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Book Review

Anthropic Bias: Observation Selection Effects in Science and Philosophy. By Nick Bostrom. Routledge, New York and London, 2002, xiii + 224 pp., $70 (hardcover). ISBN 0-415-93858-9.

Why the universe is just so? Could it have been very different? The questions have been posed by scientists and philosophers for millenia, but only very recently have we accumulated enough physical and astronomical knowledge to be able to discuss these issues in a serious and quantitative manner. And, lo and behold! what modern cosmologists began to discuss in earnest is the sort of necessary link between our own existence as intelligent observers evolved from the simplest procaryote lifeforms over billions of years and the properties of universe (and other universes!) at large. This link is technically called an observational selection effect, in both research and popular literature often known under the slightly misleading title of anthropic principle(s), and if from now on anybody wishes to seriously study these matters, *"Anthropic Bias"* is without question an excellent place to start.

Bostrom's book makes amusing, although at times quite exacting, reading. From quantum cosmology to annoying traffic jams, from many-worlds quantum mechanics to Adam and Eve thought experiments, from freak observers created by black hole radiation to the (in)famous Doomsday argument of Gott, Carter and Leslie (not to mention future totalitarian world government), the book reads as an exciting detective novel. There are three basic, tightly interrelated parts of the exposition. The first (roughly Chapters 1 through 3) deals with the "classical" anthropic thinking, definitions of anthropic principles, and many "fine tunings" revealed in the numerical values of constants of nature and cosmological parameters, from Eddington and Dirac to this day. Bostrom attempts to bring some order into the vast jungle of confusion as to the definitions and meanings of various "anthropic principles" (he counts more than 30 of them in the literature). He succeeds splendidly in this difficult task, and allows the reader

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to gain a completely new perspective, which is obscured in some of the most authoritative works on the subject thus far.[1]

This part is particularly useful as an antidote to the misconstrual of the anthropic thinking—still prevalent in some circles, slightly more in philosophy of science than in physics—as anthropocentric or "cozy" or teleological. Bostrom clearly and decisively demonstrates that this is not the case; in fact, anthropic coincidences may and should be interpreted not just disteleologically, but rather *anti-teleologically*. That is, instead of pointing out something really special about our cosmological domain and its physics (and, by extension, ourselves), they emphasize that any special feature we might observe is nothing but an illusion, a necessary consequence of our restricted viewpoint. Since we could not exist in other places (for instance in those in which there is no resonance in ^{12}C nucleus, enabling formation of elements heavier than helium), we will not observe these places, no matter how very real they are. Here, Bostrom highlights the central aspect of any serious anthropic thinking: *anthropic principle as an observational selection effect*. Physicists and astronomers have been familiar with the observational selection for quite long time, some aspects of it (e.g., Malmquist bias in astronomy[2]) being the subject of studious and detailed mathematical modeling. However, it has never been so comprehensive and (in literal sense) universal treatment as in this book.

In the same time, this treatment is the best antidote to those attacks (mainly ideologically motivated, either from the vulgar-materialist or positivist wing) on anthropic reasoning as anthropocentric, teleological or even quasi-religious.[3] But, on the other hand, defenders of the anthropic principle(s) are often motivated by the same interpretation, and one cannot help wishing this ideological layer to be both highlighted and banned from the serious discussion of these issues, the task Bostrom does with ease. In addition, he appreciates how the notion of the *multiverse* (or the *world-ensemble*), gaining ground in both cosmology and quantum mechanics, helps us understand anthropic "coincidences" as manifestations of the universal selection effect. Here, the author is not only on the track of the

[1] I.e., The Anthropic Cosmological Principle, J. D. Barrow and F. J. Tipler, (Oxford University Press, New York, 1986); "Resource Letter AP-1: The anthropic principle," Yu. V. Balashov, *American Journal of Physics* **59**, 1069–1076 (1991); *Physical Cosmology and Philosophy*, edited by J. Leslie (Macmillan Publishing Company, London, 1990).

[2] The difference between the average absolute magnitudes of stars (or galaxies or any other similar sources) in magnitude-limited and distance-limited samples, discovered in 1920. by K. G. Malmquist.

[3] A recent example of such a view is: "The Revenge of Pythagoras: How a Mathematical Sharp Practice Undermines the Contemporary Design Argument in Astrophysical Cosmology," R. Klee, *Brit. J. Phil. Sci.* **53**, 331–354 (2002).

great contemporary analytic philosophers, like David Lewis or Robert Nozick, but also the key figures in modern quantum cosmology, notably Andrei Linde, Alexander Vilenkin, Brandon Carter, or Don Page. Parenthetically, he dispells some misconceptions in the recent literature about the nature and validity of the explanations of *prima facie* improbable observations via multiverse. This would in itself be sufficient reason for writing (and reading!) of this book, but it is just the beginning.

The second part of the monograph (roughly Chapters 4 through 9) deals with statistical (in particular, Bayesian) approach to the anthropic selection effects, and problems such an approach may entail. Most of the funny and instructive thought experiments belong to this part of the discourse. The most celebrated issue here is the (in)famous Doomsday argument (DA) which, in light of its possible consequences, deserves a slightly more detailed description. DA was conceived (but not published) by the astrophysicist Brandon Carter in the early 1980s, and it has been first exposed in print by John Leslie in 1989[4] and in a *Nature* article by J. Richard Gott.[5] The most comprehensive discussion of the issues involved is Leslie's monograph of 1996, *The End of The World*. The core idea can be expressed through the following urn-ball experiment. Place two large urns in front of you, one of which you know contains ten balls, the other a million, but you do not know which is which. The balls in each urn are numbered 1, 2, 3, 4,... Now take one ball at random from the left urn; it shows the number 7. This clearly is a strong indication that the left urn contains only ten balls. If the odds originally were fifty-fifty (identically-looking urns), an application of Bayes' theorem gives the posterior probability that the left urn is the one with only ten balls as $P_{post}(n = 10) = 0.99999$. Now consider the case where instead of two urns you have two possible models of humanity, and instead of balls you have human individuals, ranked according to birth order. One model suggests that the human race will soon become extinct (or at least that the number of individuals will be greatly reduced), and as a consequence the total number of humans that ever will have existed is about 100 billion. The other model indicates that humans will colonize other planets, spread through the Galaxy, 7 and continue to exist for many future millennia; we consequently can take the number of humans in this model to be of the order of, say, 10^{18}. As a matter of fact, you happen to find that your birth rank is about sixty billion. According to Carter and Leslie, we should reason in the same

[4] "Risking the World's End," J. Leslie, *Bulletin of the Canadian Nuclear Society* **21** (May), 10–15 (1989).

[5] "Implications of the Copernican principle for our future prospects," J. R. Gott, *Nature* **363**, 315–319 (1993).

way as we did with the urn balls. That you should have a rank of sixty billion in the sequence of all humans is much more likely if only 100 billion humans ever will have lived than if the number was 10^{18}. Therefore, by Bayes' theorem, you should update your beliefs about mankind's prospects and realize that an impending doomsday is much more probable than you thought previously.

Bostrom investigates and rejects several objections to this, highly controversial, line of reasoning. He argues that DA is much stronger than people usually think, when exposed to it for the first time, and will not fail for trivial reasons (an example of trivial objection: couldn't a Cro-Magnon man have used DA in his reasoning?). However, he does not accept the gloomy DA conclusion at face value, postponing (as any fiction writer worth something) the exposition of the solution for the last part of the book.

Finally, the culmination of the drama comes in the Chapter 10, which—together with the last Chapter, the aftermath—expounds the new theory. As in any good detective story, the main culprit is finally revealed at the very end of the long thread of evidence: the universal observational selection effect, explained in detail in the Chapter 10. Here, Bostrom develops a theory which promises a unifying treatment of observations, in particular in cosmology, explicating in detail the accompanying Bayesian methodology. The central piece of it is the Observation Equation (p. 173), which subsumes seemingly vague assumptions and observational selection criteria in full mathematical rigour.

The unity of the underlying analysis is emphasized in the final Chapter, where new theory is aplied in several fields of contemporary research. From the Observation Equation it is possible to derive various anthropic results as special cases. Among several important contributions here, probably the most important one for physicists, cosmologists, and even astrobiologists is the solution of the "freak-observer" problem. Namely, in the absence of a comprehensive "Theory of Everything," there are processes which are considered random, like the Hawking evaporation of black holes. In the infinite time of an ever-expanding universe (or *eternally inflating* multiverse!) these processes will unavoidably create some observers *without preceeding evolution* we are accustomed to link to observership, from our own experience. For such "freak observers," there will be no necessity to observe delicate fine tunings on which anthropic coincidences are based. Would that invalidate statistical reasoning in cosmology? Bostrom, on the basis of the Observation Equation, says decisively no, and his argument is robust and compelling. Similarly, he offers a solution for DA, but not to disclose too much we leave to the reader to assess the strength of this newest reply to the big puzzle. And, of course, we get a new

perspective on both the thermodynamical arrow of time and the perennial question "why [an expletive] cars in the other lane get ahead faster?"

Probably the worst thing one can say about this book is that it is too short. After finishing it, the reader is left with the impression that the very scope of the new theory is such that there is enough material for an entirely new book, or at least a reconsideration of many issues treated in previous chapters. For instance, one cannot help feeling that the connection of the new theory with such important problems as the search for non-human intelligence (both SETI and AI projects) could be fleshed out in more detail. In addition, the problem of the reference class ("who, or what, counts as an observer?"), remains controversial. The re-reading potential is thus very strong. The reader will also find some consolation for finishing the book in a detailed and cleverly composed bibliography. In any case, she or he will probably never think about the relationship between man and the universe in the same way as before. All in all, *Anthropic Bias* is a wonderful achievement, which belongs on the shelf of every serious student of modern cosmology and philosophy of science.

Milan M. Ćirković
Astronomical Observatory Belgrade
Volgina 7, 11160 Belgrade, Serbia
E-mail: arioch@eunet.yu