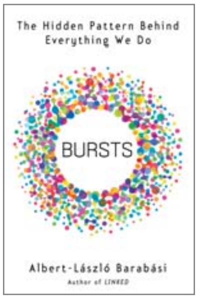
# Bursts

### The Hidden Pattern Behind Everything We Do

**Albert-László Barabási**
*Dutton, New York, 2010. $26.95 (272 pp.). ISBN 978-0-525-95160-5*

Power laws—mathematical patterns of the high likelihood of small objects and events and the rarity of large ones—have long been observed in incomes, word frequencies, city sizes, earthquakes, and many other physical and social domains. Mid-20th century mathematician Benoit Mandelbrot, who devoted an influential career to the study of self-similarity, derived power laws for phenomena ranging from taxonomies to geographical measurements. In doing so, he made a convincing case that nature is best described by fractals. Triangles, squares, and circles lose all interest when studied up close, whereas fractals—and real-life objects such as mountains, trees, and even galaxies—contain intriguing structure at all levels of observation. (Recall the short film *Powers of Ten*, which many PHYSICS TODAY readers have probably seen; it can be found on YouTube.)




A similar distinction between regularity and fractality holds in the social world. For example, designed structures such as bus schedules have a simple order, but actual distributions of bus waiting times are complex and random. In his latest book, *Bursts: The Hidden Pattern Behind Everything We Do*, complexity scientist Albert-László Barabási describes many aspects of power laws arising from human behavior. He characterizes bus waiting times and other such phenomena as "bursty": They are neither regular nor completely random. They are, in essence, patterns of human interaction that arise from processes far more complex than the simple addition and averaging that generate familiar binomial, Poisson, and Gaussian statistical distributions.

Barabási has worked for several years on models for how power laws can emerge from complex systems such as the internet. Consider, for example, this computer simulation of how he managed his busy days:

**1.** I selected the highest-priority task and removed it from the list, mimicking the real habit I have when I execute a task.

**2.** I replaced the executed task with a new one, randomly assigning it a priority, mimicking the fact that I do not know the importance of the next task that lands on my list.

The resulting simulation reproduced the power-law distribution that characterizes the waiting time he and others have noticed in e-mail responses, webpage visits, and other data. But beyond being a cute way to explain a heretofore mysterious observation, such latent-variable models suggest new directions of research, as did Einstein's theory of Brownian motion—in Barabási's case, a static analysis of waiting-time distributions can become a dynamic study of decision making. Similar work has been done by physicists Duncan Watts, Peter Dodds, and Mark Newman to model the time dynamics of social networks.

The back cover of *Bursts* promises "a revolutionary new theory showing how we can predict human behavior." I was not fully convinced on that score, but the book does offer a well-written and thought-provoking window into the author's research on power laws and network theory. In *Bursts*, Barabási distinguishes between traditional models of randomness, which are based on statistically independent events, and bursty processes, which arise from feedbacks that either suppress or amplify variation. (One familiar example not discussed in the book is the system of financial instruments that shifted risk around for years before failing dramatically in the 2008 economic downturn.)

Paradoxically, Barabási characterizes bursty processes as predictable: At one point he discusses the burstiness of people's physical locations (we spend most of our time at home, at school or work, or in between, but we occasionally go on long trips—such events are the bursts). From there, he takes a leap—for which he does not provide much convincing evidence—to conjecture a more general order to human behavior and historical events. In his opinion, bursts call into question Karl Popper's argument that human history is inherently unpredictable. Barabási backs that assessment with a lengthy historical narrative about a Hungarian peasant rebellion. He attempts to connect the predictability, or lack thereof, of the rebellion's course to claims that human behavior and social trends are potentially predictable. However, the connection to the theme of power laws and bursty processes was unclear to me. In addition, I think the book would have been strengthened by some discussion of the work of Mandelbrot and past researchers such as Vilfredo Pareto, George Zipf, and Herbert Simon, who have studied the application of self-similarity and power laws to social phenomena.

Despite my skepticism of the book's larger claims, I found many of the stories in *Bursts* interesting. The book offers an inside view on some fascinating research. I particularly liked how Barabási takes his models seriously enough that when they fail, he learns even more from their refutation. I suspect there are quite a few more bursts to come from this particular research program.

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# Quantum Transport

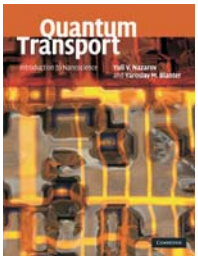
### Introduction to Nanoscience

**Yuli V. Nazarov and Yaroslav M. Blanter**
*Cambridge U. Press, New York, 2009. $99.00 (581 pp.). ISBN 978-0-521-83246-5*

The past two decades have seen a tremendous surge in the use of "nano" in engineering, physics, chemistry, biology, and various other disciplines. Interest in nanoscience arose in part from the discovery that nanostructures can have much-desired optical, electrical, thermal, and other features due to novel quantum-mechanical effects that appear at the nanoscale.

One of nanoscience's most prominent subfields is electronic transport, which is governed by the quantum properties of charge carriers. We've all come to expect rapid progress in microelectronics, and scientists are now seeing promise in such relatively new fields as quantum manipulation and quantum information processing. So, in the past decade, there have been numerous experimental and theoretical works in nanoscale electronic transport. However, existing texts, such as Yoseph Imry's *Introduction to Mesoscopic Physics* (Oxford University Press, 2002) and Supriyo Datta's *Quantum Transport: Atom to Transistor* (Cambridge University Press, 2005), and articles in conference proceedings are limited to selected topics and do not attempt to cover the present breadth of the field.

In *Quantum Transport: Introduction to Nanoscience*, theoretical condensed-matter physicists Yuli Nazarov and Yaroslav Blanter seek to do precisely that. They set out to provide an accessi-




ble introduction to quantum transport and nanoscience and to meet the demand for an updated text for graduate and advanced undergraduate courses. Both authors are well-known authorities in the field, and rumors about their book project had spread for several years, creating substantial anticipation. Could Nazarov and Blanter meet such lofty expectations?

In my view, they have done so: *Quantum Transport* presents a comprehensive and almost complete overview of nanoscale electronic transport theory. The book is organized according to the authors' areas of expertise. The titles of the six chapters indicate the topic coverage: "Scattering," "Classical and Semiclassical Transport," "Coulomb Blockade," "Randomness and Interference," "Qubits and Quantum Dots," and "Interaction, Relaxation, and Decoherence." Some subjects, such as one-dimensional systems, superconducting heterostructures, and quantum pumping, are integrated into those chapters. Others, including quantum Hall effects and numerical approaches, are not treated. I understand why: Recent monographs exist for those two topics, and with almost 600 pages, *Quantum Transport* is already quite long.

Nazarov and Blanter's general approach is to develop theoretical methods and apply them to various examples in experimentally accessible limits, so as to demonstrate the close connection between experiment and theory in nanoscience. For instance, the scattering approach to transport through a quantum point contact is used to explain the complex physics of so-called multiple Andreev reflections between biased superconducting contacts. Experimentalists have employed that effect to determine the PIN code of atomic break junctions, which allows them to characterize the detailed chemical environment of the contact and determine transport properties such as the shot noise and even the full counting statistics.

Their presentation of the theory is surprisingly comprehensible and should be accessible to advanced undergraduate students. However, being theorists, they do not attempt to address advanced experimental methods. Readers interested in sample fabrication and measurement techniques will have to consult the original literature. Nevertheless, I think experimentalists will find value in the book because it successfully relates the theoretical concepts and results to physical examples.

I warmly recommend *Quantum Transport* to lecturers and students interested in the subject. It contains a lot of illustrations and exercises that make it suitable for a one- or two-semester course. Additionally, the text facilitates self-study through integrated questions that allow readers to check their understanding of the material. In view of its comprehensive coverage of numerous topics and its accessible style, Nazarov and Blanter's text has the potential to become a standard reference in the field.

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## Granular Patterns

**Igor S. Aranson and Lev S. Tsimring**
*Oxford U. Press, New York, 2009. $110.00 (343 pp.).*
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After water, the most frequently handled materials in industry are sand, grains, and other large conglomerations