AAPT PHYSICS EDUCATION | AMERICAN JOURNAL of PHYSICS

Everywhere and Everywhen: Adventures in Physics and Philosophy

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Citation: American Journal of Physics **78**, 1071 (2010); doi: 10.1119/1.3463781
View online: http://dx.doi.org/10.1119/1.3463781
View Table of Contents: http://scitation.aip.org/content/aapt/journal/ajp/78/10?ver=pdfcov
Published by the American Association of Physics Teachers

BOOK REVIEWS

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Everywhere and Everywhen: Adventures in Physics and Philosophy. Nick Huggett. 217 pp. Oxford U. P., New York, 2010. Price: $24.95 (paper) ISBN 978-0-19-537950-1. (Katherine Brading, Reviewer.)

Nick Huggett is professor of philosophy at the University of Illinois at Chicago. He specializes in philosophy of physics and philosophy of science, and his research has focused on space from ancient philosophy through to contemporary physics. *Everywhere and Everywhen* is aimed at a general audience, including physicists and philosophers, and shows by means of examples how physics and philosophy have been, and continue to be, in fruitful dialog. It is suitable as an entry-level textbook in philosophy of physics.

The book is about space and time, and is a journey through conceptual puzzles and challenges posed, clarified, unraveled, and—frequently—as yet unsolved by contemporary philosophers and physicists. Could the universe have an edge? How could time travel be possible? How many dimensions does space have? What do Einstein's theories of relativity mean for our concepts of space and time? Could we be wrong in thinking that time goes by? When something moves, does that mean that it moves in relation to something else? If not, what *is* motion? These, and many more, questions are addressed by appeal to contemporary physics and philosophy. Some of the puzzles date back at least to the ancient Greeks, and some are the product of our present-day theories. All are live issues.

Huggett invites the reader to participate actively in thinking through such questions. Here are some examples. In Chapter 4, we are led to wonder whether space goes on for ever, or has an edge, or what. Aristotle thought that the universe is finite in size and spherical in shape, so space has an edge. Arguments against an edge predate even Aristotle. If I came to the edge, why couldn't I poke my hand through? What would happen if I tried? Huggett takes us through conceptual twists and turns, helping us see what it might mean in physical theory for space to have an edge, and ending the chapter with ways in which space might not go on for ever while also *not* having an edge. A particularly intriguing example from contemporary physics suggests that space is a dodecahedron in which pairs of faces are related in such a way that if you tried to leave through one face, you would enter instantaneously through its pair.

Chapter 8 tackles the question of whether we can do experiments to determine the geometry of space. In order to measure the shape of space, we have to use physical objects such as measuring rods and light beams. For example, we can take three beams of light and use them to form a three-sided figure, and we can then measure the internal angles and determine whether or not they sum to 180°. Suppose that they don't. This could be either because space is curved and the light beams are taking the shortest paths in that curved space, or because we have a flat space in which light beams don't take the shortest paths (the straight lines). How do we decide which of these is correct? At the turn of the 20th century, Henri Poincaré claimed that there is always some freedom that cannot be eliminated empirically: we have to make a choice. In short, whether space is curved is *not* a matter of experimental fact, but a matter of convention (or definition). Another surprise was just around the corner: with the advent of Einstein's general theory of relativity a few years later (in 1915), we discovered a theory where the relationship between matter and geometry is different; in this theory the physical geometry is not fixed by convention, but by the way that matter is distributed in space. And generally, in this theory, space will be curved. So now if we want to keep flat space (or some particular choice of geometry), we will have to add new kinds of matter that will make our chosen geometry compatible (according to Einstein's equations) with the matter distribution. The lesson to take away from this, Huggett argues, is that conventions hide in physics in unexpected places, and where they hide changes as physics progresses: we have to be on the lookout for them—there's no point in trying to do an experiment to test a definition.

This theme continues in the chapters on time. Given Einstein's special theory of relativity, we can measure how fast something travels on a round-trip journey (going off, turning around, and coming back to the starting point), but one-way speeds are a matter of convention: how long it takes light to travel from a source to a detector some distance away (and therefore how fast light travels) is not something we can test by experiment (we can check only how long light takes to make the round-trip journey back to the source). This is the heart of conventionality of simultaneity: whether or not two events happening at different places happen *at the same time* is—astonishingly—a matter of convention. This is not a limit on what we can measure in practice; it is a feature of the structure of special relativity: for spatially separated events, simultaneity is not testable, even in principle, it is fixed by definition. Huggett discusses some implications of this for our theories of time and space, and for our concepts of ourselves—of what and who we are.

One final, very brief, example: Chapter 12 opens with the question "What is time travel?" Making use of the "block universe," explained in an earlier chapter, we think about what would count as time travel by constructing a "time portal" in the block universe. We then investigate what problems might arise (such as what would happen if I entered the portal and traveled back in time to prevent myself from entering the portal) and how to think these through both logically and in the context of current physical theory.

If such questions intrigue you, then you should read this book. The material is not for the faint-hearted (the questions

are genuinely hard, and the resources brought to bear from physics and philosophy are sophisticated) but if you have been looking for a door in, then this is one you should try. Huggett's writing style is clear and accessible, the examples are plentiful and helpful, and the overall narrative structure of the book is successful, with each chapter leading into the next. Chapters 17 and 18 lie outside this overall narrative: they concern particle statistics rather than space and time, this being Huggett's other main area of research interest. There are nineteen chapters in all, each (except the concluding chapter) focused around its own central question. The text is not cluttered with bibliographical references; each chapter ends with a brief and well-chosen selection of recommended further reading.

Huggett wrote this book so that his family, friends, new acquaintances, and especially physicists and philosophers (indeed anyone willing to make a genuine intellectual investment) could understand something about what he does, as a philosopher of physics. So I asked his dad, "Did Nick succeed?," and here's what his dad said: "He's managed to reveal some of the complexities (and paradoxes) of physics and has shown how philosophical approaches can help inform the conceptual thought that underpins the science today in a language that is easy to read, with examples, and even pictures, to help us understand. I'd certainly recommend this to my friends." The short answer is, I think, yes, Nick has succeeded.

Among the details there are, of course, things I don't agree with and things I don't like, but what's important is that this book introduces philosophy of physics in such a manner that a general audience can engage critically with the issues. And not only do we engage with the questions, we also engage with the author. Huggett makes his own views clear, providing us with someone to argue with. I think this works very well pedagogically.

In addition to Huggett's target audience, this book is suitable as a resource for teaching philosophy of space and time at both undergraduate and (with appropriate supplements) beginning graduate student level. I will use it.

Katherine Brading is Associate Professor of Philosophy at the University of Notre Dame. She does research in philosophy of physics and philosophy of science.

BOOKS RECEIVED

Elasticity and Geometry: From Hair Curls to the Nonlinear Response of Shells. Basile Audoly and Yves Pomeau. 596 pp. Oxford U. P., New York, 2010. Price: $129.50 (hardcover) ISBN 978-0-19-850625-6.

Energy, the Subtle Concept: The Discovery of Feynman's Blocks from Leibniz to Einstein. Jennifer Coopersmith. 414 pp. Oxford U. P., New York, 2010. Price: $55.00 (hardcover) ISBN 978-0-19-954650-3.

Exoplanet Atmospheres: Physical Processes. Sara Seager. 255 pp. Princeton U. P., New Jersey, 2010. Price: $45.00 (paper) ISBN 978-0-691-14645-4.

How Did the First Stars and Galaxies Form? Abraham Loeb. 206 pp. Princeton U. P., New Jersey, 2010. Price: $24.95 (paper) ISBN 978-0-691-14516-7.

Lawless Universe: Science and the Hunt for Reality. Joe Rosen. 196 pp. The Johns Hopkins U. P., Baltimore, MD, 2010. Price: $30.00 (paper) ISBN 978-0-8018-9581-4.

Many Worlds? Everett, Realism, and Quantum Mechanics. Simon Saunders, Jon Barrett, Adrian Kent, and David Wallace (editors). 634 pp. Oxford U. P., New York, 2010. Price: $99.00 (hardcover) ISBN 978-0-19-956056-1.

Micro/Nano Technology Systems for Biomedical Application: Microfluids, Optics, and Surface Chemistry. Chih-Ming Ho (editor). 470 pp. Oxford U. P., New York, 2010. Price: $125.00 (hardcover) ISBN 978-0-19-921969-8.

Nonlinear and Quantum Optics: Using the Density Matrix. Stephen C. Rand. 328 pp. Oxford U. P., New York, 2010. Price: $75.00 (hardcover) ISBN 978-0-19-957487-2.

Nucleus and Nation: Scientists, International Networks, and Power in India. Robert S. Anderson. 703 pp. The U. of Chicago Press, 2010. Price: $60.00 (cloth) ISBN 978-0-226-01975-8.

Physics of the Piano. Nicholas J. Giordano, Sr. 181 pp. Oxford U. P., New York, 2010. Price: $59.95 (hardcover) ISBN 978-0-19-954602-2.

Remembering Einstein: Lectures on Physics and Astrophysics. B.V. Sreekantan (editor). 154 pp. Oxford U. P., New York, 2010. Price: $35.00 (hard cover) ISBN 978-0-19-806449-7.

Why Beliefs Matter: Reflections on the Nature of Science. E. Brian Davies. 260 pp. Oxford U. P., New York, 2010. Price: $45.00 (hardcover) ISBN 978-0-19-958620-2.

Why Does $E=mc^2$? (And Why Should We Care?) Brian Cox and Jeff Forshaw. 262 pp. Da Capo Press, Cambridge, MA, 2010. Price: $15.95 (paper) ISBN 978-0-306-81876-9.