


Editorial

Post-Editorial of “The Multiverse” Special Volume

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Received: 6 January 2020; Accepted: 14 January 2020; Published: 20 January 2020

Abstract: A successful series of papers devoted to various aspects of an idea of the Multiverse have been gathered together and presented to the readers. In this post-editorial we briefly challenge the content referring to the main issues dealt with by the Authors. We hope that this will inspire other investigators for designing future tests which could make this very notion of the Multiverse falsifiable.

Keywords: philosophy of multiverse; categories of multiverses; different physics universes; superstring multiverse; dark multiverse; multiverse entanglement; universe-antiuniverse pair creation; multiverse habitability: stars, planets, life, consciousness; falsifiability of multiverses

Although the idea of the Multiverse as a collection of possible universes has entered the area of physics long time ago, it is right now when it is taking viability and providing alternatives to confront the current cosmological conundrums.

While one may consider the studies related to the concept of the Multiverse as a new revolution that can change the current paradigm in cosmology, in fact, it can rather be understood as the next step in the Copernican transit, where our habitat has gradually lost relevance as unique, special, and also tiny as compared to early science ages thought. Nowadays, the notion of the multiverse emerges naturally from some developments in cosmology and particle physics as a consequence of the same physical theories which we experience on the Earth [1]. Since the multiverse is not a theory by itself, then there is no closed scenario or definition of it. Firstly, it depends on the definition of what we mean under the notion of the universe. Is it the Solar System, as it was thought at Copernicus age? Is it a galaxy, as it was thought till the beginning of the 20th century? Next, is it the Hubble size universe with its outer horizon bulk or something much larger and perhaps hardly achievable by current observations? Depending on the range of it, one then allows for a great diversity of multiverse theories and asks for a deeper debate about the nature of this entity even on the level of a single universe [2].

Whatever the interpretation, it seems that operationally the consideration of an idea of the multiverse could provide solutions to several open problems in physics. This is why we are interested in different approaches and proposals regarding the multiverse in this issue. However, the biggest challenge of the multiverse hypothesis is the possibility to falsify it by some observational or experimental data. Without this most important point, we cannot make it a physical theory in the sense of contemporary definition of the scientific paradigm.

Hoping it will serve as a basic and updated reference, this Special Issue covers all current research avenues on the exciting track to the Multiverse starting from philosophical aspects, throughout the theory, to its possible observational verification.

The area of philosophy and history of physics is where the debate about how to define the category of the multiverse and the need (or not) to endow it with physical meaning exists [3]. In several papers we cover the ideas that philosophy of science provide to falsify multiverse theories and describe the scientific progress.

The diversity of possible physical shapes of a universe within the multiverse can be interpreted in terms of diversity of possible ways to choose physical parameters and can be related to the issue of varying physical constants and varying physical laws [4]. Another idea related to the Multiverse we cover in the issue is the Anthropic Principle which, despite being in some sense tautological, it has been argued how it could give some insight and possible constraints onto the nature of the physics we experience here in "Our Universe", whatever it is.

One strongly studied approach is given by superstring theory which led physicists to an idea of superstring landscape and the swampland, through many ways of choosing the physical vacua due to the symmetry breaking mechanism [5]. This provides a theoretical framework for the multiverse and may as well be related to the eternal inflation theory that constitutes one of the possible mechanisms for the inflation of our universe. In the issue some of these ideas are analyzed, including the discussion about their results and criticisms.

A more recent idea of the multiverse is constituted of the quantum multiverse, in which different individual universes are classically causally separated, but quantum mechanically entangled [4]. This approach has entered strongly in the scenario, because it gives possible predictions and an opportunity to falsify the concept. Also, the problems related to the creation of the multiverse are tackled in the similar sense as the debate of the imposed boundary conditions for the creation of a single universe [6].

Last but not least, the universe and surely the multiverse by its name are everything so it is no wonder that some interesting convergence of topics in an interdisciplinary fashion should appear which can provide some wiser view on the nature and a broader view of the effects under study. For that reason, the issue also contains the investigation of the multiverse from the point of view of astrobiology. This is in tight relation to the Anthropic selection of the three fundamental constants: the fine structure constant α , the electron-to-proton mass ratio β , and the strength of gravity as expressed by the ratio of proton mass to the Planck mass γ . The selection means various levels of habitability criteria in the multiverse, beginning with the number of stars and their properties to host life [7], through the number of habitable planets [8] and the fraction of planets having a chance to develop life [9], and the fraction of that chance admitting the intelligent life [10]. All this is considered in terms of the so-called typicality or the probability of observation of the values of the fundamental constants which do not deviate from the values we know in our Universe. The habitability criterion is then expected to be the useful observational test of the multiverse concept which is the main objective of the whole story about it.

We then finally encourage the reader to dive into the ocean of all these problems since they might be quite fascinating developments of the prospective 21st century physics.

Author Contributions: A.A.-S. and M.P.D. contributed equally to this work. T.N. gave a general feedback and the consent to publish in an agreed form. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: The guest editors would like to thank all the Authors for their contributions and the Reviewers for the constructive reports. Their work helped the editors to collect this special issue.

Conflicts of Interest: The authors declare no conflict of interest.

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