AUTUMN BOOKS

THEORETICAL PHYSICS

Windows on the weird

Robert P. Crease weighs up a theoretical-physics study that cracks open a strange vista.

Can you explain loop quantum gravity to people who know next to nothing about physics? Carlo Rovelli's *Reality Is Not What It Seems* shows that you can. Following the physicist's acclaimed *Seven Brief Lessons on Physics* (Allen Lane, 2015; R. P. Crease *Nature* **526,** 37–38; 2015), this book invites the reader to see "through the window" into the beautiful and surprising world of contemporary theoretical physics. Its only drawback is an annoying and unnecessary presumption, announced by the title, that suggests that the view out of the window is into reality itself.

In most respects, this book is a model of popular science writing. The first half provides a select series of vistas on early thinkers and their ideas, to prepare the ground for the adventure of the second half. Rovelli evokes classical Greek philosophers Aristotle and Democritus to familiarize us with the question of whether, at base, the natural world is continuous and smoothly varying, like a beach seen from afar, or grainy, like a beach seen close up — that is, with no arbitrarily small amount of matter. Isaac Newton's seventeenth-century vista shows us reality as an infinite space in which time passes and particles push each other about with mathematically describable forces, such as his laws of motion and universal gravitation. Michael Faraday and James Clerk Maxwell contribute two new things:

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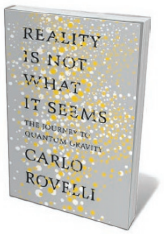

Reality Is Not What It Seems
CARLO ROVELLI
Allen Lane: 2016.

electromagnetism, which fuses electricity and magnetism into a single thing, and the idea of a field, or something suffused throughout space that acts and is acted on by electric and magnetic particles.

In the twentieth century, the entire landscape changes. Quantum mechanics fuses particles and fields, makes them indeterminate and implies that things exist only when interacting with other things. Einstein fuses space and time into space-time, then treats Newton's space as nothing more than the gravitational field itself. This effectively 'curves' space, making the world finite but without boundaries. Such a space can be described either 'from without' as a mathematical representation, or 'from within', as what a putative person on horseback, say, would encounter when travelling through it. It turns out, Rovelli shows, that such a rider, journeying in a straight line, would end up back at the point of departure, thereby traversing a loop. That provides a key image for what is to follow.

But the views through the relativity and quantum windows differ. The world of the former is curved, precise and continuous; of the latter, Euclidean, indeterminate and discrete, with no arbitrarily small amounts of matter or energy. This tension outlines the problem of twenty-first-century theoretical physics. Numerous popular-science books have covered the journey thus far, but here — about halfway through — Rovelli's becomes unique. From this point on, he aims to provide "live coverage of the ongoing research" on the particular strategy that he and his colleagues are adopting in the ambitious quest to unite relativity and quantum mechanics.

The quest was launched by the Wheeler–DeWitt equation, which describes space at small scales as having something like the frothiness of quantum fields, with no arbitrarily small amounts of space. The economy and care with which Rovelli has prepared the reader now pays off, as he uses the vistas presented in the first half of the book to assemble a portrait of loop quantum gravity. Faraday and Maxwell's description of electric force in terms of lines that close or loop around resembles how the Wheeler–DeWitt equation describes gravitation. But whereas electromagnetic lines are infinitely fine and continuous, the gravitational lines of the Wheeler–DeWitt equation are quantized — patchy and distinct like a spiderweb. Finally, Einstein used gravitation to structure space in a similar way to how the Wheeler–DeWitt equation uses loops. In a nutshell: loop quantum gravity is Faraday's lines plus the granularity of quantum theory plus Einstein's idea that these lines are the structure of space. For good measure, Rovelli includes a picture of a T-shirt emblazoned with the basic equation of quantum loop gravity.

Other quests have the same goal. String theorists, for instance, have embarked on a different path to unite gravitation and quantum mechanics. In favouring quantum loop gravity, Rovelli is conservative: he is not relying on radically new ideas. Yet his approach has radical consequences, on which he spends the rest of the book elaborating. Space is granular (with no arbitrarily small volume); time does not exist (there's no variable for it in the Wheeler–DeWitt equation); and the basic stuff of the world consists of special kinds of quantum field. What we see through the window is utterly unlike our conventional world. No problem! This, he writes, is simply because we humans are like moles living underground to whom someone describes the Himalayas. Or like the people in Plato's cave, whose imaginations are chained by prejudice, ignorance and our senses, and who can view only shadowy representations of the real. Rovelli confidently puts reality on the other side of the window from the "parochial experience" in which we ordinary humans live and work.

SPACE IS GRANULAR; TIME DOES NOT EXIST; AND THE BASIC STUFF OF THE WORLD CONSISTS OF SPECIAL KINDS OF QUANTUM FIELD.

A sceptic might react to this irksome scientism by objecting that, unlike in Plato's image, the vistas seen through the window keep changing. One can imagine, too, a book by a string theorist offering another view out of the window — just how many exits does Plato's cave have? Yet another problem is that Rovelli has a cavalier attitude towards philosophy. Plato's cave is more nuanced than he makes out, and Rovelli misinterprets a passage to claim that Socrates was disappointed by scientists. He plucks a statement out of context from a lengthy autobiographical story in which Socrates is describing youthful views from which he has since moved on (Rovelli also misquotes the translation).

Philosophers tend to have a more existential take on 'reality', not restricting it to what scientists represent but seeing it as also encompassing something of what the moles and horsemen encounter. The regrettable thing is that the scientism in this otherwise fine work is unnecessary, although I know it helps to sell books and cement the prestige of science. That's just today's reality. ■

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