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BOOK REVIEW

A journey surveying the land of space, time and motion

Nick Huggett: Everywhere and everywhen: Adventures in physics and philosophy. New York: Oxford University Press, 2010, 234pp, £15.99 PB

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"Time", Berlioz wrote, "is a great teacher, but unfortunately it kills all its pupils." Not only has time taught a great many (and killed all), but it has also spawned many great teachers of time—and of space. In fact, thinking about space and time has driven important parts of philosophy since antiquity and continues to be at the forefront of advances in fundamental physics. This has naturally led to many authors attempting to convey either the physics of space and time or their philosophical reflection to the interested non-specialist. Not few of them, however, wreck their ships navigating the narrow passage between oversimplification and inaccessibility. Others navigate this passage successfully, yet focus exclusively on either the physical or the philosophical aspects and often fail to acknowledge—let alone mine—the fruitful interaction between them. In the book under review, Nick Huggett invites us on a journey surveying the land of space, time and motion. What a delight then, when I found that not only does he steer clear of the treacherous shallows of oversimplification and the inscrutable abysses of inaccessibility but that he also masterfully weaves together the philosophical with the physical thread and forcefully shows how they cross-fertilize. This weaving mostly occurs at the end of each chapter when Huggett explains how the material in the corresponding chapter illustrates the fruitful interaction between physics and philosophy and thus offers a lesson worth reminding of also the specialists.

The first chapter starts out from the 'paradox of change', i.e. the issue of whether or not a thing can change over time yet remain that same one thing that undergoes the change. For there to be change at all, it seems as if a thing must be the same and different: if it were not different, it would not have changed, yet if it were not the same, it would be impossible to say that it is *this* thing that changed. Apart from a historical excursus on how Aristotle, Descartes and Newton conceived of change and a very brief introduction to spacetime, this chapter offers a powerful and

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well-chosen illustration of central concepts in the foundations of physics: John Conway's 'Game of Life' or simply *Life*. In *Life*, the world is imagined to be a two-dimensional grid of cells that are either 'alive' or 'dead'. The *state* of the system is then completely given by a determination for each cell of whether it is alive or dead. The system's change over (discrete) time is determined by a set of simple dynamical rules, which specify for each cell whether it will be alive in the next step as a function of the state of its neighbouring cells. Thus, these dynamical rules give the *dynamical laws* of the theory. By giving a complete description of the properties of a physical system in space over time, *Life* gives a simple but evocative example of a theory and the role laws of nature play in it.

In the following two chapters, Huggett compellingly uses Zeno's paradoxes and related 'supertasks'—i.e. attempts to perform an infinity of tasks in a finite amount of time—to exemplify how physics and philosophy mutually carry one another forward. On the one hand, advances in physics (and mathematics) often compel us to reconsider our views in philosophy, as evidenced by how physical theories of motion and the mathematical theory of calculus render some of our philosophical ideas concerning motion and infinity obsolete. On the other hand, the careful analysis of foundational concepts—the stock-in-trade of philosophers—sheds light on physical theories and sometimes engenders profound scientific revolutions, as was the case (and as is further discussed in §9.5) when Descartes, Newton and others revisited the basic notions of time and motion as conceptualized by the ancient Greeks and their mediaeval followers.

The next six chapters deal with space. More specifically, they discuss the topology, curvature, dimensionality and very nature of physical space. In them, Huggett light footedly, but authoritatively, explains why space does not have an edge, why space appears to have exactly three dimensions, what would constitute evidence for higher dimensions, why intelligent life seems to require at least three dimensions, how one ought to think about the geometry of space and whether we can *know* the true geometry of space or whether we must accept an ineliminable element of convention. The material on this so-called thesis of the conventionality of the geometry of physical space is masterfully displayed—which makes it most unfortunate that in the potentially very helpful Figure 8.2 the lines are not visible (at least not in my copy). (Figures 12.3— invisible arrowheads—and 18.1—confusing typos—are marred with similar problems. I certainly hope that this, and similar, deficiencies in layout and typography will be corrected in a second edition.) Huggett further offers a much needed antidote to, or at least some perspective for, recent writings about 'anthropic reasoning' by some prominent physicists. The last of these six chapters on space concerns the nature of space and addresses the debate between substantivalists like Newton who believe that space is prior to matter, which moves in that space, on the one hand, and relationalists like Descartes and Leibniz who deny that space is a physical substance prior to, and independently of, the matter it contains, on the other.

Next are six chapters (Chapters 10 through 15) dealing with the philosophy and the physics of time, structured into three groups of two chapters each on time, time travel and time and spacetime in relativity theory. The first chapters essentially concern the metaphysical debate between presentism (or, as Huggett calls it,

'nowism') asserting that only present objects exist and the block view rejecting the fundamentality of any distinction between past, present and future. The block view is typically motivated by the conviction that it reflects more accurately the reconceptualisations of time necessitated by modern physics, in particular by relativity. Presentism is usually driven by a desire to metaphysically undergird the fact that verbs in natural languages are tensed and the attendant commonly held beliefs that time 'flows' and that the present occupies a special position or role in that flow. The block view denies that the phenomenology of temporality, which grounds much of presentism, requires the stipulation of a metaphysics at odds with our currently best physics. This denial, as Huggett emphasises, implies that an advocate of the block view must show how our experiences can be so vividly animated even when the world is, at its ontological ground level, nothing but an eternally unchanging four-dimensional block. Huggett takes on this explanatory task and convincingly sketches the outlines of such a blockist account of the phenomenology of temporality.

Is time travel possible according to our best physical theories? A surprisingly affirmative answer is given by general relativity, which permits time travel into both the future and the past. Since time travel into the past threatens to create paradoxical situations such as that when a time traveller kills her earlier self, the question arises whether theories permitting time travel such as general relativity make sense at all. General relativity and theories similarly permissive of time travel are safe if there are consistency constraints in place, i.e. constraints that ensure that no paradoxical scenarios become actualized. Huggett argues—effectively and very accessibly—that these constraints are written into the precise physical state of the time travellers. Moreover, they seem to restrict, for example, the sort of actions that can be performed by human agents in universes with time-travel portals in their future, which leads directly to considerations concerning the compatibility of free will with theories permitting time travel. While I agree with Huggett that indeterministic theories are hardly compatible with free will, I would insist that the argument he produces in §13.4 does not establish the compatibility of determinism with free will, but only that with an *illusion* of free will.

After a fairly standard review of the main issues in special relativity in Chapter 14, Chapter 15 turns to a presentation of the notorious twin paradox and some features of time in general relativity. Unfortunately, this chapter contains some subtle misrepresentations. As a first concern, it seems to assert that the *cause* of the difference in duration as measured by the two twins' watches is the fact that the travelling twin moved non-inertially, while the one remaining on earth moved (approximately) inertially. But this is not quite right. First, the proper time along different paths between two fixed points in Minkowski spacetime generally also differs between two non-inertial paths. Second, for an inertial path between any two timelike related events in Minkowski spacetime, there are piecewise inertial paths with shorter proper time than that of the original inertial path. So we could have two inertially moving spacecrafts, one being launched from earth and moving to meet in outer space the other that will later arrive on earth. Suppose these spacecrafts only exchange some information as they pass one another (e.g. a count of how many ticks their clock counted since departure). The combined number of seconds as measured

along the two inertial legs of space travel (first leaving earth and then returning to it) is smaller than that as measured by an identical clock on earth. To be sure, this complaint could be pushed back by rejecting this purely geometrical explanation of the twin paradox in favour of a 'dynamical' explanation of the kind recently advocated by Harvey Brown.

A second misgiving I have is that the chapter promulgates the inaccurate statement that a general relativistic spacetime "looks flat in small enough regions" around any point. This is not true in general, at least not if the flatness is measured by the scalar curvature. This curvature typically does not vanish, even in arbitrarily small neighbourhoods. The quoted statement is true, however, if flatness is interpreted to mean a 'flat' covariant derivative. This is a rather subtle point—too subtle perhaps for an expressly accessible book—but it is illustrative of my impression that this chapter does not quite live up to the very high standard set by the rest of the book.

The final part of the book consists of three chapters on handedness and quantum statistics, followed by a brief concluding chapter. While the chapter on handedness adds an authoritative discussion of a sometimes neglected aspect of space—and an intriguing discussion of the brain-teaser that a mirror reflects right-left, but not up-down—I could not help the impression that the two chapters on the (in)distinguishability of quantum particles and their statistics—in spite of their excellence—are somehow grafted onto an otherwise cohesive book dealing with philosophical and physical aspects of space and time. Surely, they will find an interested readership, but their connection to the rest of the book is less than obvious.

The book offers engaging, but short and easily digestible chapters—perfect for the interested non-specialists who can get their daily fix without incurring any risk of overdose. It is well written and so eminently quaffable that to refrain from starting the next chapter becomes an exercise in will power. I am not sure to what extent the book would lend itself as a textbook to be used in an introductory course at the university level as the chapters may simply not contain enough material for one lecture and would thus have to be supplemented.

In conclusion, Huggett states that his goal was not to pull results out of a magic hat, but rather to explain concepts and methods used in the intersection of physics and philosophy. In this, he fully succeeds. The resulting book elevates the art of making highly abstract ideas accessible, of motivating and explicating them and of showing how they lend themselves to an enriching adventure in physics and philosophy (as the book's subtitle promises) to a new level. I warmly recommend it.