Marianne Talbot Student Essay Competition: Hilary 2025

1st Prize: Pirin Erdoğdu (UAE)

Ornithology for birds? Do cosmologists need philosophy?

As Kuhn argued in The Structure of Scientific Revolutions (1962), criteria for evaluating theories are not explicitly taught as philosophical principles in most scientific fields. Instead, they are absorbed informally during doctoral training. Consequently, most early-career scientists internalize standards for what a “good” theory looks like without engaging in a deeper, philosophical discussion about why they are valid or necessary. This issue becomes especially important in cosmology given how theoretical and underdetermined the field often is.

Cosmology has long served as a testing ground for philosophy; Karl Popper called it the most philosophical science, as it addresses fundamental, large-scale questions often at the edge of empirical testability (Popper, 1963). Still, some argue that philosophy has little to offer cosmologists. Stephen Hawking famously declared “philosophy is dead,” claiming it failed to keep pace with science, while Steven Weinberg compared its role to ornithology for birds. Philosophers of science often focus on well-defined theories, while physical cosmologists rely on complex, synthetic models that defy formal philosophical analyses. Traditional philosophical methods such as axiomatization, logical structuring and conceptual analysis may seem inadequate in modern science. Nonetheless, scientific theories often rest on philosophical assumptions, whether acknowledged or not. Unexamined philosophical standpoints are still philosophical standpoints (Beisbart, 2007).

Theory Choice in Cosmology

When it comes to criteria for a good scientific theory, cosmologists have largely adopted Kuhn’s epistemic values (1977) as summarised by Ellis (2006):

1. **Satisfactory structure:** internal consistency, simplicity, and aesthetic appeal;

2. **Intrinsic explanatory power:** logical tightness, the ability to unify otherwise separate phenomena, and probability of the theory or model with respect to some well-defined measure;

3. **Extrinsic explanatory power, or relatedness**: connectedness to the rest of science, and extendibility;

4. **Observational and experimental support:** testability, falsifiability and confirmation.

Not all cosmological theories meet all these criteria. When students learn which theories are considered “good” or “promising”, they’re rarely asked why these criteria matter. A student working on inflation might prioritize explanatory power (e.g. solving the horizon and flatness problems), while another studying multiverse or string theories might focus on internal structure and ignore observational support. Neither may be asked why these criteria outweigh others like testability or falsifiability. Some argue that theoretical physics and cosmology are now driven more by “mathematical elegance” than empirical rigor. It’s becoming harder for scientists to step outside their frameworks and question foundational assumptions.

Unlike laboratory-based physics, cosmological theories deal with questions that cannot always be tested experimentally. Cosmology deals with one universe, there are no control experiments, no comparative observations. Uncertainty will always remain about what exists on the largest scales and statements about the origin of the universe will always be speculative, making the philosophical foundations of theory evaluation especially important. For this reason, cosmologists—particularly junior researchers—must critically examine their methods, chosen criteria, and underlying assumptions.

Are cosmologists realists or antirealists in their choice of theories?

Scientific realism holds that scientific theories aim to describe the world, and accepting a theory means believing it to be “approximately” true. In contrast, antirealism argues that science does not need to provide a literally true account of reality, and accepting a theory does not necessarily require believing it to be true. One of the central claims of contemporary realism is that we must take seriously the involvement of theoretical and metaphysical beliefs in scientific methodology. As Quine (1951) proposed, our knowledge is structured like a web of beliefs. This is indeed what we see when we look at the theory choice criteria above.

Cosmologists, like most working scientists, are realists—or at the very least, structural realists. However, when we examine their criteria for theory choice in cosmology—such as satisfactory structure, explanatory power, and empirical support—it becomes clear that the situation is more complex. Different contexts emphasize different criteria, and the weight given to factors like mathematical elegance, testability, or explanatory reach can shift depending on the nature of the problem.

For example, simplicity is often justified on Bayesian grounds: simpler theories generally have higher prior probabilities because they make fewer assumptions. Simplicity is a metaphysical virtue if one believes that the universe itself follows simple underlying principles, whereas to anti-realists, simplicity is a pragmatic virtue. Cosmologists are almost always Bayesian in their methodology but not necessarily in their philosophy of science. The core challenge lies in the choice of priors, particularly in fundamental questions such as the theories of multiverse, fine-tuning, and initial conditions. In these cases, assigning objective priors is highly non-trivial and since different priors can lead to radically different conclusions, Bayesian reasoning in cosmology remains more of a pragmatic tool than a fully accepted epistemological foundation. Similarly, intrinsic and extrinsic explanatory power, such as unification, logical tightness, connectedness to other sciences and extendibility are realist arguments if one assumes that deeper explanatory structures correspond to reality. Anti-realist philosophers like Van Fraassen (1980) reject the idea that the explanatory power of a theory necessarily makes it a realist one but acknowledge it as a pragmatic virtue rather than a sign of truth. On the other hand, observational and experimental support such as testability and confirmation are strongly realist arguments; Popperian falsifiability and the success of novel predictions suggest that theories track reality. Aesthetic appeal is also a metaphysical virtue, as it relies on an assumption that beauty or elegance correlates with truth. Some of the most famous physicists, like Paul Dirac and Albert Einstein, have argued that mathematical beauty is a guide to reality, while others criticize it as aesthetic bias rather than scientific reasoning.

Underdetermination in Cosmology

Underdetermination -- the idea that different theories or explanations can fit the same empirical data -- is a major problem in philosophy of science as it challenges the idea of scientific realism. Holistic underdetermination applies broadly to all areas of science as it is due to theory falsification. Contrastive underdetermination, however, is more relevant to cosmology, where unobservable theoretical entities make it difficult to determine which of multiple plausible explanations is correct. Scientists often dismiss concerns about underdetermination due to their Bayesian approach to theory confirmation and the belief that large data sets will eventually favour one theory over others, even when fundamental theoretical choices remain unresolved.

Cosmologists are remarkably comfortable with underdetermination. In fact, modern cosmology owes its very existence to a foundational instance of underdetermination: Einstein’s equivalence principle in general relativity. The principle states that there is no local experiment that can distinguish between acceleration and gravitational effects, meaning that whether we are in free fall due to gravity or in an accelerating frame is fundamentally underdetermined by observation alone. This ambiguity in perspective -- whether motion is due to gravity or acceleration -- sets the stage for the geometric formulation of gravity and, ultimately, the expansion of relativistic physics into cosmological models of the universe. In this sense, cosmologists have always worked within a framework where fundamental theoretical choices remain underdetermined by empirical data. Many key concepts in modern cosmology (e.g. inflation, dark matter and dark energy) are theoretically powerful but remain empirically underdetermined. In these cases, cosmologists often adopt Van

Fraassen's constructive empiricism: we use these concepts because they work, but we do not need to commit to their metaphysical reality.

This pragmatic, antirealist tendency is even more apparent in discussions about the origins of the universe. When asked what happened before the Big Bang, most cosmologists will say the question is meaningless -- like asking what lies north of the North Pole -- since time itself began with the universe. This response reflects an antirealist stance; if a question is conceptually incoherent within the Big Bang framework, it is scientifically meaningless. In the end, whether we treat such questions as meaningless or as gaps in our understanding depends on where we place the demarcation between science and philosophy.

So, the jury is out on whether cosmologists see their theories are truth. In fact, many caution against overcommitting to realism in cosmology (e.g. Peebles, 1980). For example, Binney et.al. (2025) emphasize that while the ΛCDM model[1] serves as a strong approximation to reality, it remains incomplete and contains open questions and anomalies that could lead to further theoretical revisions. However, as Lipton (2004) famously put it, "the history of science is littered with the corpses of discarded theories once thought to be true" -- a sentiment echoed in Laudan's pessimistic meta-induction (1981), which argues that because so many once-successful theories have ultimately been abandoned, we have little reason to think our current ones are immune. This suggests that cosmological models, despite their empirical success, do not necessarily provide a final or fully accurate depiction of the universe. Such caution opens the door to a more anti-realist perspective on cosmological models, where they are viewed as pragmatic tools for organizing observations rather than definitive representations of the underlying structure of reality.

Whether cosmologists recognize it or not, the realist and anti-realist assumptions that shape their models are inherently philosophical. Engaging with them meaningfully -- rather than relying on implicit commitments -- requires philosophical reflection, making it difficult to justify the idea that philosophy is merely ornithology for birds.

Bibliography

Beisbart, C. (2017) "Moving boundaries? – comments on the relationship between philosophy and cosmology," in K. Chamcham et al. (eds.) *The Philosophy of Cosmology*. Cambridge: Cambridge University Press, pp. 66–75.

[1] The ΛCDM model is the standard cosmological model, describing a universe dominated by cold dark matter (CDM) and a cosmological constant (Λ) representing dark energy.

Binney, J. *et al.* (2025) “Manifesto: challenging the standard cosmological model,” *Philosophical transactions. Series A, Mathematical, physical, and engineering sciences*, 383(2290), p. 20240036. Available at: https://doi.org/10.1098/rsta.2024.0036.

Cover J.A. , Curd, M. and Pincock, C. (2013) *Philosophy of science: The central issues*. 2nd ed. New York, NY: WW Norton.

Ellis, G.F.R. (2006) “Issues in the philosophy of cosmology,” *arXiv [astro-ph]*. Available at: http://arxiv.org/abs/astro-ph/0602280.

Ellis, G.F.R. (2017) “The domain of cosmology and the testing of cosmological theories,” in K. Chamcham et al. (eds.) *The Philosophy of Cosmology*. Cambridge: Cambridge University Press, pp. 3–39.

van Fraassen, B.C. (1980) *The Scientific Image*. London, England: Oxford University Press.

Godfrey-Smith, P. (2003) *Theory and reality: An introduction to the philosophy of science,* Chicago, IL: University of Chicago Press.

Kuhn, T.S. (1962,2012) *The structure of scientific revolutions*. 50th ed. Chicago, IL: University of Chicago Press.

Kuhn, T.S. (1977) *Essential tension: Selected studies in scientific tradition and change*. Chicago, IL: University of Chicago Press, p320-39

Ladyman, J. (2021) *Understanding philosophy of science*. 2nd ed. London, England: Routledge.

Laudan, L., (1981). A confutation of convergent realism. Philosophy of Science, 48(1), pp.19–49.

Lipton, P., (2004). Inference to the best explanation. 2nd ed. London: Routledge.

Peebles, P.J.E. (1980) *The large-scale structure of the universe*. Princeton, NJ: Princeton University Press.

Popper, K. (1963) Conjectures and Refutations: The Growth of Scientific Knowledge. London: Routledge & Kegan Paul.

Quine, W.V. (1951) “Main trends in recent philosophy: Two dogmas of empiricism,” *The philosophical review*, 60(1), p. 20. Available at: https://doi.org/10.2307/2181906.