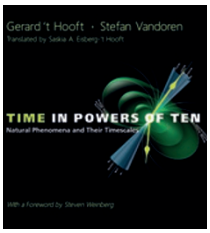
The fantastically marvellous universe



Time in Powers of Ten: Natural Phenomena and Their Timescales

By Gerard 't Hooft and Stefan Vandoren; translated by Saskia Eisberg-'t Hooft

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There is certainly no shortage of popular and scientific books on time. It has always been an endlessly fascinating topic for physicists and philosophers alike: from Plato and Aristotle to St Augustine, Leibniz and Newton, Kant and Heidegger, Einstein and Hawking. In the context of this history, it would seem difficult to find a new angle — and it does take a certain level of self-confidence to write 'yet another book about time'. But Gerard 't Hooft and Stefan Vandoren boldly took the challenge in their book *Time in Powers of Ten*, first published in Dutch in 2011, but now updated and translated into English by Saskia Eisberg-'t Hooft.

The book is a bit unusual. It is not an essay and stays away from any philosophical digressions about time. *Time in Powers of Ten* is more of an illustrated encyclopaedia of timescales. The format is inspired, as the authors acknowledge, by the 1957 book *Cosmic View: The Universe in 40 Jumps* by Kees Boeke (available at http://www.vendian.org/mncharity/cosmicview/). Boeke's book is a selection of graphics and explanations illustrating different length scales from the subatomic world to the large astronomical structures in the Universe. It also inspired the 1977 short documentary *Powers of Ten: A Film Dealing with the Relative Size of Things in the Universe and the Effect of Adding Another Zero* by Charles and Ray Eames (available at http://www.powersof10.com/film).

With today's wealth of high-definition images from astrophysics to biology and material science, illustrating various length scales is much easier than it was in the 50s or 70s. Nowadays, kids would look quizzically at Boeke's simple illustrations. After all, they grew up with Google Earth. A three-year-old can now use her fingers to zoom in and out on images of our Galaxy or cells with apps such as Cosmic Eye. But I find Boeke's black-and-white illustrations rather charming (especially the first photograph of a girl with a cat, proving that cats had taken over physics well before invading the Internet) and the explanations much more informative and compelling than the brief notes provided in the app. And the *Powers of Ten* short film is equally delightful with its soundtrack reminding one of the original *Star Trek* series.

Visualizing length scales is not that difficult — with a stretch of imagination, one might even picture the vastness of galactic clusters, the smallness of an atomic nucleus or the emptiness between it and its electrons. But time is much more difficult to grasp. 't Hooft and Vandoren not only take the challenge of writing about time, but also attempt to illustrate this elusive concept. *Time in Powers of Ten* is a bold enterprise — giving the reader a feeling of the various timescales, quantified by the powers of ten, through fascinating examples of natural phenomena. The authors call it a coffee-table book and the beautiful illustrations certainly make it delightful to browse. Some parts are light and very accessible even to the general reader, while others require scientific background and inclination to fully appreciate. I would hesitate to call it truly popular science, as the authors don't shy away from writing down nuclear reactions or Feynman diagrams, and they invoke a zoo of subatomic particles — enough to intimidate even scientists.

The writing style is factual and a bit dry, reminiscent of a traditional university lecture, but one can feel the authors' touch in the selection of examples and in the few humorous remarks that lighten the text. The very format reminds one of a textbook — for instance, the colour-coded examples of decay times of various chemical elements and subatomic particles, orbital and rotational periods, times in the history of the Universe, distances travelled by light, or periodical signals and vibrations.

The first part of the book starts from one second — a heartbeat — going to 10^{32} seconds and the unimaginably long timescales on which planets and galaxies would have long broken apart and faded beyond the observable horizon and protons would have decayed. The second part begins with the unimaginably short Planck time (10^{-44} seconds) before making its way back to one second. *Time in Powers of Ten* can then be read in any direction or one can randomly jump from chapter to chapter.

The book is rich in examples from nuclear and particle physics: half-lives of different isotopes and subatomic particles. I would perhaps have liked more examples from other areas, especially of ultrafast phenomena; but the authors promise a future fleshier version of the book, to which I will be looking forward to. And overall, the authors have compiled a refreshing mix of historical anecdotes and examples from music to sport and biology to astronomy to lighten up the heavier taste of particle physics and cosmology. I am quite sure that anyone, physicist or layperson, could open the book at a random page and find some interesting fact that he or she was not aware of. And I admit that after reading the book, I felt quite tempted to think about my life in powers of ten: my daily tube commute takes $2 \times 10^3 \pm \varepsilon$ seconds (delays can be quite significant), my lunch break is 0.36×10^4 seconds, my son was born 7.8×10^6 seconds ago, and I have ~10^9 seconds until retirement. And by the way, this book review was written in ~2.1×10^4 seconds.

Time in Powers of Ten is both an enjoyable read and very pleasant to browse at leisure. But does it manage to provide a visual image of timescales? To a certain extent it does, although ultrafast phenomena, such as meson decays, and 'dark eternities' much longer than the current age of our Universe still remain unfathomable. This is hardly surprising, as these phenomena are at the borders of what physical theories can describe today. However, the authors' aim is to show that "the variety of time is much richer than distance" and to provide a glimpse of the fascinating diversity of our Universe. Indeed, *Time in Powers of Ten* fully conveys the authors' amazement at — as Feynman put it — our fantastically marvellous universe. ❐

REVIEWED BY IULIA GEORGESCU