



Article

Aesthetic Criteria in Fundamental Physics—The Viewpoint of Plato

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Abstract: I discuss the role of beauty in physics. Physicists are sometimes described as platonists for their conviction that the fundamental laws are elegant and aesthetic arguments represent an important epistemic tool. After a review of the ideas of Plato and some of the leading figures of modern physics, which suggest that this is indeed the case, I present a list of current aesthetic criteria. I focus on symmetry and unity and demonstrate their increasing relevance in an array of experimentally verified theories. I also deal with an open issue of naturalness as the third criterion. The laws of nature appear increasingly beautiful as we uncover them, and it is important to see if the trend continues in the future.

Keywords: beauty in fundamental laws; aesthetic criteria in physics; symmetry; unity; naturalness



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1. Introduction

Physics brings deep philosophical insights into the nature of the universe. One of them is the role of beauty in natural science. Throughout history, many leading physicists contemplated this role. Some claimed beauty was an inspiration for them to do science, another group argued beauty is a signpost to the truth and a few ventured to say they preferred beauty to truth in their work. Although they did not agree on all points, one thing seems clear: from Kepler to Einstein, Dirac, Weinberg, and Arkani-Hamed, aesthetic arguments have always been important. A recent study has found that 75% of respondents, mostly physicists and biologists, encounter beauty in their research [1]. According to the survey, beauty motivated most of the participants to pursue a scientific career, helps them persevere through difficult times, and most scientists believe beauty is key to communicating science. Given such a huge influence, the amount of literature written on the subject is relatively modest (for a review see [2,3]). The burden of rigorous treatments is on the shoulders of philosophers of science, e.g., [4–6], while physicists, if at all, prefer to express their views in popularization books [7–11] or talks [12–15].

Part of the reason is the perception of beauty as being in the eye of the beholder, a valid position, but the one which seems to make meaningful discussion difficult. What use is a vague concept in a rigorous discipline? On the other hand, when physicists who describe fundamental laws as profoundly beautiful are prompted to be specific, they give descriptions that frequently agree—a possible indicator of the existence of an objective element of beauty. Moreover, they do not just perceive aesthetic properties such as simplicity, symmetry, and unity in the laws of physics, but also actively use them as key ingredients to building new theories, elevating beauty well beyond a decorative role. Two discoveries in the last decade, both leading to the Nobel prize, stand as milestones confirming this practice. The Higgs boson, discovered by the ATLAS and CMS collaborations at the Large Hadron Collider (LHC) at CERN in 2012, was the triumph of the Standard Model of particle physics, and gravitational waves, detected by the Advanced LIGO detectors in 2015, paid tribute to Einstein's General relativity.

The treatment of beauty as an objective entity has its roots in the works of Plato. He associated beauty with knowledge, in particular the knowledge of mathematics and philosophy. Beauty was, along with goodness, central to Plato's philosophy since it provided a

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