adding, "although quantum cosmology can clarify questions about the universe in unprecedented ways, it does leave modest freedom for the myths."

Bojowald's honesty is to be commended. Of the many valuable lessons we learn in *Once Before Time*, a most relevant one is that physics is an empirical science. As Bojowald himself puts it, "It is important to remember what the aim of science is: to describe Nature; and Nature has her own sense of beauty." In science so far removed from experimental guidance, it is wise to be humble.

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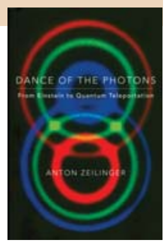
## Dance of the Photons

### From Einstein to Quantum Teleportation

Anton Zeilinger
Farrar, Straus and Giroux, New York, 2010. $26.00 (305 pp.).
ISBN 978-0-374-23966-4




Anton Zeilinger is an unequivocal expert in the field of experimental quantum information, which alone is reason enough for you to read *Dance of the Photons: From Einstein to Quantum Teleportation*. Originally published in German in 2005, *Dance of the Photons* is written from the perspective of an omniscient third party who details the adventures of archetypes Alice and Bob as they explore the fascinating world of entangled quantum particles. Although the book covers many topics, the story of Alice and Bob is a step-by-step description of one of the more important ongoing experiments of our time—testing the violation of Bell's inequality.

Although a popularization, the storyline in *Dance of the Photons*, which is based on experimental quantum physics, won't excite you the way a thriller or romance novel would. The difference, of course, is that this story is based in reality and the others in fantasy. Quantum physics is a factual description of the microscopic world. Or is it? To determine whether a particular view of the world accurately describes reality, one criterion could be to require positive verification based on what can be known to the senses (that is, "measured"). That is what Zeilinger presents in *Dance of the Photons*.

Zeilinger shies away from conflating interpretation and observation, basing the story of Alice and Bob on their measurements of entangled photons. In so doing, he fulfills half of the believability criterion. The other half is a bit more subtle and involves the violation of Bell's inequality.

On a high level, Bell's inequality is the foundation for a test to verify a key component of quantum mechanics, entanglement. If you really want to understand Bell's inequality, you should study quantum physics for a few years and then pour over a measurement chart created by an experimentalist you trust. The second best way is to read Zeilinger's description of entanglement in the appendix, in which he gives a clear description of the key idea without resorting to formal mathematics. Indeed, that section is a must read for everyone studying quantum physics, regardless of their formal training.

The possibility of the conveyance of keen insights into the quantum world is most assuredly facilitated by *Dance of the Photons*. That makes it a force to be reckoned with among quantum physics texts, even if some readers may need to supplement their knowledge to fully appreciate what is contained therein. But for his part, Zeilinger has clearly presented the thought process and pedagogy needed to shift one's perspective from local realism to a more valid way of viewing the world.

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## Complex Webs

### Anticipating the Improbable

Bruce J. West and Paolo Grigolini
Cambridge U. Press, New York, 2011. $75.00 (375 pp.).
ISBN 978-0-521-11366-3


From taking an airplane to how much we earn, many aspects of our daily lives are connected to webs and networks. That idea is stressed by Bruce West and Paolo Grigolini in their eminently readable inquiry, *Complex Webs: Anticipating the Improbable*, in which they note the global pursuit by scientists and engineers to develop the field of network science. Past attempts have met with limited and often disappointing results; those attempts include generalized systems theory, complexity theory, catastrophe theory, and the theory of complex adaptive systems. The present search for a network science differs from past efforts in that the theory is now guided by large empirical data sets.

Recent books highlighting different aspects of network science can be roughly separated into popular works that lay out an integrated scientific view of humans and modern technology; manuals and references focused on specific application areas such as biophysics, econophysics, psychophysics, or sociophysics; and texts that explore advanced networks-related topics that go beyond particular disciplines. *Complex Webs* most closely matches the last (and smallest) category, as it interweaves various topics from statistical physics to support the understanding of complex networks; perhaps in the future those topics will form the foundation of a network science.

*Complex Webs* is mathematically rigorous, data rich, and entertaining. The first two chapters emphasize that hundreds of complex phenomena dominating our lives have statistical properties described by inverse power laws instead of by the normal Gauss distribution. An unpredictable bridge collapse, the bursting of an economic bubble, or the onset of a heart attack—each is part of a different elaborate web. Gaussian statistics cannot predict those phenomena because such events have their roots in the complexity of webs that represent the flow of such commodities as information, finance, food, and transportation.

This web complexity is manifest in time series that have divergent second moments and that are nonstationary, nonergodic, and non-Poisson. How the new perspective influences fields of investigation such as physiology and bioengineering is an interesting story and provides a context for the authors to introduce many of the mathematical ideas used in understanding webs. For example, in their discussion of fractal physiology and like phenomena, the authors introduce fractal geometry and fractal statistics that follow from the scaling behaviors of power laws.

Our ability to predict the operation of inanimate objects but not of living things means that we can understand the devices cluttering up our world but not much about their relationship to us. To model the lack of understanding, in chapter three the authors provide the physicist's rationale for randomness. They discuss the shift in prediction from a single trajectory that solves the equations of motion to an ensemble of such trajectories, whose distribution solves the phase-space equations for the probability density. Thus, a preliminary understanding of nature is expressed in terms of averages, fluctuations, and non-Gaussian distributions.

In chapter four, the authors introduce the mathematical techniques used to describe randomness and chaos, and in chapter five they transition to applications of the fractional calculus. There are two distinct strategies for modeling the dynamics of complex webs: "dynamic" dynamics describing the phenomenon and the evolution of the associated probability density. The authors systematically develop both methods and explain the extension into the fractional calculus to incorporate memory; those methods give rise to fractional stochastic differential equations in the first approach and fractional diffusion equations in the second.

Chapter six contains an all-too-brief review of some contemporary developments in network theory. It reflects the authors' tastes instead of presenting exhaustive coverage of a vast amount of high-quality research from the past decade. The authors tell the familiar story of the progression in our understanding from random networks, to small-world networks, to scale-free networks, and they discuss various measures that allow comparisons of real-world networks to mathematical idealizations.

In chapter seven, the authors discuss recent research findings, including some they themselves have published; they somehow avoid being dogmatic in their presentation. Among the new results described is a generalization of linear response theory clarifying a misconception that appeared in the physics literature a few years ago. The generalization is used to explain how information transfer between complex networks depends on the measures of complexity. It is also used to derive a generalized Onsager principle.

West and Grigolini artfully develop mathematical models for understanding data sets drawn from a variety of venues, and they highlight examples, anecdotes, and historical vignettes that bring the mathematics and its application to life. Consequently, *Complex Webs* presents a distinctive perspective that makes it stand out. I strongly recommend this remarkable book to those interested in learning the mathematical underpinnings of the science of networks and, more importantly, to those thinking of teaching a course in it.

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## new books

### plasmas and fusion

**Electron Cyclotron Emission and Electron Cyclotron Resonance Heating (EC-16).** R. Prater, ed. Proc. wksp., Sanya, China, Apr. 2010. World Scientific, Hackensack, NJ, 2011. $168.00 (409 pp.). ISBN 978-981-4340-26-7, *CD-ROM*

### popularizations

**101 Quantum Questions: What You Need to Know About the World You Can't See.** K. W. Ford. Harvard U. Press, Cambridge, MA, 2011. $24.95 (291 pp.). ISBN 978-0-674-05099-0

**The Blind Spot: Science and the Crisis of Uncertainty.** W. Byers. Princeton U. Press, Princeton, NJ, 2011. $24.95 (208 pp.). ISBN 978-0-691-14684-3

**Crashes, Crises, and Calamities: How We Can Use Science to Read the Early-Warning Signs.** L. Fisher. Basic Books, New York, 2011. $23.99 (233 pp.). ISBN 978-0-465-02102-4

**The New Universe and the Human Future: How a Shared Cosmology Could Transform the World.** N. E. Abrams, J. R. Primack. *The Terry Lectures Series*. Yale U. Press, New Haven, CT, 2011. $28.00 (238 pp.). ISBN 978-0-300-16508-1

**Physics of the Future: How Science Will Shape Human Destiny and Our Daily Lives by the Year 2100.** M. Kaku. Doubleday, New York, 2011. $28.95 (389 pp.). ISBN 978-0-385-53080-4

**Relativity for the Questioning Mind.** D. F. Styer. Johns Hopkins U. Press, Baltimore, MD, 2011. $65.00, $30.00 *paper* (184 pp.). ISBN 978-0-8018-9759-7, ISBN 978-0-8018-9760-3 *paper*

**Seven Tales of the Pendulum.** G. L. Baker. Oxford U. Press, New York, 2011. $44.95 (227 pp.). ISBN 978-0-19-958951-7

**Six Easy Pieces: Essentials of Physics Explained by Its Most Brilliant Teacher.** R. P. Feynman. Basic Books, New York, 2011 [1995, reissued]. $13.99 *paper* (146 pp.). ISBN 978-0-465-02527-5

**Six Not-So-Easy Pieces: Einstein's Relativity, Symmetry, and Space-Time.** R. P. Feynman. Basic Books, New York, 2011 [1997, reissued]. $14.99 *paper* (154 pp.). ISBN 978-0-465-02526-8

**Soft Matter: The Stuff That Dreams Are Made Of.** R. Piazza. Copernicus Books/Springer, New York, 2011. $24.95 *paper* (279 pp.). ISBN 978-94-007-0584-5

**Strange New Worlds: The Search for Alien Planets and Life Beyond Our Solar System.** R. Jayawardhana. Princeton U. Press, Princeton, NJ, 2011. $24.95 (255 pp.). ISBN 978-0-691-14254-8

**Visions of the Multiverse.** S. Manly. New Page Books, Pompton Plains, NJ, 2011. $15.99 *paper* (271 pp.). ISBN 978-1-60163-129-9

**You Are Wrong, Mr. Einstein! Newton, Einstein, Heisenberg and Feynman Discussing Quantum Mechanics.** H. Fritzsch (translated from German by J. Rostant). World Scientific, Hackensack, NJ, 2011. $35.00 (178 pp.). ISBN 978-981-4324-99-1

### quantum physics

**Deep Beauty: Understanding the Quantum World Through Mathematical Innovation.** H. Halvorson, ed. Cambridge U. Press, New York, 2011. $99.00 (472 pp.). ISBN 978-1-107-00570-9

**Heisenberg's Quantum Mechanics.** M. Razavy. World Scientific, Hackensack, NJ, 2011. $120.00, $61.00 *paper* (657 pp.). ISBN 978-981-4304-10-8, ISBN 978-981-4304-11-5 *paper*

**Mathematical Foundations of Quantum Information and Computation and Its Applications to Nano- and Bio-systems.** M. Ohya, I. Volovich. *Theoretical and Mathematical Physics*. Springer, New York, 2011. $169.95 (759 pp.). ISBN 978-94-007-0170-0

**Non-Hermitian Quantum Mechanics.** N. Moiseyev. Cambridge U. Press, New York, 2011. $105.00 (394 pp.). ISBN 978-0-521-88972-8

**Quantum Bio-Informatics IV: From Quantum Information to Bio-Informatics.** L. Accardi, W. Freudenberg, M. Ohya, eds. *QP–PQ: Quantum Probability and White Noise Analysis 28*. World Scientific, Hackensack, NJ, 2011. $190.00 (490 pp.). ISBN 978-981-4343-75-6

**Quantum Field Theory and Its Macroscopic Manifestations: Boson Condensation, Ordered Patterns and Topological Defects.** M. Blasone, G. Vitiello, P. Jizba. Imperial College Press, London, 2011. $150.00 (526 pp.). ISBN 978-1-84816-280-8

### society and government

**Nanotechnology Standards.** V. Murashov, J. Howard. *Nanostructure Science and Technology*. Springer, New York, 2011. $129.00 (260 pp.). ISBN 978-1-4419-7852-3

### space and planetary science

**Drifting on Alien Winds: Exploring the Skies and Weather of Other Worlds.** M. Carroll. Springer, New York, 2011. $39.95 (238 pp.). ISBN 978-1-4419-6916-3

**The Kaguya Lunar Atlas: The Moon in High Resolution.** M. Shirao, C. A. Wood. Springer, New York, 2011. $39.95 (173 pp.). ISBN 978-1-4419-7284-2

### statistical physics and thermodynamics

**Bayesian Inference and Maximum Entropy Methods in Science and Engineering.** A. Mohammad-Djafari, J.-F. Bercher, P. Bessière, eds. *AIP Conference*