as family *a*; it is, however, recorded in the stemma codicum as a different branch, since paraphrastic elements were incorporated into the text through Pachymeres's emendations and additions. Pachymeres's paraphrase of the *Mechanica* is important in constituting the text, since it was written at the same time or even shortly before the authentic Aristotelian manuscripts were composed. Finally, there is a group of contaminated manuscripts which include aspects of different manuscript families. Not all of these writings contain the complete text, but only excerpts from it.

Both manuscripts in family *a*, *Marc.gr.* 214 and *Vat.gr.* 253, belong to the oldest preserved manuscripts of the *Mechanica*, and derive independently of each other from the hyparchetype α . They share readings which separate them from the other families, for example at 848b24 $\pi\lambda\epsilon\upsilon\rho\tilde{\omega}\nu$ *a*: $\pi\lambda\epsilon\iota\acute{\omicron}\nu\omega\nu$ *cett.*; 857b12 $\omicron\tilde{\upsilon}\tau\omega\varsigma$ *a*: $\acute{\epsilon}\lambda\acute{\alpha}\tau\tau\omega\nu$ *cett.*; 858b11 $\kappa\alpha\iota$ $\tau\acute{\omicron}\tau\epsilon$ $\mu\acute{\epsilon}\nu\epsilon\iota$ *a*: $\kappa\alpha\iota$ $\tau\iota\theta\acute{\epsilon}\alpha\mu\epsilon\nu$ $\epsilon\iota$ *cett.*

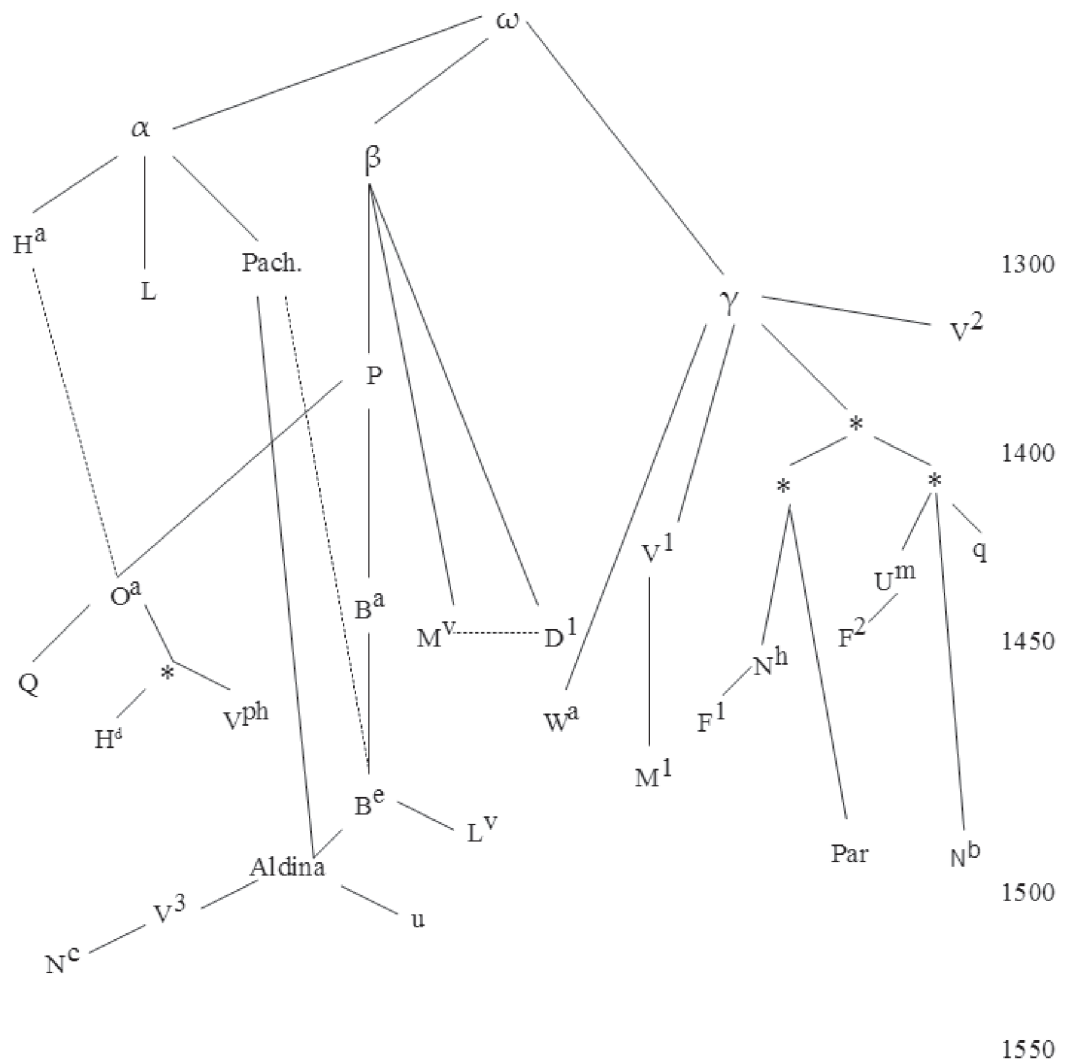
The oldest and best-known manuscript of family *b* is *Vat.gr.* 1339, which was copied at some point during the second half of the fourteenth century. *Vat.gr.* 1339 provided the source for some other manuscripts, of which *Bern.* 402 is highly interesting. The copyist of this manuscript is Niccolò Leonico Tomeo, an Italian humanist and professor of Aristotelian philosophy in Padua. Leonico owned this manuscript and used it for his Latin translation of the *Mechanica* from the year 1525. The manuscript *Bern.* 402 contains many emendations which were inserted by the same hand both in the margins and within the text. Some of these emendations agree with variant readings contained in the paraphrase by Pachymeres. Others, however, have no connection with any extant manuscript and are probably based on Leonico's own interpretation of the text. Interestingly, some of the emendations in *Bern.* 402 were adopted in all modern editions of the *Mechanica*. An important task for a new critical edition of the treatise, therefore, is to distinguish Leonico's impact on the treatise from the authentic Aristotelian manuscript readings.

Family *c* is distinguished from the other manuscripts families among other things by the presence of scholia. The manuscripts in this family also contain some characteristic readings which are not present in the other manuscript families, for example at 848b10 $\lambda\acute{\iota}\gamma\omega$ / $\acute{\omicron}\lambda\acute{\iota}\gamma\omega$ *c*: $\lambda\acute{\omicron}\gamma\omega$ *cett.*; 850a35 $\acute{\alpha}\nu\tau\iota$ $\sigma\alpha\rho\tau\acute{\iota}\omicron\upsilon$ $\gamma\acute{\iota}\nu\epsilon\tau\alpha\iota$ *c*: $\acute{\epsilon}\varsigma$ $\tau\acute{\omicron}$ $\sigma\alpha\rho\tau\acute{\iota}\omicron\nu$ ($\gamma\acute{\iota}\nu\epsilon\tau\alpha\iota$) *cett.*; 857a12 $\acute{\epsilon}\pi\epsilon\iota\delta\eta$ $\delta\iota\acute{\omicron}\tau\iota$ *c*: $\acute{\alpha}\acute{\iota}\tau\iota\omicron\nu$ $\delta\acute{\epsilon}$ $\acute{\omicron}\tau\iota$ *cett.* In contrast to Bottecchia's edition, in which family *c* was for the most part neglected, this family certainly contains some important variants which should be considered in a new critical edition of the *Mechanica*. The manuscripts *Vat.gr.* 905 and *Urb.gr.* 44 are of especial importance, since they stem directly from the hyparchetype γ .

The independent tradition of the paraphrase by Pachymeres does not occupy an isolated position, but has instead influenced various manuscripts of the *Mechanica*. Georgios Pachymeres was a Byzantine historian and philosopher who wrote a compendium of Aristotle's philosophy in twelve books around 1300. The *Mechanica* is in the final book, and is less a paraphrase than an almost literal quotation of the Aristotelian text. Because

of this, it is complicated to distinguish Pachymeres's writings from the authentic Aristotelian text, with the result that manuscripts containing Pachymeres's paraphrase have often been regarded as being by Aristotle. Both the *editio princeps* of the *Mechanica*, printed by Aldus Manutius in Venice, and the modern editions of the treatise contain aspects from this paraphrase. One of the fundamental tasks for a new edition of the treatise will be to remove these traces of Pachymeres from the text of the *Mechanica*.

The results of this examination of the manuscript tradition of the *Mechanica* can be illustrated by the following stemma codicum:



In a new critical edition of the *Mechanica*, the manuscripts of all three families should be analysed to an equal degree, with a special emphasis on those manuscripts that can be traced back to a hyparchetype, namely *Marc.gr.* 214, *Vat.gr.* 253, *Vat.gr.* 1339, *Urb.gr.* 44, and *Vat.gr.* 905. Such an analysis could favour certain variants which differ from those favoured in previous editions of the treatise, but a far more important task for a new edition is to remove all foreign influences from the text of the *Mechanica*. The Byzantine paraphrase by Georgios Pachymeres, and to some extent the variants offered by the humanist Niccolò Leonico Tomeo, have influenced all previous editions of the treatise, including the latest edition by Bottecchia. These paraphrastic traces should be evaluated individually, but need to be distinguished from the authentic Aristotelian text.

Apart from a critical edition of the text of the *Mechanica*, the project is also preparing a critical edition of the diagrams contained in the manuscripts. It was not until the recent important work by Reviel Netz (1999) on practices involving diagrams in Greek mathematics that this subject received detailed attention. The editions of the *Mechanica* almost completely ignore the fact that the manuscripts contain diagrams, although a systematic examination of these diagrams can broaden our understanding of ancient mechanics. Furthermore, the study of diagrams can significantly contribute to the validation and refinement of the stemma codicum.

The first results on the examination of the diagrams in the *Mechanica* were presented in 2010 in the working group on diagrams within Topoi (in cooperation with research group D-III-1 *Diagrams*). In the next research phase, the diagrams in the *Mechanica* will be interpreted in terms of the textual representation of mechanical principles. Diagrams in other mechanical treatises will be examined as well: for example Heron's *Mechanica*, and the Arabic mechanical tradition, which is closely related to Greek mechanics. Important texts in this context are: *Nutaf min al-hiyal*, a partial Arabic version of the Aristotelian text, contained in the fifth book of al-Khāzinī's *On the Balance of Wisdom*, and the mechanical treatises by Thābit ibn Qurra and al-Isfizārī. Analysed as well will be the reception of the Aristotelian diagrams in translations, commentaries, and paraphrases of the *Mechanica* up to the Renaissance, with the aim of shedding light on practices involving diagrams in ancient mechanics, determining how these practices differ from those of later periods, and discovering whether there are standardised diagrams in mechanics. This comparative study on diagrams in mechanical treatises combines the philological tradition with the more philosophical and mathematical aspects of texts in order to attain a clearer picture of the history of mechanics.

An inventory of diagrams and figures preserved in the extant manuscripts of Aristotle's natural philosophy is being prepared under the guidance of Dieter Harlfinger at the Aristoteles-Archiv of the Freie Universität Berlin. The first, now completed phase of this project focused on the cosmological treatise *De Caelo*; in the future, this project could be extended to other Aristotelian treatises. A total of 175 manuscripts were examined, ca. 65 of which transmit the primary text of *De Caelo*, whereas the remaining manuscripts contain ancient and medieval commentaries on this treatise. In each case occurrence, position, and type of diagram (geometrical diagrams, logical figures, line diagrams, tree diagrams, other drawings) were registered, as well as the relevant part of the text. More precise data (incipit and explicit of the relevant folium, precise conjunction of text and diagram) were registered for witnesses of particular importance for the transmission and reception of the text, while the relevant sections of the microfilms were scanned and archived. The results of this research form an important basis for future textual editions, since they contribute to the validation and refinement of the stemma codicum, and they can also help in producing more adequate interpretations of the text.

The project on diagrams in the extant manuscripts of Aristotle's natural philosophy is connected with other projects of the cluster: diagrams from antiquity and the medieval period form an important historical background for the reconstruction of cosmological models, as undertaken by research group D-I-1 (*Cosmology*). On a more general level, group D-III-3 *Mechanics* communicates with several projects in the areas D-II-1 (*The Ontology of Space*) and D-II-2 (*Place, Space, and Motion*) which focus on the mathematical aspects of Aristotle's general theory of animal locomotion. Mechanical concepts are also highly relevant to Aristotle's theory of animal locomotion as expounded in *De Motu Animalium* and *De Anima*.

In addition to the aforementioned topics, the research projects in this group will throw light on the following issues: the place of the *Mechanica* in Aristotelian philosophy of nature, its place among other Peripatetic scientific writings, and among other ancient mechanical treatises. Another question that needs to be addressed is the authorship of the treatise. Although it is commonly assumed in the literature that the work is not by Aristotle himself, but instead by some later Peripatetic writer, possibly of the third century BC, this assumption is often based on questionable presuppositions. Another questionable move found often in the literature is the suggestion that the author of the treatise could be Strato of Lampsacus, the second successor after Aristotle as the head of the Lyceum. In a paper published in 2010, István Bodnár argues that the evidence for this hasty suggestion consists entirely of the fact that the ancient catalogue of Strato's works also contains a work on mechanics. Nevertheless, doctrinal considerations make it highly unlikely that the Aristotelian *Mechanica* as it exists today could be identical with Strato's mechanical treatise.

2 Publications

Bodnár, István. 2010. »The Pseudo-Aristotelian Mechanics: The Attribution to Strato«. In Marie-Laurence Desclos – William W. Fortenbaugh (eds.), *Strato of Lampsacus: Text, Translation and Discussion*. New Brunswick/London: Transaction Publishers. 443–455.

Prapa, Christina. Forthcoming. »Diagramme in der Handschriftentradition. Ein methodologischer Beitrag anhand der Überlieferungsgeschichte von Aristoteles' *De Caelo*«.

Schiefsky, Mark. 2009. »Structures of Argument and Concepts of Force in the Aristotelian Mechanical Problems«. *Early Science and Medicine* 14.1–3, 43–67.

Van Leeuwen, Joyce. Forthcoming. »The Text of the Aristotelian Mechanics«.

Online presentation of the manuscript *Berol.Ham.* 512, which contains an autograph of Pachymeres' Φιλοσοφία (Dieter Harlfinger, Lutz Koch); detailed descriptions of relevant *Mechanica* manuscripts, e.g. *Bern.* 402 and *Berol.Phill.* 1507 (Dieter Harlfinger), <http://www.teuchos.uni-hamburg.de/testversion>

Recorded data

- Collations of the complete text of the *Mechanica* in all 31 extant manuscripts (Joyce van Leeuwen).
- Inventory of the diagrams in a total of 175 manuscripts which contain the primary text of *De Caelo*, as well as its ancient and medieval commentaries (Dieter Harlfinger. Student Assistant: Christina Prapa).

3 Citation

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