Chemical Bond. Although this in itself should constitute a chapter in any biography of Pauling, it is not treated in Serafini's book.) Apparently, Pauling discovered the helical structure (the alpha helix) of the polypeptide chain by folding a piece of paper while sick in bed. (Ironically, the structural data as then known was misleading, and others who paid more attention to data, like Sir Lawrence Bragg, missed the opportunity to make this important discovery. Bragg later called this "the biggest mistake of my scientific career."[2])

Likewise, Pauling intuited the molecular origin of sickle-cell anemia. While many criticized Pauling's style, Francis Crick credits Pauling with the correct theoretical approach to biological problems.[3]

After World War II Pauling became a political figure. In the climate of those times, his antinuclear stance, his campaigns for disarmament, his opposition to atmospheric nuclear testing and his generally liberal positions raised the suspicions of Senator Joseph McCarthy and others of his ilk. Although Pauling was accused of being a "fellow traveler," the accusation was never verified. Nonetheless, Pauling was repeatedly subpoenaed to appear before Congressional investigative committees, and his passport was denied because he was deemed a security risk. These were not proud years for Americans.

To the general public, Pauling is probably best known as the crusader for the therapeutic effects of Vitamin C. Pauling's activity in this arena is consistent with his highly intuitive style. Pauling has raised the ire of the medical community through both his methods and his claims. Here again, Serafini's book fails: No basis is provided for understanding how Pauling became devoted to the vitamin-C cause. Here is a case where direct contact with Pauling himself might have been helpful.

The issue of direct contact with the biography's subject raises another question about *Linus Pauling: A Man and His Science.* The author acknowledges Pauling "for making himself available to me." However, I did not read one quote identified as a statement made by Pauling directly to the author. It would have been nice if Pauling's voice had been heard in connection with his groundbreaking chemistry as well as the many controversies that swirl around his career.

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1. Robert S. Mullikan, *Life of a Scientist,* Springer-Verlag, New York (1989), p. 60.
2. Crick, *What Mad Pursuit: A Personal View of Scientific Discovery,* Basic Books, New York (1988), p.58
3. See ref 2 p.60.

From Quarks to the Cosmos: Tools of Discovery

Leon M. Lederman and David N. Schramm
W. H. Freeman, New York, 1989. 242 pp. $32.95 hc ISBN 0-7167-5052-X

The most important discovery made in elementary particle physics in 1989 was that there are only three families of quarks and leptons, or at least only three light neutrinos of the type associated with families. Ten years earlier, this situation had been anticipated by calculations of the production of helium in the early universe. The fraction of helium relative to hydrogen depends weakly on the number of light neutrinos, and three was the family number deemed most likely.

This is just one example of the close relationship between the smallest objects (elementary particles) and the largest (the universe) considered in science. During the last two decades, particle physics and early-universe cosmology have been steadily converging.

From Quarks to the Cosmos presents a description of both areas and their overlap, at a level typical of *Scientific American* and hence accessible to undergraduates and even to senior high school students. The two authors of this nicely produced book are superbly qualified for their task. Leon Lederman, the former director of Fermilab, is a particle experimentalist who played a leading role in discovering members of the second and third families of quarks and leptons. David Schramm is a theoretical astrophysicist at the University of Chicago and was a pioneer in the analysis of cosmological nucleosynthesis and its dependence on family number.

The book contains another beautiful example of the inner (subatomic) space and outer space linkage. In 1987 the neutrinos emitted in a supernova explosion over 100 000 light-years away were sensed on Earth in detectors constructed to find evidence for proton decay, which was predicted by ambitious unified particle theories. None of the detailed predictions of the unified theories has been confirmed by experiment, and yet the theories initiated serendipitously the first neutrino astronomy.

The book includes two chapters on particle physics, followed by one on Big Bang theory, and one on their interrelationship. Finally, there is a chapter called "Tools for the 1990s." This chapter naturally encompasses the Superconducting Super Collider in Texas and the Hubble Space Telescope.

A shortcoming of the book is the lack of discussion of the relative accuracy of measurements in the two disciplines. The lifetime of, say, the muon particle in the microworld is known to better than 0.01% accuracy; the present age of the universe is not known even to 10% accuracy. The number of quark and lepton families could be estimated only roughly from cosmological theory but was measured precisely in particle experiments in 1989. That cosmology is generally the less quantitative of the two sciences does not clearly emerge from the text. I say "generally" because the recent Cosmic Background Explorer data (PHYSICS TODAY, March 1990, page 17) provide the first exception to this rule.

I liked this book both in style and substance and would unhesitatingly recommend it, especially to teachers, for an informed overview of the interrelationships between physics of the infinitesimally small and the almost infinitely large.

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Quantum Description of High-Resolution NMR in Liquids

Maurice Goldman
Clarendon (Oxford U. P.), New York, 1988. 268 pp. $65.00 hc ISBN 0-19-855639-X

Since its development in the late 1940s, nuclear magnetic resonance has grown into one of the most widely used spectroscopic techniques in modern molecular science. From crystalline materials at milli-kelvin temperatures to protein–DNA complexes in aqueous solution, nmr is capable of yielding a wealth of information on molecular structure and dynamics. To adequately describe such a broad field, nmr texts have, in the past, assumed encyclopedic proportions. Maurice Goldman's new book, *Quantum Decription of High-Resolution NMR in Liquids,* departs from this traditional reference format and specializes in a particular, widespread application of nmr.

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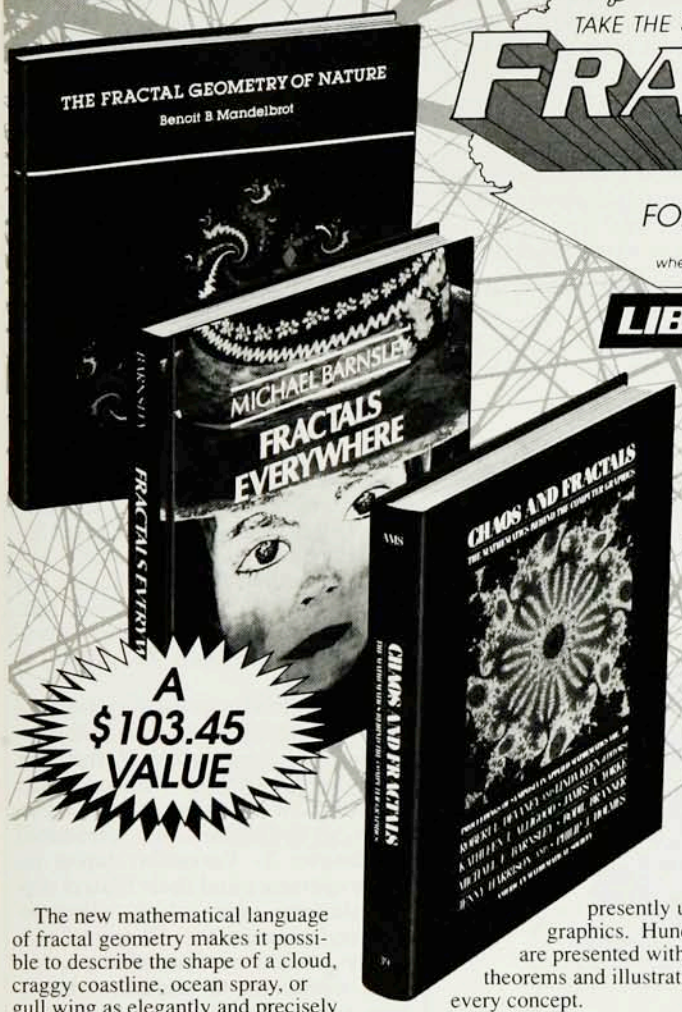

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Physics Today 5/90

In 1961 Anatole Abragam published *Principles of Nuclear Magnetism* (Oxford U. P., Oxford, UK) the first monograph on the quantum physics of nuclear spins interacting with resonant radio-frequency fields. This seminal work covered a broad range of topics including the nature of nuclear dipolar interactions, electron–nuclear interactions, quadrupolar effects, thermal relaxation in liquids and so on. However, the subsequent development of Fourier-transform, multiple-pulse and multidimensional nmr techniques required the preparation of at least another monograph. This niche has been filled by the work of Richard Ernst, Geoffrey Bodenhausen and Alexander Wokaun entitled *Principles of Nuclear Magnetic Resonance in One and Two Dimensions.* (Oxford U. P., New York, 1987)

These two books are valuable as references, but, because of their broad scopes, cover no single topic in exhaustive detail. However, as nmr continues to be used extensively throughout chemistry and now in biochemistry, biology and the materials sciences, the need for more specialized nmr texts is greater than ever.

By far the largest number of scientists using nmr are studying molecules in the liquid state and thus are employing high resolution nmr spectroscopy; of particular importance are two-dimensional nmr techniques. Goldman's text specializes in this particular type of nmr, providing a quantum mechanical description of two-dimensional nmr in liquids.

As the author notes in his preface, Chapter 1 introduces the elements of nmr and is largely a condensation of the introductory chapters of Abragam's 1961 monograph. Goldman describes nmr classically using the Bloch equations and introduces the steady-state response of nuclear spin systems to continuous rf irradiation and the ir response to pulsed rf irradiations.

However, to progress very far into Fourier-transform nmr, a quantum-mechanical formulation of the spin response is required. Fundamentals of quantum mechanics and mathematical formalisms are introduced in Chapter 2. Particular topics include operators and their matrix representations, eigenvalues, eigenvectors and propagators. Chapter 3 is a nicely written account of the quantum mechanics of angular momentum and nuclear spin and includes a description of angular-momentum operators and their matrix representations along with Euler angles. However, it does not mention irreducible tensor operators or Wigner rotation matrices.

Because nmr involves the interaction of large numbers of nuclear spins with rf radiation, quantum-statistical techniques are required to formulate the spin response. Goldman deals with such matters in Chapter 4. This is an especially important chapter because the density operator, the essential tool for practical nmr calculations, is not generally covered in adequate detail in statistical mechanics texts commonly used in graduate courses in chemistry departments. Chapter 4 contains a detailed discussion of the equation of motion of the density operator, the general expression for the equilibrium density operator in the high-temperature limit and expressions for the average value of a physical variable and its time evolution.

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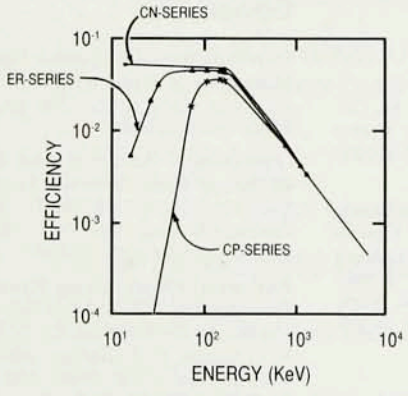

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spins to a resonant rf field is reformulated quantum mechanically in Chapter 5, and two-dimensional spectroscopy is formally introduced in Chapter 6. This latter chapter is brief but vital, introducing expressions for two-dimensional line shapes, apodization, amplitude and phase modulation. The 2D-J experiment illustrates the principles of two-dimensional spectroscopy.

J spectroscopy is rarely performed today. Single-quantum coherence transfer and multiple-quantum spectroscopy, introduced in Chapters 7 and 8, respectively, are of greater importance. Chapters 7 and 8 are perhaps the most important portions of Goldman's book for readers interested in acquiring a familiarity with the principles of practical two-dimensional homonuclear and heteronuclear experiments. In Chapter 7, Goldman derives in admirable detail coherence transfer within a system of weakly coupled spin-1/2 nuclei for a variety of pulse sequences, including $\cos y$, relayed $\cos y$ and $\cos y - \theta$. Multiple-quantum spectroscopy of systems of weakly coupled spins is thoroughly described in Chapter 8.

Goldman's book is important and timely, written in a thorough, careful manner. It treats a selected number of fundamental two-dimensional nmr experiments at a level appropriate for a general graduate course in two-dimensional nmr spectroscopy.

GARY DROBNY
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