striking these days how everybody becomes thinner", and Leipzig, where newspapers carry obituaries of young people dying. "I myself am often so sad and downcast," he writes to Li, "without you I would not quite be able to cope". Food is scarce; Werner preserves cherries from his Berlin garden. His work, directing research on nuclear fission, "makes no sense".

In 1945, between air raids, Werner advises Li that as the front moves closer to southern Germany, she should watch for attack planes and the children should practise throwing themselves to the ground near a wall. Li makes her own yeast and worries about getting enough flour for bread. They tell each other that they are thinner and more exhausted. "Love," he writes, "stay well and prepare for the more difficult times."

Near the war's end, Heisenberg and other German nuclear scientists are arrested by the Allies. They are held for six months in England; few letters are allowed. For lack of food, Li puts two of the children into a home. She cares for Heisenberg's dying mother and cuts their firewood. He's released in January 1946. "I want to build a containing wall around you from all the love I have in my heart," writes Li. The letters end that June, with the family reunited and living in Göttingen; in 1950, they have a seventh child.

Hirsch-Heisenberg writes that the letters were chosen and edited for relevance and concision. We cannot know what other filters, if any, children apply to the publication of their parents' letters. Hirsch-Heisenberg gives no sources, but makes the case that her father's motives for working on a German atomic bomb were to control atomic research and to convert it to peaceful uses, but that building an actual bomb was "out of the question". Judging from these letters, Heisenberg was doing what it took to wait out the dreadful storm so that he could get on with his life with physics and Li. ■

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THEORETICAL PHYSICS

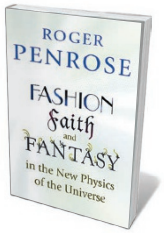
The emperor's new physics

Richard Dawid examines a critique of quantum mechanics, string theory and inflationary cosmology.

The eminent theoretical physicist Roger Penrose is worried about the current path of physical research. In *Fashion, Faith, and Fantasy in the New Physics of the Universe*, he argues that the eponymous triad of trends has become overly powerful in contemporary fundamental physics. This core message is delivered in language that demands some mathematical sophistication of the reader. Penrose also discusses some of his own ideas, such as twistor theory — his take on a synthesis of quantum theory and general relativity.

Penrose claims that even well-confirmed theories, such as quantum mechanics, are 'oversold' with respect to their presumptive stability. Quantum physics has had an impressive record of predictive success, ranging from quantum chemistry to elementary particle physics. But it faces a deep conceptual problem. Whereas quantum mechanics has a perfect internal consistency when it describes a system that evolves without being measured, the way in which it represents measurements is not coherently embedded in that description. To Penrose, this indicates that the fundamental principles of quantum mechanics have not yet been found and will rely on the elusive full integration of gravity into quantum physics. He argues that the success of quantum mechanics tends to make physicists insensitive to the theory's conceptual problem and generates an unjustified degree of faith in its basic principles as a solid foundation of physics.

Another source of undue trust in a theory, Penrose asserts, is the physics community's tendency to follow fashion — that is, to settle on one strategy of dealing with a problem before severely testing the theory's empirical predictions. Penrose views string theory (a theory of quantum gravity) as the pre-eminent example.

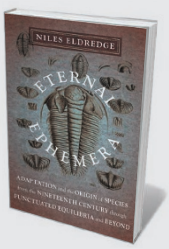


Fashion, Faith, and Fantasy in the New Physics of the Universe
ROGER PENROSE
Princeton University Press: 2016.

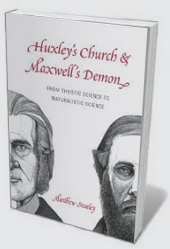
The final trend in Penrose's triad is fantasy — that is, a wildly speculative idea that goes far beyond what is implied by the known data. Penrose assigns that category to inflationary cosmology, which he argues is treated as an established theory despite a lack of evidence.

Of these three, Penrose's discussion of quantum mechanics ('faith') is the most successful. On the basis of an inspired presentation of quantum mechanics, he makes a case that the theory's enormous scientific success does not remove serious doubts about the finality of its basic principles. His discussions of fantasy and fashion, however, are problematic. He paints an exaggerated picture of their role and systematically underrates the merits of the theories he criticizes.

Fashion and fantasy are presented in separate chapters as independent influences that have become too powerful. But, as Penrose acknowledges, fantasy has always been at the root of new theories. Just think about the atomist speculations that led to the kinetic gas theory in the nineteenth century. For Penrose, the trouble arises when fantasy



Eternal Ephemera
Niles Eldredge (Columbia Univ. Press, 2016)
Palaeontologist Niles Eldredge presents an insightful history of evolutionary biology, from transmutation's forefather, Jean-Baptiste Lamarck, comparing fossil molluscs in 1801, to the theory of punctuated equilibria, whereby rapid speciation disrupts periods of stasis.



Huxley's Church & Maxwell's Demon
Matthew Stanley (Univ. Chicago Press, 2016)
The context of Victorian science swung smoothly from the theistic to the naturalistic, shedding supernatural causality along the way. Matthew Stanley attributes the relative amity between Christian and atheist scientists to shared ideals such as intellectual freedom.

is given too much credit before a theory is empirically tested. This occurs, he says, when a theory becomes the subject of fashion. In this light, it is difficult to see the independent role of 'fantasy' in Penrose's argument.

Inflationary cosmology is, moreover, not a good illustration of fantasy, even by Penrose's own account. As he acknowledges, recent precision measurements of the cosmic microwave background agree with typical predictions of inflationary cosmology, so it seems difficult now to call it a mere flight of fancy. Penrose presents his important criticism that inflation generically does not explain the low initial entropy of the Universe (although explanations have been suggested in certain models; see S. M. Carroll and J. Chen. https://arxiv.org/abs/hep-th/0410270; 2004). But he presents the case against inflation in a way that hides the independent significance of problems that can be solved by it, such as explaining the homogeneity and flatness of the observed Universe.

There are similar issues with Penrose's claim that fashion is the main reason for string theory's influential position. His analysis of its problems is not up to the task of debunking proponents' physics-based reasons for confidence. Penrose's main complaint about string theory is that it lacks a clear specification of its number of degrees of freedom. He tries to show this in several contexts. However, he tends to omit information that could make the situation less confusing than he takes it to be. For example, he expresses unease about 'gauge–gravity duality', the claim that string theory is empirically equivalent to a quantum field theory in a lower-dimensional space. (If generally valid, that would mean that a string theory in three extended spatial dimensions was empirically equivalent to a quantum field theory in two spatial dimensions.) Such a claim looks startling, because one would naively expect that a three-dimensional theory has more degrees of freedom than a two-dimensional one. Penrose presents this as one of many questionable implications of string theory.

Curiously, however, he presents his case without mentioning that Gerard 't Hooft, who is cited in the book, provided a general understanding of the reduced number of degrees of freedom in quantum gravity without any reference to string theory, before cases of gauge–gravity duality were conjectured in the context of string theory (G. 't Hooft. https://arxiv.org/abs/gr-qc/9310026; 1993). In this light, by generating examples of gauge–gravity duality, string theory does not, as Penrose maintains, make one more prima facie implausible claim, but opens up perspectives for a more thorough understanding of a characteristic of quantum gravity that had already been suggested.

It is always inspiring to read Penrose's uncompromisingly independent perspective on physics. He seems more at home with developing visionary ideas than with detailed criticism of prevalent theories. Unfortunately, this book offers too few of the former and too much of the latter. ■

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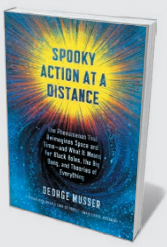
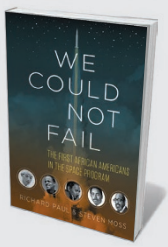


Spooky Action at a Distance
George Musser (Scientific American/Farrar, Straus and Giroux, 2016)
Bending time, space and minds, George Musser investigates nonlocality — two distant particles acting in harmony. With lessons in photon entanglement, particle teleportation and string theory, he ponders how space evolved after the Big Bang.



We Could Not Fail: The First African Americans in the Space Program
Richard Paul and Steven Moss (Texas Univ. Press, 2016)
Profiling NASA's first ten black employees, Richard Paul and Steven Moss show what the space age meant for African Americans. In 1962, NASA granted US$181,000 to a study of the space programme's impact on race relations.