***NATURE* | AUTUMN BOOKS**

Theoretical physics: Windows on the weird

Robert P. Crease

Nature **538**, 32–33 (06 October 2016) doi:10.1038/538032a
Published online 05 October 2016

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

Print

Reality Is Not What It Seems

Carlo Rovelli *Allen Lane*: 2016.
ISBN: 9780735213920

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Illustration by Eoin Ryan

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: 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.

“Space is granular; time does not exist; and the basic stuff of the world consists of special kinds of quantum field.”

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.

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.

Author information

Affiliations

Robert P. Crease is a professor in the Department of Philosophy at Stony Brook University, New York.

Corresponding author

Correspondence to: Robert P. Crease

Comments

2016-10-05 04:11 AM

Pentcho Valev said: "Einstein fuses space and time into space-time"

Nowadays most theoreticians repudiate Einstein's spacetime:

Nobel Laureate David Gross observed, "Everyone in string theory is convinced...that spacetime is doomed. But we don't know what it's replaced by." https://www.edge.org/response-detail/26563

What scientific idea is ready for retirement? Steve Giddings: "Spacetime. Physics has always been regarded as playing out on an underlying stage of space and time. Special relativity joined these into spacetime... [...] The apparent need to retire classical spacetime as a fundamental concept is profound..." https://edge.org/response-detail/25477

"Spacetime is any mathematical model used in physics to explain physical phenomenas of the universe by combining space and time in one continuum. [...] Arkani-Hamed said."Because of the existence of gravity and quantum mechanics, we believe that the concept of spacetime is doomed and there are many simple thought experiments that tell us that space time is doomed." http://www.thebatt.com/science-technology/leading-princeton-physicist-nima-arkani-hamed-visits-aggieland/article_a661bb68-8395-11e6-97dd-0f73aa345281.html

Since the consequence, spacetime, is "doomed", the undelying premise, Einstein's 1905 constant-speed-of-light postulate, is false. The combination "wrong consequence, true premise" is forbidden by logic:

"Special relativity is based on the observation that the speed of light is always the same, independently of who measures it, or how fast the source of the light is moving with respect to the observer. Einstein demonstrated that as an immediate consequence, space and time can no longer be independent, but should rather be considered a new joint entity called "spacetime." http://community.bowdoin.edu/news/2015/04/professor-baumgarte-describes-100-years-of-gravity/

Pentcho Valev

2016-10-05 07:36 AM

Pentcho Valev said: Any correct interpretation of the Doppler effect contains the information that the speed of light is not a constant:

https://en.wikipedia.org/wiki/Relativistic_Doppler_effect "Assume the observer and the source are moving away from each other with a relative velocity v (v is negative if the observer and the source are moving towards each other). Considering the problem in the reference frame of the source, suppose one wavefront arrives at the observer. The next wavefront is then at a distance ?=c/fs away from the observer (where ? is the wavelength, fs is the frequency of the wave the source emitted, and c is the speed of light)."

The observer measures the frequency to be

fo = fs(1 – v/c),

and the speed of the light relative to the observer is, accordingly,

c' = ?.fo = c – v,

in violation of Einstein's relativity.

It is easy to see that the "relativistic time dilation" introduced in the Wikipedia article does not change the fatal conclusion that the speed of the light relative to the observer is different from the speed of the light relative to the source.

Pentcho Valev

2016-10-06 01:05 AM

Pentcho Valev said: Einsteinians explain why slowing the speed of light in a vacuum is not dangerous for Einstein's relativity. The speed of light was slowed down but "this doesn't mean they actually changed the speed of light":

"Last year, a team led by the University of Glasgow in Scotland took the first step and successfully managed to slow light down in a vacuum. They did this by sending photons through a 'mask', which altered the physical form the photons and slowed down their journey. And now a team from the University of Philippines' National Institute of Physics has taken things even further and demonstrated a new way that light can be 'slowed down', simply by changing the way it twists around itself. [...] As we mentioned before, this doesn't mean they actually changed the speed of light - they simply altered its path so it took a longer time to get where it's going. But the potential applications are just as exciting." http://www.sciencealert.com/physicists-have-found-a-way-to-slow-light-down-by-twisting-it

In Einstein schizophrenic world arguments of this kind – the speed of light changes but actually it does not change – are highly valued. Without them, Einstein's "theory" would have been long forgotten.

Pentcho Valev

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Nature ISSN 0028-0836 EISSN 1476-4687

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