Journal of Philosophical Theological Research
ISSN Print: 1735-9791 Online: 2538-2500

A Critical Review of Mario Alai's Solution to the Problem of Underdetermination of Quantum Mechanics Theories in Defense of Scientific Realism

Jalal Abdollahi[1], Seyyed Hedayat Sajadi[2]

Received: 2022/08/04 | Revised: 2022/12/16 | Accepted: 2022/12/29

Abstract

Empirical underdetermination is one of the problems that challenges the position of scientific realism regarding the unobservable level of scientific theories. In response to this problem, Mario Alai claims that underdetermination cannot seriously trouble the realist's position. Like other realists, he introduces theoretical virtues to break the underdetermination and offers special solutions to get rid of the objections to using theoretical virtues. Although Alai believes that theoretical virtues can break the existing underdetermination in most cases, he admits that today, despite using theoretical virtues, the underdetermination between the alternatives of quantum mechanics theories – Standard Quantum Mechanics (SQM) and Bohmian Quantum Mechanics (QBM) – cannot be broken. For this reason, defending the realist position in this special case, he proposes (and brings up) a new solution that pays attention to the unobservable agreements assumed in the ontologies of alternative theories. In this article, by critically examining Mario Alai''s approach to the problem of empirical underdetermination, it is shown that his solutions to solving the objections of using theoretical virtues are not without difficulties. Also, after examining some similarities of Alai's new proposed solution to maintain a realist position regarding quantum mechanics theories with the approach of structural realists, it is shown that his solution faces three drawbacks: 1) Reducing alternative theories to each other and dismantling the problem instead of dealing with it, 2) inconsistency and ambiguity in the truth of parts of the agreements of alternative theories, and 3) lack of guarantee in the existence of parts of the agreements, and ineffectiveness to generalize the solution for other possible cases.

Keywords: underdetermination, scientific realism, structural realism, theoretical virtues, Standard Quantum Mechanics, Bohmian Quantum Mechanics.

Research Article

1. M.A. in the Philosophy of Science, Sharif University of Technology; Physics Teacher in Ministry of Education, Tehran, Iran **(Corresponding author)**. jalaljalal13721372@gmail.com
2. Assistant Professor of Philosophy of Science and Technology, Department of Physics Education, Farhangian University, Tehran, Iran. hedayatsajadi@gmail.com

▣ Abdollahi, J. & Sajadi, H. (2023). A Critical Review of Mario Alai's Solution to the Problem of Underdetermination of Quantum Mechanics Theories in Defense of Scientific Realism. *Journal of Philosophical Theological Research*, 24(94), 101-126. https://doi.org/10.22091/jptr.2022.8473.2744

Introduction

According to scientific realism, scientists are not blocked by underdetermination because they don't look just for empirical data. Rather, they seek theories that have theoretical virtues such as simplicity, explanatory power, unification, and consistency with accepted theories and background beliefs.

Theoretical virtues and their inconclusive objections

But the utilization of theoretical virtues has two following objections: First, the concepts of these virtues are somewhat vague, and context-dependent, so they may be borderline and ambiguous cases. In reply, Alai claims that there is no reason to deny that they have epistemic value at least in clear-cut and univocal cases. For instance, he mentioned the Copernican and Ptolemaic systems that are underdetermined by empirical data. Alai says some unifying and explanatory features of the Copernican system speak for the truth of this system today just as they did five centuries ago, in a completely different cultural and epistemic situation. But the example that Alai narrated is not compatible with historical facts. In late 16^{th}-century astronomy, there is a struggle between three theories: Ptolemaic geocentrism, Copernican heliocentrism, and Tycho Brahe's geoheliocentricism. While Alai ignores Brahe's theory and does not consider its coherence with accepted theories and background beliefs. Brahe's compromise system preserved the explanatory achievements of the Copernican approach and remained in agreement with most of the received physics and cosmology. Hence, the scientific community chose this theory. It is unclear why Alai ignores Brahe's theory and its coherence. Thus, the example that Alai presents is defective.

Second, different theoretical virtues may recommend different theories: If theory T has virtue X and theory T′ has virtue Y, we may be uncertain which one to choose. Alai says that scientists want a theory to have (to a reasonable extent) all of those virtues, for they assume that a true and informative theory would have all of them. But it is seem that this reply hided an unnecessary assumption. Alai assumes that only one theory can have all of the virtues, yet there is no obstacle that we meet many (not only one) theories that have all of the virtues. By the usage of *epistemic underdetermination* concept, we try to exemplify why Alai's assumption is incorrect.

Alai's solution to the underdetermination of Quantum Mechanics Theories

Alai focuses on alternative theories in quantum mechanics and admits that the theoretical virtues cannot break the underdetermination between those theories. For example, the following theoretical shortcomings can be mentioned: BQM postulates an instant dependence of everything on everything that the scientific community evaluates as an implausible and unsupported idea; SQM avoids the above shortcomings, but it provides no picture of the unobservable mechanisms and no explanation of the empirical regularities. Now, the position of scientific realism is faced with a serious threat. For this reason, Alai proposes a new solution that pays attention to the unobservable agreements assumed in the ontologies of alternative theories. He says all theories associate the quantum state with a peculiar physical field, all include the Schrödinger equation centrally in the dynamics, all endorse a strong form of ontic-structural nonseparability, and all agree on geometrical relations between sub-systems. Now, those agreements (and unobservable) matters about which realists have well-founded beliefs and probably even knowledge.

Assessment and evaluation of Alai's solution

But, it seems that this solution faces three criticisms. Regarding the first criticism, relying on making the agreements between the two alternative theories – SQM and BQM – leads to the problem that many basic components of Bohmian quantum mechanics theory (including the quantum potential) are ignored, and that means that BQM doesn't have a distinctive characteristic from SQM, and this cannot be accepted by the advocates of the Bohmian theory in any way. Because it is demonstrated that without the existence of these conceptual components of Bohmian theory, BQM reduces SQM. So, that causes us to dismantle the problem instead of dealing with it.

Concerning the second criticism, inconsistency, and ambiguity in the truth of parts of the agreements, Alai says the serious theoretical shortcomings of alternative theories indicate that, despite their compatibility with available evidence, none of them is true. In defense of the realist position, he proposes that we could rely on unobservable entities of agreements as part of alternative theories. It is not clear how the unobservable agreement parts of alternative theories (none of which are true due to theoretical shortcomings) can be considered true. On the one hand, Alai considers none of the theories to be true due to theoretical shortcomings; on the other hand, he considers the agreement parts of the theories to be true!

Finally, the third criticism is the lack of guarantee in the existence of parts of the agreement and the ineffectiveness to generalize the solution for other possible cases. According to Alai's view, the different theories and interpretations are constrained by the empirical findings, which limit the possible options. But there is no reason to accept that constrained theories by empirical data can guarantee existing great agreement in alternative theories. The same empirical underdetermination is a good reason to confirm that we can construct greatly different theories with equal empirical data.

Furthermore, some differences and similarities between the approach of structural realists and Alai's solution are pointed out. For example, it seems that the main idea of Alai is approximately similar to the view of structural realists. Because both attribute the claim of truth (and successful empirical predictions in scientific theories) to the commonality between alternative theories.

References

Acuña, P and Dieks, D. (2014). Another look at empirical equivalence and underdetermination of theory choice. *European Journal of Philosophy of Science*, 4(2), 153–180

Alai, M. (2019) The Underdetermination of Theories and Scientific Realism, *Axiomathes* 29, 621–637.

Carrier, M. (2011). Underdetermination as an epistemological test tube: expounding hidden values of the scientific community, *Synthese*, 180(2), 189–204

Dieks, D. (2017). Underdetermination realism and objectivity in quantum mechanics, In Agazzi E (ed.) Varieties of scientific realism. *Objectivity and truth in science*. Springer, Cham, pp. 295–314.