math. Instead, he makes abundant use of analogies and thought experiments. Some of those are the classical invocations of elevators, trains, and airplanes; others are of Melia's own invention. Rich with cultural allusions, his analogies are sometimes as elaborate as the physics he is trying to convey, and they may be rather distracting to the lay reader. Nonetheless, I found them to be a laudable effort to bring a remote subject to the terrain of real-world experience.

Melia's history tour also illuminates the subject of collapsed stars, knowledge of which is essential if one is to understand how nature effects the incomprehensible compression and vast times required to make a stellar-mass black hole. (To get a feel for that compression, imagine trying to squeeze Earth to the size of a golf ball.) Subramanyan Chandrasekhar was mentioned in a few contexts, in particular as the namesake of the *Chandra X-ray Observatory*, which enabled the discovery of x-ray emission from the accretion flow onto the galactic black hole. However, he could have been more prominently credited for his circa 1930 work in which he showed—notwithstanding the disbelief of some of his notable contemporaries—that sufficiently massive stars would inevitably collapse.

In any case, the galactic black hole, with a mass 4 million times greater than that of our Sun, is more than just a collapsed star. It is, as Melia points out, inexorably growing by disrupting hapless stars that wander within its tidal grasp and by sucking gas out of the nearby interstellar medium through the intermediary of an accretion disk. Indeed, Melia has been a prolific member of the cadre of theorists working to explain the accretion flow and its emergent spectrum. Naturally, his own work and ideas are emphasized in the book. The reader should be cautioned, though, that some of Melia's theories (for example, the production of the radio source Sagittarius A East by the tidal disruption of a star) are presented as accepted fact and a few important theories (such as the importance and role of a jet emanating from the galactic black hole's accretion disk) are not mentioned.

The galactic black hole is but the title character in Melia's story of extreme gravity; it just happens to be the most accessible representative of a vast population of supermassive black holes lurking in galactic nuclei. The most extreme examples are quasars, which are abundantly distributed across the universe and powered by gas accretion onto black holes up to 1000 times more massive than our comparatively puny galactic black hole. Researchers still do not agree on what mechanism forms those supermassive black holes. They are currently attempting to decide from among the possibilities: seeding by primordial black holes; dynamical collapse of a stellar cluster, either before or after the epoch of galaxy formation; and a succession of direct stellar collisions in a high-density environment.

Melia opts not to discuss the origins of supermassive black holes, although a section on the topic would have deepened readers' appreciation of what can be learned from these monsters. He does make it clear, however, that for some time to come, our own galactic black hole promises to be astrophysicists' best laboratory for investigating how a black hole interacts with its environment.

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D-Branes

Clifford V. Johnson
Cambridge U. Press, New York
2003. $60.00 (548 pp.).
ISBN 0-521-80912-6

In the mid-1990s, theorists realized that string theory contained other objects in addition to strings. Those extended "p-branes" appeared as solutions to the theory in the classical limit of vanishing Planck's constant. P-branes can have various dimensionalities. A 0-brane has zero spatial dimensions, so it is a point particle. A 1-brane has one spatial dimension like a string. A 3-brane, with its three extended spatial dimensions, could be like the world we live in. Dirichlet-branes, or D-branes for short, are p-branes on which open strings can end. The name arises because the strings may be said to have Dirichlet boundary conditions at their endpoints.

As Joseph Polchinski showed in a seminal 1995 paper published in *Physical Review Letters*, D-branes can be described in a simple and precise mathematical fashion. That understanding has led to a plethora of interesting and important results. Among the most notable are the explanation of the microscopic origin of black hole entropy; string dualities relating strong and weak coupling; the connection between gravity on certain negatively curved spacetimes called anti–de Sitter (AdS) spaces and "conformal" field theories (CFTs) that are reminiscent of quantum chromodynamics; and the realization that we might live on a 3-brane that is part of a larger space with millimeter-sized extra dimensions.

Clifford Johnson's *D-Branes* presents the basic mathematical technology necessary for dealing with this subject. It also nicely describes many of the important results that D-branes have led to. The author starts with an overview of string theory and then describes D-brane properties. He systematically introduces many topics that provide insight about D-branes. Examples include the study of anomalies in theories whose fields live on the world volume of D-branes propagating through spacetime, supergravity solutions associated with D-branes, bound states of D-branes, and D-branes as probes of geometry at length scales smaller than the string length. One chapter, which details the connection between D-branes and black holes, clearly explains how one can compute the microscopic origin of black hole entropy. That first-principles entropy calculation was one of the landmark achievements of string theory as a theory of quantum gravity, and a thorough understanding of the physics of D-branes is necessary for deriving it. In a couple of chapters that consider the AdS-CFT correspondence, Johnson puts special emphasis on comparing the thermodynamics of the theories.

D-branes have led to new approaches to "compactifying" string theory so that only the four familiar spacetime dimensions are large. They have inspired new ways to think about the origin of gauge symmetry. Because D-branes naturally have gauge fields defined on their world volumes, they suggest that matter could be localized on a 3-brane that lives in a higher-dimensional space. Johnson details various simple supersymmetric models realizing that suggestion.

Johnson has first-hand experience with the material he discusses and has made important contributions to many of the topics described in his book. Together with Polchinski and Shyamoli Chaudhuri, he wrote the first review on D-branes (1996), which was based on lectures delivered by Polchinski. Johnson's book is more extensive and grew out of material he presented in various courses and summer schools.

D-Branes is an excellent complement to other existing texts on string theory, such as the two-volume *Super-*

string Theory (Cambridge U. Press, 1987) by Michael Green, John Schwarz, and Edward Witten or Polchinski's two-volume *String Theory* (Cambridge U. Press, 1998), which has a chapter devoted to D-branes. Johnson's book has a clear and direct presentation, and contains nice clarifying inserts explaining various bits of commonly used mathematics. I expect it will be a valuable tool for graduate students who intend to work in string theory and also a useful reference for active researchers.

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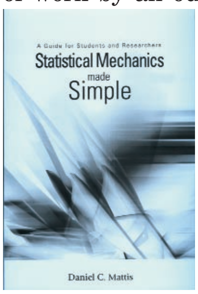
Statistical Mechanics Made Simple: A Guide for Students and Researchers

Daniel C. Mattis
World Scientific, River Edge, NJ, 2003. $48.00, $24.00 paper (252 pp.). ISBN 981-238-165-1, ISBN 981-238-166-X paper

Daniel Mattis's *Statistical Mechanics Made Simple: A Guide for Students and Researchers* is an admirable piece of work by an outstanding expert in the field. But its title is rather misleading, and I question the author's view on the appropriate audience for it. Mattis explains that the first four or five chapters are "suitable for an undergraduate course for engineers and physicists" and that the final five chapters "treat topics of recent interest to researchers." His approach, though, leaves a big gap. It almost seems appropriate to review the first and second parts of the book separately. The first part is undoubtedly a difficult read for beginners; the second, however, is an engaging study of statistical mechanics for experts in the field.



The early chapters cover a good deal of elementary material, but on a fairly advanced level and from a different perspective than is normally taken. The author makes a number of clever observations or assumptions that lead to his obtaining nontrivial results in a few lines. However, compactness is not the same as simplicity, and my concern is that the intended audience of undergraduates might not be able to follow all the arguments.

The first chapter begins with a brief but excellent introduction to binomial and Poisson probability distributions. Mattis then introduces a multinomial distribution and presents its logarithm. Without further elaboration, he writes, "We then arbitrarily identify the first bracket on the rhs of the equation . . . with the negative of the energy of the system," and the second bracket "with the product of its entropy and the temperature." For experts, this approach is a clever way of pointing to the fundamental mathematical structure of the theory, but for beginning undergraduates, the author's presentation will probably be completely mysterious.

Mattis's introduction of the thermodynamic definitions of temperature, pressure, and chemical potential is likely, unfortunately, to present similar difficulties for students encountering the terms for the first time. Instead of showing readers that these thermodynamic definitions logically follow basic physical principles, Mattis makes them seem arbitrary. The same problem arises when the author introduces statistical mechanics in chapter 4. He begins by defining the quantum mechanical partition