

The Universe – Order Without Design by Carlos I. Calle, Prometheus Books, Amherst NY, 2009, pp. 304. Scope: monograph. ISBN 978-1-59102-714-0. Level: general reader.

The author's goal is to provide a description of modern cosmology, accessible to the general reader, giving an account of recent developments in conceptual terms without recourse to equations or mathematics. In doing so, he seeks to answer the questions "Where did everything come from?" and "Is there any need for a Creator?".

These questions are of course age-old. They arise naturally in the mind of every enquiring human but, in the last few decades, many of the answers have started to emerge at least in general terms. It is now possible for science to "broad brush" a more-or-less complete description of how everything happened from the Big Bang onwards, explaining in a plausible way the evolution of galaxies, stars, planets, and life on Earth. Of course there are still many gaps in the story, e.g. the steps in the initial appearance of life, and whether it arose spontaneously in the Earth's early oceans or arrived from elsewhere. But the overall picture seems compellingly clear to most scientists, and the general assumption is that the gaps will progressively be filled.

However, there remains the tantalising problem of the "fine tuning" of parameters. It seems almost as though the Universe was explicitly designed in such a way that long-lived stars, planets, and life as we know it would eventually appear. The author discusses several examples where the value of a physical constant is just right, and where even a tiny difference would have led to a totally different kind of Universe. One of the seemingly least likely instances is the tuning of the fine-structure constant in just such a way that the energy of an excited state of the ^{12}C nucleus exactly matches the combined energies of a ^8Be and a ^4He , thus enabling the nucleosynthesis of carbon to occur in the interior of a star (a coincidence predicted by Hoyle prior to its discovery on the grounds that, without it, nucleosynthesis of the higher elements would be impossible). There are numerous other such coincidences, each one of which is separately essential for the present form of the Universe and without which we would not exist. Why?

Earlier thinkers, e.g. Augustine, Aquinas, Paley had attributed the order, structure and beauty of the world to a designer. However, the complexity, variety and intricacy of living systems can now be accounted for convincingly in terms of mutations in DNA and Darwinian selection processes. It seems that, once life gets going, it will inevitably evolve – perhaps not necessarily towards us, but to the development of enormous diversity at all levels including bacteria, plants and sentient creatures. So for life, despite its extraordinary variety, the existence of a designer need not necessarily be evoked. But what of the physical Universe to which such principles are seemingly not applicable? This

is the central question that Calle's book addresses.

The author provides a detailed description of inflationary cosmology in several variants, together with the conceptual framework of physics that supports it including the Newtonian picture, special relativity, general relativity, quantum mechanics, the laws of physics, the building blocks of matter, the Higgs mechanism, the Standard Model, and grand unification. The description ranges from facts and principles that most scientists would regard as being well-established to other ideas that are far more speculative and where experimental or observational support is currently slight or absent. The latter include supersymmetry, string theory, branes, M-theory, quantum gravity, eternally oscillating universes, and multiple universes.

The multiple universes idea, combined with the anthropic principle, is discussed as a possible explanation of the fine tuning: our universe is the one (or one of the few) out of the 10^{500} possible universes that can give rise to us. The others have different tunings – different physical laws and different values of physical constants – and could not give rise to us. As Calle points out the argument is plausible but close to being a tautology. Nonetheless, he uses it to conclude that if that or a similar model turned out to be correct, there would be no need for a designer: “The fine-tuning observed would be the result of the laws of physics... that evolved purposelessly and mindlessly to create the equilibrium and order we see today.” Well, maybe. Many people, including scientists, will see this book as concentrating very much on the “How?” of reality and never venturing anywhere near the “Why?”. We are now understanding the mechanisms of the Universe in increasing depth and detail but, as ever, it remains a choice for the individual whether to postulate that this reality has always existed or whether to attribute its existence to a Creator.

In style, the book is more like *Scientific American* or *New Scientist* than a scientific text, and the language is chatty and colloquial with short punchy sentences. The ordering of the material is not sequential, and it lacks the measured consideration of e.g. Delsemme's earlier *Our Cosmic Origins*. There are extensive footnotes (annoyingly at the end of the book rather than at the bottoms of pages), some of the key original references, a lot of explanatory diagrams, colour plates including Hubble images, appendices for non-scientists, and a glossary of technical terms. There is significant repetition of ideas so that, up to a point, each chapter can be read separately as an essay in its own right – which will be a great benefit to those who wish to dip in and read selectively. They are likely to enjoy doing so.

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