

Aspects of the methodology of Galileo Galilei in his two writings *Sidereus Nuncius* and *Dialogue on the two main world systems, the Ptolemaic and the Copernican*.

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Concerning a historical characterization of the early modern period, its transformative character is often emphasized. It is generally described as an epoch in which both, traditions and new approaches can be found, often in close connection. Various developments led in the long run to a loss of the political enforceability of the medieval world view and the interpretive sovereignty of the reality of the Catholic Church. (Kunzmann, Wiedmann 2007, Fischer 2015) Also, developments in scientific thinking in the early modern period play a central role in the critical examination of the world view conveyed by the church. Galileo's criticism of the Aristotelian-Ptolemaic doctrine and the scholastic methodology, as well as his commitment to the Copernican world view and the associated search for alternative methods, can be placed in this context. (Kinder, Hilgemann, Hergt, 2008)

Galileo's investigations focused on the question of how contradictions between Aristotelian kinetics and mechanical principles, as they originated in the tradition of Archimedes and Euclid, could be solved. Accordingly, his research stems from the processing of conceptual, empirical and theoretical questions of classical natural philosophy. (Fischer 2015) Thus also questions of the methodical procedure become relevant in order to locate Galileo's achievements for the long-term implementation of a new world view - the heliocentric world view.

What methodology does Galileo base his research and criticism of the Aristotelian-Ptolemaic doctrine on? This question is related to two writings from Galileo's later work. On the one hand there is *Sidereus Nuncius*, published in 1610, that presented new astronomical observations. On the other hand, there is the *Dialogue on the two main world systems, the Ptolemaic and the Copernican*, published in 1632.

Sidereus Nuncius is central to the study of the Galilean methodology because it describes the role of the telescope not only in Galileo's discoveries but also in his approach to observing astronomical phenomena. (Fischer 2015) *Sidereus Nuncius* is therefore examined to answer the question which methodological aspects of Galileo's research are expressed in his descriptions of the use of the telescope. Concerning the question which epistemological and metaphysical assumptions justify Galileo's methodology, it is important to focus on the dialogue. The fact that such aspects can be found in this work becomes clear when one considers that the verdict of 1632 against Galileo was based on the dialogue and directed against his metaphysical and epistemological assumptions which fund his methodology. This also means that neither his methodical approach nor his findings and discoveries can be explained by the use of the telescope alone. (Heichele 2016, Fischer 2015)

With regard to Galileo's methodical approach, it becomes clear that the scholastic method is rejected in favor of a mathematical procedure. (Mudry 1987) As the writing *Sidereus Nuncius* makes clear, Galileo uses a geometric method for his investigations. It is a demonstrative and comparative geometry related to Euclid. For Galileo, geometry is measuring and measuring is a form of comparison. What is real is what can be measured, compared and determined. For Galileo, mathematical structures are the world's constituent elements that have objective

validity. This is not only related to astronomical investigations, as expressed in *Sidereus Nuncius*. It is also in contrast to the Aristotelian doctrine, related to the field of physics, as the dialogue makes clear. (Heichele 2016)

An epistemological and a metaphysical assumption are providing a basement for Galileo's geometric method. This happens according to the epistemological assumption, that the world and the cosmos include mathematical structures (geometry). Galileo's assumption as he describes it in the *Sidereus Nuncius*, for example, can be integrated into a historical development. There, nature was more and more seen as something independent with its own value. Related to this is the idea of a mathematical nature that has been discussed in various facets since antiquity and the Middle Ages. But Galileo's understanding was new because it does not merely treat the role of mathematics hypothetically. Mathematics represents reality and not an image. Connected with this epistemological assumption is the metaphysical one that the world and the cosmos build a whole and do not represent different spheres. This is opposed to the view of natural processes of the Aristotelian natural philosophy. Mathematical-quantitative procedures in connection with systematic observation produce knowledge and not a sensual experience. Galileo's criticism of the Aristotelian-Ptolemaic doctrine, his rejection of the scholastic method as well as his use of the telescope as a measuring instrument is based on epistemological and metaphysical prerequisites. However, this does not legitimize the observations made with the telescope. Only the consistent scientific application of the telescope and the geometric method in the sense of Galileo's epistemological and metaphysical assumptions justify the reinterpretation of the observed phenomena. (Heichele 2016, Leinkauf 2017)

The astronomical use of the telescope can be interpreted as an expression of the development of an early modern understanding of perspectivity, which can be characterized by a transition from a "perspectiva naturalis" to a "perspectiva artificialis". The latter is characterized by a mediating link that shapes the perspective, such as the soul, the image, the text or the visual instrument. Also in astronomy in the 17th century, a gradual objectification of the process of observation can be seen. The process of observation was detached from its exceptional function and classified into physical functions. "The 'intellectual eye' is placed by the side of the sensual eye [...]". (Leinkauf 2017)

Galileo's achievement in developing a new interpretative network on the basis of his discoveries and methodology can thus also be interpreted as an expression of a changed way of dealing with visibility. Galileo's interpretations hollowed out the old Aristotelian-Ptolemaic world view in central aspects both theoretically and empirically. By attempting to integrate his observations into the overall context of the declarations of nature and to use them as the basis for a new cosmology and physics, Galileo offered an alternative to the old view of the world. (Fischer 2015, Leinkauf 2017)

References

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