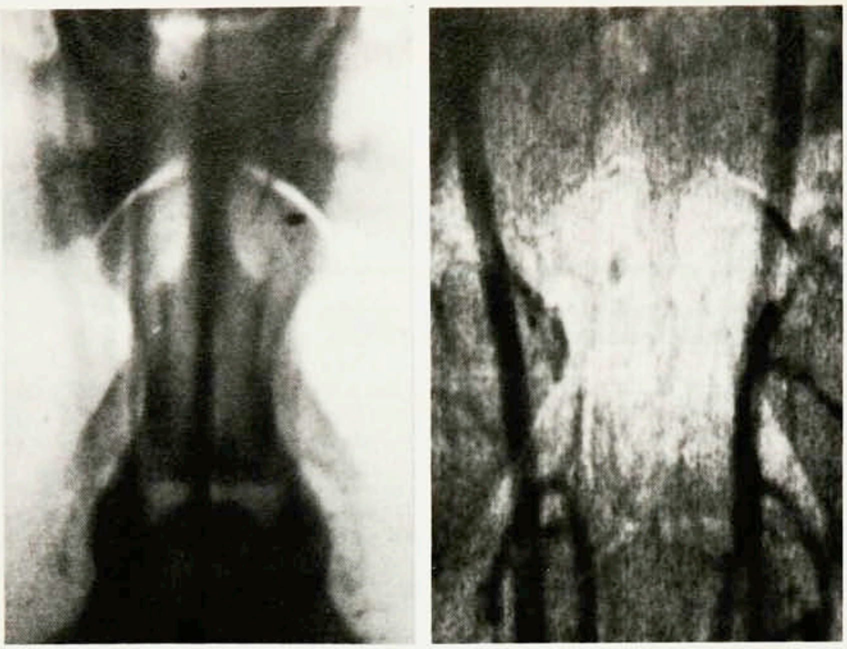

Digital radiographs of arteries near the spinal column. The image at left was obtained after a radio-opaque medium was injected into the arteries. The image at right was obtained from that at left by subtracting from it an image obtained before the injection. (Courtesy R. W. Redington.)

medicine, are left behind the times. Several new books have come out recently to bridge the gap between the current level of understanding of professionals and the new technologies. In one, P. N. T. Wells has compiled seven articles on various topics on medical imaging for a varied group of professionals. As one might expect, difficulties abound in attempting to write one source book for "doctors, radiographers, technicians, engineers and physicists." Each specialty has a different background, different vocabulary, different approach and different needs. Any one book aimed at this diverse audience must be limited in its goals. Wells has sought to describe fundamental principles at a level similar to *Scientific American* articles. The resulting work, while containing much useful and interesting information, includes items of varying quality and has a somewhat limited usefulness. The only readers with the background to comprehend most of the chapters will be physicists and engineers. In general it appears that limited space has forced authors to choose among clinical, technical, and basic material; this choice is not consistent among the authors.

G. A. Hay's chapter on "traditional imaging" is spotty. It includes some excellent sections (for example, on film design, blurriness of images, and contrast vs. detail in images) and some insufficient ones (image improvement with scanning slits, image enhancement, mammographic radiological equipment). The brief bibliography of this chapter is useful and necessary in filling gaps.

Malcolm Davison's chapter on computerized tomography, a quite adequate literature review, has a good discussion of artifacts, using examples, and a good bibliography. The weakest portion of the chapter is its discussion of resolution. The author's outline of a quality assurance program is welcome.

D. A. Weber and R. E. Omara's section on radionuclide imaging is concise and up-to-date. It gives brief discussions of pharmaceuticals, equipment performance (but not principles) and comparitive resolutions and many tables. The best part of this chapter is on clinical applications; its biggest weakness is its lack of radiation dosimetry considerations (a necessary topic for physicists in medicine).

Wells's section on ultrasound is an excellent introduction, with minimal mathematical and technical detail in the text but many specifics and computations in numerous sketchlike figures. Discussions of transducers, artifacts, the Doppler effect, transmission scanning, microscopy, biological hazards, are thought-provoking and fairly complete.

C. H. Jones's short section on thermographic imaging discusses liquid-crystal thermography and the use of bolometers and pyroelectric detectors, including their inherent limitations in temperature differentiation. Figures on clinical applications illustrate the technique's use in various diseases.

E. R. Andrew's section on the rapidly growing area of nuclear magnetic resonance imaging is admittedly incomplete but provides basic reviews of the physics of nmr interactions and their technological needs. Andrews presents both the physics in their design and the initial clinical results obtained from several of the currently used techiques of imaging. He presents the limited data on biohazards and views the wide open future of the field.

The final chapter, by M. Susan Chesters, is perhaps the hardest to evaluate. Perception and evaluation of images is undoubtedly the least understood of the topics covered in the book. Chesters describes various models of the visual system both neurologically and mathematically. Clinical data to evaluate models are scanty, as they are in most psychophysical systems. Therefore, the chapter, serving mostly as a compendium of phenomena, touches on such topics as the usefulness of image enhancement and restoration, the interaction of images with noise, and the usefulness (but not the theory or detailed techniques of construction) of ROC curves, matched filters, and so on.

This book can be useful especially to professional medical scientists who wish to get an introduction to another area of medical science: imaging. While it is a textbook neither in medical imaging nor in medical physics, it is a starting point for study in a field where there are few.

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Stochastic Processes in Physics and Chemistry

N. G. van Kampen

419 pp. North-Holland, New York, 1981. $76.50

Macroscopic evolution equations may be used successfully to model a wide variety of nonequilibrium physical and chemical processes. These describe the relationships between macroscopic quantities such as concentrations and phenomenologically determined quantities such as rate constants or diffusion coefficients, whose relations, in turn, to microscopic dynamics appear in the appropriate averages of microscopic rates or in the fluctuation–dissipation theorem. A familiar example of the latter is Langevin's treatment of Brownian motion, which introduces a frictional force term in the classical equation of motion of the Brownian particle, with the friction coefficient related to the statistical properties of the fluctuations that are the microscopic origin of the friction itself. The resulting Langevin equation is one special case, the Fokker–Planck equation another, of a large and important class of evolution equations called master equations. Such equations arise in theories of rate processes, first-passage problems, population biology, arrival of calls at switching stations, critical-point dynamics and laser dynamics, to name a few. In many applications, not only are relations between probabilities of macroscopic observables and phenomenological constants needed, but the fluctuations themselves must be modeled. When is it possible to describe nonequilibrium or steady-state dynamics via rate equations? What are the relationships between the quantities in such equations and microscopic dynamics? If fluctuations themselves play a crucial role—beyond simply determining the phenomenological coefficients—how are they coupled to the time evolution of averaged macroscopic quantities? These are a few of the questions the theory of stochastic processes addresses.

Nicolaas G. van Kampen, of the Institute for Theoretical Physics, University of Utrecht, long a world center for the study of nonequilibrium statistical mechanics, has produced a superbly written, physically motivated introduction to the theory of stochastic processes. In this case "stochastic processes" means the application of master equation techniques to physical and chemical problems. The text is readily accessible to the novice, whether a senior or beginning graduate student who has had a good one-semester statistical mechanics course, or a research worker suddenly confronted with the literature and in need of a unified and physically motivated introduction to the field. Such a comprehensive introduction written especially for physical scientists did not previously exist, although several very useful reprint collections have been available.

The text begins with a concise but highly readable review of elementary statistical concepts and then rapidly develops the theory of general stochastic processes. Specializing to Markov processes, the exposition turns to the master equation and its approximate versions, the Fokker–Planck, Langevin, and Kramers equations. Van Kampen develops these ideas with exceptional pedagogical acumen and includes many hundreds of useful exercises, remarks, warnings, illustrations of the dangers of naiveté, historical comments and physical illustrations. Literature references from the 19th and early 20th century abound, as do modern references through 1980. A particularly strong aspect of the development is the stress on physical, rather than mathematical, underpinnings for the introduction of "non-linear" terms in phenomenological equations. For example, in generalizing the diffusion equation to include the possibility of spatial inhomogeniety and a position-dependent diffusion constant $D(x)$ are we to write

$$\frac{\partial P(x,t)}{\partial t} = \frac{\partial}{\partial x}\left[D(x)\frac{\partial P(x,t)}{\partial x}\right]$$

or

$$\frac{\partial P(x,t)}{\partial t} = \frac{\partial^2[D(x)P(x,t)]}{\partial x^2}$$

Van Kampen refers to this ambiguity as the Itô–Stratonovich dilemma [K. Itô, Mem. Amer. Math. Soc. **4**, 51 (1951); R. L. Stratonovich, SIAM J. Control **4**, 362 (1966)]; it can arise in any nonlinear generalization of the Fokker–Planck or Langevin equation and in determinations of appropriate choices of variable discretization in the theory of path integrals. This latter relation to path-integral theory is, of course, not an accident given the stochastic nature of the path-integration measure.

In the latter portions of the book, van Kampen introduces a physically motivated systematic expansion technique for finding differential equations that may be expected to approximate reasonably the master equation in different physical situations. This work, related to van Kampen's own research, yields a procedure that avoids the Itô–Stratonovich dilemma. It leads naturally to a more systematic and sophisticated discussion of such topics as diffusion in inhomogeneous media, bistability, and critical fluctuations, and to applications to a wide range of physical and chemical problems.

The book has appeared at an auspicious time: It summarizes what is becoming a mature theoretical approach to a rapidly developing field. Current emphasis in non-equilibrium dynamics tends to focus on the detailed microscopic dynamics of non-linear and/or dissipative systems. The present work decidedly does not address the determination of such microscopic dynamics. It focuses instead on use of such knowledge to work up to the macroscopic level. Thus, it omits such concepts as path integrals (in spite of close relationships), renormalization, chaotic dynamics, universality, scaling, fractals and results of computer simulations, which are playing an increasingly important role in this area.

What is not done in the area of detailed dynamics, however, in no way detracts from the fact that van Kampen has written an excellent introduction to the use (and avoidance of abuse) of master equations. It should be in every physics and chemistry library. It would also make an excellent, though very expensive, text.

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Geometry, Particles and Fields

B. Felsager
643 pp. Odense U.P., Denmark, 1981.

The present volume is a welcome addition to the growing number of books that develop geometrical language and use it to describe new developments in particle physics. Although more technical treatments of differential geometry and of gauge field theories are available, Bjørn Felsager's book is a well-balanced introductory text. It provides a clear treatment that is accessible to graduate students with a knowledge of advanced calculus and of classical physics.

Felsager devotes the first half of the book to classical and quantum field theory, in particular, to electromagnetism and the changes brought about by the inclusion of magnetic monopoles. He discusses magnetic and Dirac strings and after developing Lagrangian and Hamiltonian mechanics, applies them to obtain the path-integral formulation of quantum mechanics. By starting with an infinitely long discrete string he develops the dynamics of classical fields. He also treats the Lagrangian and Hamiltonian formalism for relativistic fields, giving the standard applications—including the Cauchy problem—to the Klein–Gordon fields, the Maxwell field and the massive vector field. The book begins to develop its special character in the discussion of solitons and instantons. Felsager develops nonlinear field theory with degenerate vacua in the ϕ^4 model (topological charges and winding numbers appear here); solitary waves and the Backlund transformation; the Wick notation and the resulting Euclidian field.

The second half of the book deals with the principles of differential geometry and its applications, with a mathematical machinery of very wide range. Here clear line drawings and illustrations supplement the multitude of mathematical definitions. This section, in its clarity and pedagogy, is reminiscent of *Gravitation* by Charles