couldn't find work in that field. So he stuck with physics and, inspired by Einstein's praise of de Broglie, came up with a theory called 'wave mechanics.' It led to a set of equations that governed de Broglie's wavelike behavior of electrons, which Schrödinger (giving half credit where he thought it was due) called 'Einstein–de Broglie waves'" (page 330).

Isaacson rarely mentions quantitative confirmation of Einstein's physics, except for general relativity. The author's shunning of mathematical formulas, except $E = mc^2$ and a wrongly copied gravitational field equation, leaves the discussion of the physics mystifying and incoherent. It does not help that Isaacson says a tensor is "sort of a vector on steroids"(page 194). The author's intense focus on relativity and $E = mc^2$ in discussing Einstein's physics is particularly interesting. In *Einstein: The First Hundred Years* (Pergamon Press, 1980), an article titled "Assessing Einstein's Impact on Today's Science by Citation Analysis," by Tony Cawkell and Eugene Garfield, examined the 11 papers in the exact sciences from physics to physiology published before 1912 that were the most cited between 1961 and 1975. The four listed papers written by Einstein—the only author who had more than one paper cited—were his 1905 dissertation, published as "A New Determination of Molecular Dimensions," in 1906; his 1905 paper on Brownian motion; his 1911 correction of the 1906 paper; and his 1910 theory of critical opalescence. His papers on light quanta, special relativity, and L/V^2 = mass (later written as $E = mc^2$) are nowhere on the list.

Isaacson includes a few errors and misprints. For example, he mixes up Marcel Grossmann and Hermann Minkowski (page 33) and misspells Henry Siedentopf's name (page 106) and *kosmologische Glied* (page 255). In addition, contrary to what Isaacson writes, Armand Fizeau's measurement of the entrainment coefficient is not a null experiment (page 112); time dilation has an impact on our everyday life because it is responsible for cosmic rays near sea level and a functioning global positioning system (page 130); clocks run slower not in intense gravitational fields but in higher gravitational potentials (pages 148 and 349); the "fabric of spacetime" has to be credited to Minkowski (page 232); and Bohr escaped three years after, not during, the Nazi takeover of Denmark (page 482).

Despite the above errors, *Einstein* is a thoughtful, well-researched story about the physicist's life. But the wonderful book by Pais, which was republished by Oxford University Press in 2005, with a preface by Roger Penrose, is still the best introduction to Einstein's physics.

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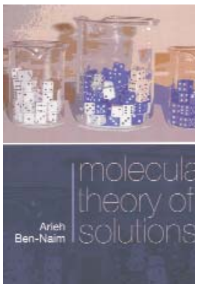
Molecular Theory of Solutions

Arieh Ben-Naim
Oxford U. Press, New York, 2006. $168.00, $64.50 paper (380 pp.).
ISBN 978-0-19-929969-0, ISBN 978-0-19-929970-6 paper

The problem with solutions is that they are messy. In both a formal and a practical sense, liquids, especially concentrated aqueous solutions, pose complex problems. Many great scientists in the field of statistical mechanics, including Max Born, Peter Debye, John Kirkwood, Lars Onsager, Joseph Mayer, and Harold Friedman, have worked on those vexing problems in the last century. Progress has been in fits and starts for the most concentrated aqueous solutions. Neither analytical predictions since Debye and Erich Hückel's research on solutions at infinite dilution nor accurate ways to analyze the experimental data have been easy to come by.



In *Molecular Theory of Solutions*, Arieh Ben-Naim, a professor in the department of physical chemistry at the Hebrew University of Jerusalem, gives a cogent view of how we can begin to work solution thermodynamics problems of such complexity. Do not confuse Ben-Naim's book with Ilya Prigogine's *The Molecular Theory of Solutions* (Interscience, 1957), which focuses on cell and lattice models. Also, Ben-Naim's text is not about liquid-state theory and many-body approaches, as covered in Jean-Pierre Hansen and Ian R. McDonald's *Theory of Simple Liquids* (Academic Press, 1976) or Keith E. Gubbins and Christopher G. Gray's *Theory of Molecular Fluids: Fundamentals* (Oxford U. Press, 1984). Ben-Naim's is truly a book on multicomponent liquid solutions.

Although *Molecular Theory of Solutions* introduces pair distribution functions and their associated moments—concepts from modern liquid-state theory—that feature is but a prelude to the real focus of this tome. The author's intent, it seems to me, is to show the power of one of the main branches of solution theory, namely, the Kirkwood–Buff (KB) approach, which was formulated in the early 1950s by Kirkwood and Frank P. Buff. It is one of a small number of unique approaches to the multicomponent liquid-state solution problem; others include one by William G. MacMillan and Mayer, which gets some small mention in the book, and a more obscure one by Steven Adelman.

What makes Ben-Naim's presentation of KB theory so convincing is in part the beautiful applications that he has chosen. The book incorporates many seminal advances in the understanding of aqueous solutions of macromolecules, especially protein solutions. A good example is how Ben-Naim treats macromolecular associations. It is in this arena that the MacMillan–Mayer approach, usually embodied in the analysis of the second osmotic virial coefficient, is demonstrably misleading for concentrated solutions. The author shows how necessary it is to take correlations in the fluctuations to higher order, and KB theory is an appropriate vehicle for doing so.

Yet if choosing KB theory is so clear, why has it taken since the 1950s for the community to embrace the methodological structure? Simply put, researchers were mostly waiting for theoretical advances that could make quantitative predictions; those advances have been slow to appear. The emergence in the last few decades of computer simulations for the structure and thermodynamics of complex fluids has measurably improved our understanding of the correlations and has partly alleviated the problem. A simulation is not a theory, but it can provide the probability distributions, such as those considered in Ben-Naim's book, as input for solving another problem.

However, what can be said, in quantitative terms, about the inverse problem—the liquid-state structures that give rise to the thermodynamics? Many degenerate structures in a liquid are consistent with a particular thermodynamic observation. Probability distributions reduce that nonuniqueness, but they do not eliminate it. Through KB theory, Ben-Naim makes a convincing argument for using the distribution's low-order moments, which can be related to rigorous sum rules for inverse analysis at the correct concentration of components.

Quite a few solution theorists still make good use of osmotic virial coefficients and the potential of mean force between solutes, the central objects of MacMillan–Mayer theory. Although that approach is likely to remain important for quite a while, *Molecular Theory of Solutions*, with its numerous illustrations of distribution functions and their moments, provides a practical view of methods to analyze solution experiments via KB theoretical constructs. The book is not a comprehensive review of the field by any means. It is, however, a well-stated view from a single perspective. I think it will be useful not only as a research monograph but also as a text in advanced courses on the topic. Although it is more than somewhat biased toward the KB view of solutions, Ben-Naim's text has energy and readability that make it compelling for many uses.

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The Physics of the Cosmic Microwave Background

Pavel D. Naselsky, Dmitry I. Novikov, and Igor D. Novikov
Cambridge U. Press, New York, 2006. $125.00 (255 pp.). ISBN 978-0-521-85550-1

The Physics of the Cosmic Microwave Background by Pavel Naselsky, Dmitry Novikov, and Igor Novikov is basically a record of what the authors have worked on in their studies of the CMB and is not a systematic textbook or review of it. In the first chapter, the approach works out well, especially since Igor Novikov, of the Niels Bohr Institute at the University of Copenhagen, was present at the beginning of the field's creation. The historical discussion is also quite interesting.

In other places, however, their presentation is not so useful. In chapter 3, for instance, the authors give a long calculation and discussion of the epoch of recombination and the distortions of the blackbody spectrum produced by recombination lines. But the effects shown in figure 3.17, at a level of 10^{-26} W/(m^2 Hz sr) or 1 Jy/sr, are completely swamped by the 1 MJy/sr cosmic far-IR background and the several MJy/sr of galactic and solar-system foregrounds.

A similarly odd emphasis occurs in chapter 7 on the statistical analysis of the anisotropy and polarization of the CMB. About 2 of the chapter's 36 pages