The Grid: A Journey Through the Heart of Our Electrified World

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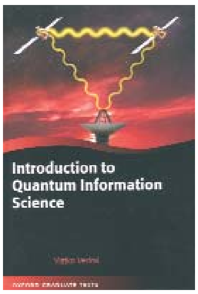
what a computer could do and what resources would be needed to do it seemed to be largely independent of its physical construction. The connection between information and physics, thermodynamics in particular, has been developed during the past 50 years or so. A famous example of that relation was discovered by Rolf Landauer, who in 1961 showed that erasing, or otherwise irreversibly losing, a bit of information in a computer must dissipate at least $kT \ln 2$ of energy.

That idea, now called Landauer's principle, was succinctly summarized in his declaration that "information is physical," which has become a mantra in the fields of quantum information science and quantum computing. (See Landauer's article in PHYSICS TODAY, May 1991, page 23.) We now know that a computer that exploits the unique features of quantum mechanics can solve some problems more efficiently than any classical computer, a result that firmly links computer and information science to physics. Quantum information science, broadly defined, has expanded enormously over the past two decades, and numerous books on the subject at all levels have appeared, including Phillip Kaye, Raymond Laflamme, and Michele Mosca's *An Introduction to Quantum Computing* and Vlatko Vedral's *Introduction to Quantum Information Science*.



An Introduction to Quantum Computing covers a small subset of the topics in Michael Nielsen and Isaac Chuang's *Quantum Computation and Quantum Information* (Cambridge U. Press, 2000), which has become a standard text in the field. That tome, still relevant eight years after its publication, is probably too unwieldy for most undergraduates looking for an introduction to the field. In contrast, Kaye, Laflamme, and Mosca's book is very accessible. LaFlamme and Mosca are on the faculty of the Institute for Quantum Computing at the University of Waterloo in Canada and are well-known researchers in quantum information science; Kaye is a doctoral student at the university. Based on a course taught by the authors, the text is tightly focused on quantum computing and carefully leads the reader through Deutsch's, Shor's, and Grover's algorithms, among others. Coupled with the authors' careful exposition is a cadre of exercises, integrated into the text, that forms an important pedagogical aid. A series of exercises presented early in the book, for example, guide the reader to the existence of a universal set of quantum gates. For better or worse, in some places important results are simply declared as theorems without proof.

The authors do an excellent job breaking up Shor's factoring algorithm into pieces that students can easily digest. They take the approach—not original, but deftly presented—of reducing the order-finding problem at the heart of factoring to the problem of finding the eigenvalues of a unitary operator, delegating much of the work to the reader through exercises. The book contains a chapter on quantum complexity that is more formal than the rest of the text and may not appeal to some readers. However, readers who skip or skim that chapter will have little trouble digesting the remainder of the text.

Vedral's *Introduction to Quantum Information Science* is billed as a graduate text but is not really—it contains no exercises. Distilled from a series of lectures by Vedral, a professor of quantum information science at the University of Leeds in the UK, it is a bit uneven, both in the selection of topics and style of presentation. Sometimes more space is given to the algebra of a simple example than to a fairly abstract proof.

Most of the book focuses on quantifying quantum entanglement, the author's primary current research field, and quantum information by using entropic measures. That approach pervades his treatment of quantum computing, measurement, and error correction. Formal results are sometimes followed by clear discussions of analogies to thermodynamics. Error correction, for example, is cast in terms of swapping quantum states and entropy into environmental degrees of freedom. The book is a good, technical read, with many pithy or whimsical footnotes sprinkled throughout. Unfortunately, Vedral's text contains numerous typographical errors and notational ambiguities. Most are merely distracting, but some may lead to real confusion. In contrast, the few errors I found in Kaye, Laflamme, and Mosca's text are almost entirely inconsequential.

Both *An Introduction to Quantum Computing* and *Introduction to Quantum Information Science* would benefit from a stronger adherence to Landauer's dictum. If information is physical, discussions of quantum information need to be coupled with concrete examples of physical implementations. Although the fundamental results of quantum information science depend on the logical structure of quantum mechanics—unitary evolution in Hilbert space and, perhaps, the projection postulate—and not on any specific qubit implementation, neglecting experimental realizations is unwise. A novice reading Kaye, Laflamme, and Mosca's book, for example, might reasonably reach the conclusion that if there is a universal set of gates, clearly delineated quantum algorithms, and error-correcting codes on paper, then a large-scale quantum computer should be just around the corner. The reader should at least be given a glimpse of the challenges involved in making a robust controlled-NOT gate or performing a complete Bell-state measurement; both are primitives on the quantum information theorist's palette but are challenging to perform in the lab. The closest these books come to discussing experiments are brief mentions of idealized Mach–Zehnder interferometers. Remarkably, because of an algebra mistake, Vedral gets that example wrong—the photon exits the wrong way from the symmetric interferometer.

There is another, deeper reason experiments in this field deserve more attention. If researchers fail to construct a large-scale quantum computer, it may be because of some practical limitation, or it may be the sign of something more interesting. A spectacular, albeit speculative, possibility is that we find quantum mechanics breaks down, and there emerge some fundamentally new laws of physics and, by extension, of information.

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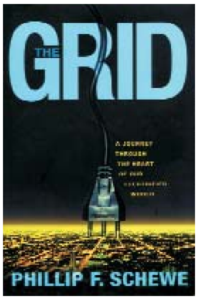
The Grid

A Journey Through the Heart of Our Electrified World

Phillip F. Schewe
Joseph Henry Press, Washington, DC, 2007. $27.95 (311 pp.). ISBN 978-0-309-10260-5

Electricity uniquely combines three attributes: It is crucial, even for minimally developed societies; fragile, in that prohibitive storage costs require production to equal use by the minute; and interconnected, because failure of one supplier to meet demand can black out half a continent. In *The Grid: A Journey Through the Heart of Our Electrified World*, Phillip Schewe, chief science writer at the American Institute of



Physics, admirably and accessibly portrays each of those attributes. Specialists and general audiences should find the book entertaining, despite its occasionally distracting literary devices and flourishes.

After some introduction, Schewe's tale begins in 1882 with the first grid, powered by Thomas Edison's DC generator at the Pearl Street station in New York City's lower Manhattan. Edison's company eventually lost out to George Westinghouse's AC system, which could transmit power over longer distances by relying on transformers and the AC generators and motors designed by Edison's former employee, Nikola Tesla. The story fascinatingly turns to another former Edison employee, the now largely forgotten Samuel Insull, who created the regulated utility system that dominated the 20th century. Schewe describes the growth of the grid in Vladimir Lenin's Russia and in Franklin Roosevelt's US, with particular focus on the Tennessee Valley Authority. Ironically, in attempting to contrast the developments in Russia and the US, he shows the unintended similarities between centrally planned power and publicly regulated and funded utilities.

The most dramatic story comes next: the 1965 Northeast blackout. To tell the tale, Schewe melds stories from the streets of New York City and the utility control rooms. The power failure forced industry and government to pay attention to reliability, just as fuel prices started rising, environmental issues gained traction, and competition began intruding into Insull's regulated monopoly legacy. The 2001 California energy debacle of rolling blackouts and utility bankruptcies is briefly covered; unfortunately, the author focuses more on Enron Corp rather than on California's idiosyncratic regulatory policy as the culprit. Schewe then turns to alternatives to giant, fossil-fuel plants, with a fair look at the benefits and problems of solar, wind, and nuclear power. After describing a fascinating transformer-repair field trip with Idaho Power, one of the high points in the book, the author concludes with observations on electrification in developing countries and on the similarities between the Apollo moon landings and the massive "Big Allis" generator that provides power to New York City as large-scale technological missions.

If readers drawn to *The Grid* want to learn more about whether competition has led to improved performance or just higher prices or about global warming and conservation tips, they will likely be disappointed. Technical and policy experts may want more detail: For example, nowhere in the book can readers find an intuitive explanation of "reactive power." However, those shortcomings ironically illuminate the book's strength—the focus on what it takes to get this amazing, pervasive system to work at all.

One important minor flaw, likely from a tight publication budget, is the absence of graphics. The text lacks even the standard "generator transmission distribution user" diagram provided in almost every other book about electricity. A map and timeline of the 1965 blackout would help keep the story straight, and power-pool maps would show how grids go beyond boundaries of not just individual power companies but also states and countries. Photographs would also help attract a general audience. I confess to wondering what this Insull looked like.

The author may be more to blame for the book's peculiar organization. We don't find out how the grid works until the penultimate chapter, and the reader won't learn about kilowatt-hours, the unit of energy most homeowners actually buy every month, until the final chapter. Insull falls from grace in chapter 3, but we don't learn what happens to him until the end of chapter 4. Florid musings on the downside of technology are liberally dropped throughout the text graced with selected quotes from Henry Adams and Henry David Thoreau. Conservation is important, especially in the midst of global warming, but the book would be stronger if that topic were left to the end rather than inserted here and there.

Schewe's baroque flourishes, Waldenesque contemplation, and nonlinear organization suggest that he doubts that readers share his fascination, and mine, with electricity. The assumption is understandable. When I tell acquaintances that I work on electricity economics, "boredom squared" is in their eyes. And I bet when Schewe told fellow dinner-party guests that he was working on a book on electricity, it probably took milliseconds for someone to interrupt with "Anyone seen a good movie lately?" Much of *The Grid* might offer promising material for Hollywood producers. I hope Schewe, also a dramatist, is working on screenplays for the 1965 New York City blackout miniseries and the Insull biopic. Those stories would be worth seeing.

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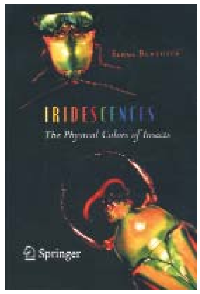
Iridescences

The Physical Colors of Insects

Serge Berthier
(translated from French by Capucine Lafait)
Springer, New York, 2007. $139.00 (160 pp.). ISBN 978-0-387-34119-4

Serge Berthier's *Iridescences: The Physical Colors of Insects* is purported to be a "new, improved, and substantially modified version" of his *Les couleurs des papillons ou l'impérative beauté: Propriétés optiques des ailes de papillons*, or *The Colors of Butterflies or Imperative Beauty: Optical Properties of the Wings of Butterflies* (Springer, 2000). Berthier is a professor of physics at the University of Paris Diderot–7 and researches biological structures, colors, and biomimetics at Pierre and Marie Curie University. The one positive aspect of *Iridescences*, originally published in French in 2003, is that it does have wonderful color photographs that show some amazing detail of the structure and morphology of the orders Coleoptera, which includes beetles, weevils, and fireflies, and Lepidoptera, which includes butterflies and moths.

Berthier's book could have been a very nice piece of work if it had been proofread to correct the plethora of errors in grammar, history, and references to figures. For example, on page 3 in the first chapter, the author refers to "Lord Raleigh"—yes, with the last name misspelled the same way each time the physicist is mentioned—as fourth baron, who was at Imperial College London, which is correct. However, when most physicists see the name "Lord Rayleigh," they think of the more famous Rayleigh, John William Strutt, who was third baron and taught at Cambridge University. Berthier is actually referring to Robert J. Strutt, Lord Rayleigh's eldest son who inherited the title after his father died in 1919.



In chapter 2, Berthier takes readers through plausible arguments about the myriad of color variations found in insects, and in chapters 3 and 4 he focuses on the different characteristic lengths of scales of insect wings in both Coleoptera and Lepidoptera. He then discusses in chapter 5 how pigmentation and structure are responsible for most color variation. He introduces equation 5-1, which shows how to get an interference reflection minimum from a thin layer, yet there is no figure or explanation as to where the equation comes from; unless the reader is already familiar with thin-film interference theory, the equation will mean nothing.

Another repeated annoyance is that the descriptions and labels of figures are written in a mixture of French and English. The labels in figure 11.3 are entirely written in French while the figure caption is written in English. In chapter 13, the author introduces the trichromatic coordinates R, G, B but then in equation 13-3 uses normalized r, v, b coordinates. One has to assume that the v stands for "vert," the French word for "green." In addition, many of the figures are poorly done. For instance, figure 6.3, which shows the Fresnel reflection coefficient, has no scale for the ordinate. It should also be noted that the Fresnel formulas are not presented until chapter 7. Also, in chapter 6, the author introduces the Kramers–Kronig relations, equation 6-7, that are incorrect as presented.

In chapter 7, "1-Dimensional Structures: Interferences," Berthier attributes the laws of reflection and refraction to both Willebrord Snel van Royen and René Descartes. However, back in figure 6.2 the law of refraction is called Descartes' law, and on page 90 in chapter 8, "2-Dimensional Structures: Interferences and Diffraction," Berthier refers to it as "Snell's law." But the law of refraction was actually first discovered by Thomas Harriot in 1602, though that was not known until 1959. Chapter 9, "3-Dimensional Structures: Crystalline Diffraction," deals with periodicity in three dimensions. Berthier introduces the Bragg relation, equation 9-1, as $2d \sin\theta = k\lambda$, in which he uses k to represent an integer, another hassle because we are used to seeing k as the wave number. In the sentence above the equation, he refers to Φ as the angle to be used in the equation, which contains θ, not Φ. That equation and the accompanying figure 9.1 give no clue as to why constructive interference occurs. The author then goes on to introduce a two-dimensional Fourier transform in equation 9-2, again with no explanation.

In Chapter 10, "Amorphous Structures: Scattering," Berthier discusses the concept of larger-size particle scattering within the framework developed by Gustav Mie in 1908. The author later gives credit for the first development to Ludwig Lorenz; however, although Lorenz developed the theory in 1890, he only published his research in Danish. Most people today give credit to both men and refer to the Lorenz–Mie theory. Berthier then ties the theory to the scattering structures found in certain butterflies, which allows readers to understand the insects' color variation. Chapter 11 treats selective absorption and some of the chemistry necessary to explain it.

I found chapter 12, on thermoregulation and spectral selectivity in butterflies, quite informative; it explained how essential heat transfer is to the survival of those marvelous insects. In the final chapter, 13, "Vision and Colorimetry," the author uses trichromatic coordinates to explain insect vision. He briefly discusses the perception of polarized light by insects but does not mention the enormous amount of work already published on the subject.

In short, if you are looking for a book that offers some understanding of the relationship between the basic laws of physics and the coloring of insects, *Iridescences* leaves much to be desired. On the other hand, if you want to see some wonderful photographs that show the intricate and delicate struc-