

move forward even when the task at hand is daunting or scary.” The authors urge readers to have the courage to investigate who they are and why they do things the way they do them. Then Snieder and Schneider suggest ways to overcome feelings of being stuck, blocked, or stalled. Chapter 7 focuses on integrity, which the authors define as having all the elements of one’s life working together. We are all integrated beings who think, speak, and act at home and at work. How well have we integrated our personality with the different aspects of our lives? The authors believe strongly in the power of narratives to help make sense of life changes they want to encourage, and they include interviews with people who have had

experience with the concepts under discussion.

A recurring theme in *The Joy of Science* is that scientists often do not recognize that their response to stress frequently causes at least some of their difficulties. One of the book’s most important points, which wasn’t emphasized enough in my view, is that students, postdocs, and faculty feeling under the gun often think that they are alone and that others who usually put up a good front don’t feel such pressures. *The Joy of Science* can convince scientists under stress that they are not alone, and thus it can immediately begin to achieve its goal.

Gordon Kane

*University of Michigan
Ann Arbor*

Effective Spacetime

Understanding Emergence in Effective Field Theory and Quantum Gravity

Karen Crowther

Springer, 2016. \$109.00 (205 pp.). ISBN 978-3-319-39506-7



Over the past few years, “emergence” has become an increasingly popular buzzword in physics. The term captures something important. In condensed-matter physics, for example, objects that are not fundamental entities, such as phonons, rotons, and Cooper pairs, still give the “right” higher-level descriptions. But as soon as we move away from the obvious cases, the notion of emergence is exasperatingly fuzzy. Is thermodynamics emergent from statistical mechanics? Is classical physics emergent from quantum mechanics? If phonons are emergent, are protons or, for that matter, photons? Particularly in an area like quantum gravity, where we have no well-established theory to start with, discussions can quickly become frustrating.

Karen Crowther is a philosopher at the University of Geneva. Philosophers are good at clarifying fuzzy concepts, so one might hope that her new book *Effective Spacetime: Understanding Emergence in Effective Field Theory and Quantum Gravity* might offer some clarity. Sadly, part of Crowther’s conclusion seems to be that emergence is as fuzzy in philoso-

phy as in physics—“a vast and thorny thicket,” as she puts it. But the philosophers’ discussions that Crowther details in her book offer some interesting new insights into how physicists might think about the question.

This book, definitely written for philosophers, would not be an appropriate place to learn about quantum gravity. Rather than attempt to survey the field, Crowther has picked out a few particular research programs, some popular and some obscure, to illustrate her points. String theory is almost entirely missing, but a quarter of a chapter is devoted to an idiosyncratic approach called “quantum causal histories” that has inspired perhaps 20 papers in 17 years.

Physicists will be frustrated by misstatements and misunderstandings. For instance, in an early discussion of quantum mechanics, Crowther writes that “a system described by any initial state will naturally evolve into a superposition,” a statement that means about as much as “any number can naturally be written as the sum of other numbers.” Readers in general will be frustrated by the frequent typos: Examples include recurring refer-

ences to “p. xxx” with no page numbers inserted and “1032” for 10^{32} .

The acknowledgments thank several philosophers, many of them with some expertise in physics, but I can’t help but think the book would have been better if the author had spent more time talking to physicists actually working on quantum gravity; they might have warned against drawing broad conclusions from what is very much a work in progress. And of course the book is already out of date, as any book on quantum gravity will inevitably be. In particular, Crowther just missed one of the most fascinating cases of emergence in quantum gravity, the early indications that spacetime could emerge from quantum entanglement.

But a physicist who is willing to put up with some frustration (“No! That’s not what a Gaussian fixed point means!”) may find some interesting ways to look at the universe. I was especially taken by Crowther’s emphasis on “autonomy,” the independence of emergent low-energy theories from details of the high-energy degrees of freedom. As Crowther stresses, that autonomy is familiar both from effective field theory, in which the high-energy degrees of freedom merely renormalize low-energy coupling constants, and from second-order phase transitions, for which theories with vastly different fundamental degrees of freedom can lie in the same universality class. She rightly warns researchers in quantum gravity that there may be many different “quantum theories of gravity” with the same low-energy limits.

I also enjoyed discussions of the subtle relationship between emergence and reduction, whether “not predictable in principle” is really very different from “not predictable in practice,” and the role of “higher organizing principles” such as patterns of symmetry breaking.

For a reader who wants to learn about quantum gravity, or even about the emergence of spacetime in particular approaches to quantum gravity, I can’t recommend *Effective Spacetime*. But for a physicist who would like to see intriguingly different perspectives on some of the important abstract questions we deal with in quantum gravity, it’s an interesting read.

Steven Carlip

University of California, Davis