J. Indian Inst. Sci., Nov.–Dec. 1992, **72**, 579–584.

Book Reviews

Diffusion process and related problems in analysis: Vol. II–Stochastic flows edited by Mark A. Pinsky and Voker Wihstutz. Birkhauser Verlag, CH-4010, Basel, Switzerland, 1992, pp 347 + viii, SFr 98. Indian orders to Springer Books (India) Pvt Ltd, 67, Community Centre, Panchsheel Park, New Delhi 110 017.

The volume under review constitutes the proceedings of a conference held at the University of North Carolina, Charlotte, in March 1990, focussing on recent advances in stochastic flows. Volume I of this title is likewise the proceedings of an earlier conference at Northwestern University on diffusion processes.

A flow on a 'state space' S (usually a Euclidean space, a Banach space or a differentiable manifold) is a family of bijections $\{F_t\}$ from S to S indexed by the time parameter t, satisfying certain regularity hypotheses (usually a diffeomorphism, *i.e.*, a smooth map with a smooth inverse) and the group property:

$$F_t \circ F_s = F_{t+s}, \; F_0 = \text{identity}. \tag{1}$$

Here 'o' denotes the composition of functions. The parameter t may be either discrete ($t \in \{\ldots, -2, -1, 0, 1, 2, \ldots\}$) or continuous ($t \in R$). For discrete t, $F = (F_1)^t$ for $t \geq 0$ and $= (F_1^{-1})^{|t|}$ for $t \leq 0$. Thus, $\{F_t\}$ is simply the family of iterates of a function (for t positive) or its inverse (for t negative). For fixed $x \in S$, $F_t(x)$, $t = 0, \pm 1, \pm 2, \ldots$, can be considered as the trajectory of a particle which is at x at time zero and whose evolution is governed by the 'equation of motion' $x_{t+1} = F_1(x_t)$, $t = 0, \pm 1, \pm 2, \ldots$. For continuous t, such an interpretation is not obvious, but a standard source of continuous flows is indeed a well-posed differential equation $\dot{x}(t) = f(x(t))$. Here, $F_t(x) = x(t)$ when $x(0) = x$, $t \geq 0$ and $F_{-t} = (F_t)^{-1}$. Viewing $F_t(x) = x(t)$ as the trajectory of a moving particle, $\{F_t(x), x \in S, t \geq 0\}$ implies simultaneous consideration of one particle at each $x \in S$ or, in other words, a 'flow' of particles. The shift from (2) to the associated flow is simply a shift in one's perspective (which we owe to Poincaré). The qualitative theory of such flows has emerged as an important area of twentieth century mathematics, embodying a discipline that has come to be known as 'differentiable dynamics'.

The next level of complexity is to make $\{F_t\}$ random while retaining (1) and the regularity hypotheses. These constitute the stochastic flows. In analogy with the situation in deterministic flows, discrete stochastic flows are the iterates of random maps and the most interesting stochastic flows in continuous time are those associated with well-posed stochastic differential equations. The subject underwent rapid initial progress through the works of Bismut, Kunita, Harris and others in the late seventies and the early eighties. It continues to remain one of the directions of active research in stochastic processes. The present volume is a compilation of 15 'state-of-the-art' presentations on various topics in stochastic flows, further classified under five subheadings. A brief summary follows.

The first part, titled 'Diffusion processes and general stochastic flows on manifolds' comprises two extensive survey papers. The first, by Baxendale, surveys equilibrium behaviour of stochastic flows arising from stochastic differential equations. The second, by Elworthy, surveys stochastic flows on Riemannian manifolds. Equilibrium behaviour for stochastic flows is what 'attractors' are for deterministic motions and one sees a lot of analogy between the study of the two. An important concept here is the Liapunov exponent (rather, the stochastic version thereof), which, very very crudely put, does for nonlinear systems what 'modes' do for linear systems. Alternatively, it gives a clue as to how trajectories starting with different initial conditions behave in relation to each other for large times. Baxendale's survey is a succinct treatment of these issues. Elworthy's treatment in comparison is more geometric in nature.

The second part, captioned 'Special flows and multi-point motions' contains four papers. The first is a survey by Richard Darling of 'isotropic flows', *i.e.*, flows that retain translational and rotational invariance of certain statistical entities. The second paper by Liao deals with isometric flows. P. Sundar's paper studies time reversal of stochastic differential equations driven by Levy processes with implications to stochastic flows. Cinlar and Kao study flows with an additional feature that the particles can be generated or 'killed' stochastically. The last three papers are the authors' recent research.

Part III, on 'Infinite dimensional systems' has two contributions to the fledgling field of infinite dimensional stochastic flows. The first, by Mohammed, studies flows associated with stochastic affine hereditary systems. The second, by A. Mukherjea, deals with convergence in distribution of discrete stochastic flows generated by a class of infinite dimensional random matrices.

Part IV deals with the ergodic theory and structural stability of stochastic flows and contains contributions by Colonius and Kleimann (connections between the ergodic theory of s.d.e.s. and topological dynamics of an associated deterministic 'control system', in the spirit of the celebrated Stroock–Varadhan support theorem), M. Pinsky (singular perturbation analysis of a harmonic oscillator with a small noisy parametric excitation) and Wihstutz (singular perturbation analysis in the small mass limit of a Newtonian particle under multiplicative noise).

The fifth and final part on 'Iterated function systems' presents three research contributions to discrete stochastic flows. These are by Arnold and Crauel, Elton and Ezzine, and M. Berger, all dealing with various aspects of ergodic theory of discrete stochastic flows.

On the whole, this is a valuable collection of surveys and research papers. Coming at a juncture when the subject has not yet been codified into standard treatises and textbooks (the only treatise on the topic that I know of is Kunita's *Stochastic flows and stochastic differential equations*, Cambridge Univ. Press, 1990, which has a somewhat different emphasis), it is particularly useful as a sourcebook for an interested researcher or student. No library of any institution with an interest in stochastic differential equations and allied fields would be complete without this volume.

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Applied group theory for physicists and chemists by G. H. Duffey. Prentice Hall, Englewood Cliffs, New Jersey 07632, USA, 1992, pp 383, $ 88.30.

Symmetry arguments not only simplify a variety of physical and chemical problems but also lead to additional insights into the nature of the solutions. As a result, group theory is a core subject for post-graduate students and research scientists in physics and chemistry. There are several books available on the subject, some of which have become standard texts. It is indeed a challenging proposition to write another book on group theory without going over the same ground. The book under review represents an attempt.

The book is quite different from its predecessors both in terms of the organization of topics as well as in its overall emphasis. As the title implies, much of the book is concerned with applications of group theory. The basic concepts are covered rather quickly. For example, the critical topic of identifying spatial point groups is disposed of in less than a page of text and a flow chart, without any example being worked out! However, the brevity in introducing the subject is compensated by detailed discussion of applications to a wide range of problems.

In the first chapter, symmetry operations are discussed. The coverage is kept as general as possible, without being restricted to spatial symmetry. However, chemistry students would find it daunting to see simple symmetry operations discussed exclusively in mathematical terms. For example, operations like

rotation, rotoreflection, etc., are defined with their appropriate transformation matrices, but without any example or pictorial representation. The chapter contains interesting discussion of the structure of various groups in terms of generators and Cayley diagrams.

The second chapter deals with classes and characters. Two procedures for deriving the characters of groups are described. The importance of the orthogonality property of characters is emphasized.

The next chapters are applications of group theory to the problem of normal vibrations and symmetry-adapted stresses and strains of crystals. Fundamental group-theoretical concepts like matrix representations for the elements of groups, the direct product, etc., are postponed to later chapters. The development of these ideas is interspersed with applications.

A wide range of problems are considered in the remaining chapters. The simplification achieved by using symmetry in π molecular orbital theory is discussed with benzene as an example. Product groups are used for explaining the coupling of angular momenta and for deriving Clebsch–Gordon coefficients. Electronic states in systems with partially filled shells are obtained using permutation groups. Continuous groups and the basics of Lie algebra are presented in another chapter. Next, the SO(3) and SU(2) groups are considered in some detail. In the last chapter, these concepts are applied to problems in particle physics.

There are many features of the book I liked. First of all, the wide sweep of topics covered is impressive. The author does not restrict the discussion to the spatial point groups as is commonly done, but has given equal importance to spin matrices, rotation groups, space groups, etc The general tone is one of rigour and precision. There are numerous problems with solutions. The obligatory appendix of character tables is more exhaustive and is likely to be more useful. The print is clear and invitingly readable.

In spite of the above-mentioned merits, the book is not a good introduction to the subject. Some preliminary exposure is needed to fully appreciate the many interesting applications given in the book. Further, molecular structures are far too few in number, and those that are included are poorly drawn (*e.g.*, C_5H_5 on page 188). Applications involving specific molecules would have been more interesting than the abstract systems considered (*e.g.*, the vibrational problem of 'four equivalent mass elements bound equivalently to the corners of a square' is unlikely to enthuse a chemist). There is no mention of the role of symmetry for understanding chemical reactivity, arguably the most useful application in chemistry.

The book would be useful as supplementary reading material in a course and as a source of reference, but is likely to be affordable only to the more endowed libraries.

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Radon integrals by Bernd Anger and Claude Portnier. Birkhauser Verlag, CH-4010, Basel, Switzerland, 1992, pp 338, SFr 88. Indian orders to Springer Books (India) Pvt Ltd 67, Community Centre, Panchsheel Park, New Delhi 110 017.

The book deals with a unified functional analytic approach to Radon integrals. Let $\mathcal{F}$ be a cone of functions from a set X into $\mathbb{R}^- = \mathbb{R} \cup \{+\infty\}$ and μ a $\mathbb{R}^-$-valued function on $\mathcal{F}$. If μ is additive and positively homogeneous then it is called *linear* and *regular* if $\mu(s) = \sup(-\mu(t): t \in \mathcal{F}, -t \leq s) \; \forall \; s \in \mathcal{F}$. One defines μ^* and μ_* by: $\mu^*(f) = \inf\{\mu(s): f \leq s, s \bullet s\}$ and $\mu_*(f) = -\mu^*(-f)$. A *Radon integral* is a regular linear functional μ on the cone of all lower semi-continuous functions on a Hausdorff space X. A function f in this cone is called *integrable* if $-\infty < \mu^*(f) = \mu_*(f) < \infty$. This treatment applies to Radon measures in the sense of Choquet, Loomis' abstract Riemann integrals for positive linear forms, Daniell and Bourbaki integration theories as well as integration with respect to contents on lattices of sets.

The abstract theory of Radon integrals yields clarity in the Riesz representation theorems with convergence properties playing no role at all.

The authors introduce the concept of an *upper functional* which is an abstract version of an upper integral. Their integration theory is based on this concept.

A basic result of the book says that tight regular linear functional on a sufficiently rich cone of lower semicontinuous functions is represented by a unique Radon integral.

The book is well written; it is a must for anyone interested in abstract theories of integration. However, young readers may find the material dry and monotonous. Perhaps, shifting a few proofs to exercises would have helped.

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Prospects for interstellar travel (Volume 80, Science and Technology Series, American Astronautical Society) by John H. Mauldin. Univelt, Inc., PO Box 28130, San Diego, California 92198, USA, 1992, pp 370, $ 50.

This is a review of the prospects for interstellar travel, intended to be accessible to anyone interested in science, technology, space or the human future. It attempts to tackle a difficult subject like interstellar travel where all estimates can only be correct to within a factor of ten.

In the introduction, the author briefly mentions four possible model missions and estimates the comparative difficulty.

In Chapter 1 (Basics of travel in space), it is pointed out that chemical rockets, because of their comparatively slower velocity, seem to be out of the reckoning for interstellar travel. Rather, it is suggested that the interstellar spaceship be assembled in orbit. Planetary and stellar flybys for increasing speed by gravity to tens of km/s are also discussed.

In Chapter 2 (Advanced propulsion methods), solar-powered missions are considered. It is suggested that solar cells mounted on the starship may not provide sufficient power for interplanetary missions even with a close encounter (15 km) with the Sun. Nuclear fusion rocket drive based on the Project Daedalus study (a flyby of Barnard's star 5·9 light years away in 50 years at 0·12 light velocity) is described but this is only for a one-way robotic mission with a starship mass of 53,000 tonnes and a payload of 450 tonnes. Solar sailing has very good potential for small but slow (1000 years) missions.

Chapters 3 and 4 (Relativity and interstellar travel and relativistic drives and problems) cover the theory and methods for travel from about 0·2 C (60,000 km/s) up to light speed c itself. With such speeds the effects of relativity are noticeable but, more importantly, a round-trip mission to a star would be possible within a human lifetime.

In Chapter 5 (Starships as systems), a general description is given of the starship size and big heavy duty subsystems, the fine subsystems, the subsystems for basic human needs, subsystems for advanced human needs, staging and landing and optimization.

Chapter 6 (Missions) lists several stars which could be possible destinations for the interstellar mission: Epsilon Eridani (10·7 light years away), Tau Ceti (11·9 light years away), Epsilon Indi (11.2 light years away) and BD + 50 1725 (15·0 light years away). Both human and robotic probe missions are discussed.

Chapter 7 (Astrogation, observation and communication) covers the on-course navigation by star fixes using sophisticated instruments, active detection of dust particles and other obstacles, passive detection of other civilisations and communication with Earth.

In Chapter 8 (Technological requirements and hazards), closed systems and leakage, deterioration and reliability, conservation, repair and replacement, radiation damage, erosion and shielding, computers and self-reproduction, data storage, breakdowns and transport are discussed.

Chapter 9 covers the biological requirements for living in a starship. Included are physical requirements of life in closed systems, artificial gee, food and ecosystem, waste recycling, generations and lifetimes, radiation and other hazards to life and health.

In the chapter Personal, social and political considerations, the author points out that the starship would need to be built in a space colony to avoid a cost factor of 100 or more in launch costs. Other topics covered include: people for an interstellar mission, psychological considerations, command and community, social and philosophical context, political and economic context, cost estimates, and technical programs.

A complete chapter (11: Interstellar life and civilizations) is devoted to SETI (Search for extra-terrestrial intelligence).

Chapter 12 (Long-term prospects) discusses the possibilities of pushing technology well beyond current limits and the basic scientific breakthroughs needed.

This book aims to put in a practical perspective the vast amount of science fiction generated on interstellar travel. But the estimates of cost (money, manpower, material) confine the subject to one of sending a robotic probe only.

Perhaps reduced spending on military programmes may provide the resources for an interstellar probe. To quote the author, 'Already over ten trillion US dollars have been spent on military armaments, enough money to build ten space colonies or send a small interstellar probe instead. Surely, a modest mission to a star would provide more inspirational, philosophical, scientific and economic benefits to many nations than preparing for war has'.

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Spacecraft tables, 1957–1990 by Jos Heyman. Univelt Incorporated, PO Box 28130, San Diego, CA 92198, 1991, pp 266, $60.

A public record of space launches of all space-active nations from 1957 to 1990 is compiled in this wonderful book. The book contains a list of spacecraft owned by 23 user countries and eight international organizations spanning the globe. The satellites of USA, USSR (now defunct), other countries and also that of commercial organizations are grouped in four parts.

The information pertaining to various spacecraft can be retrieved from well-indexed tables in terms of date, name program, designation, country, organization, purpose of the mission, etc. Each table more or less begins with a headline explaining the purpose of a set of spacecraft included in the table, followed by individual entries of spacecraft and a short remark on each entry. For example: Table III.1.5: India/ other has two entries. The first entry is as follows: Name: Aryabhata, Int. Des.: 1975 033A, Launch date: 19.4.1975, Re-entry: (blank space indicates satellite still orbiting the Earth), Short notes: Astronomy and ionospheric studies. Likewise, Table I.B.7: Space Shuttle describes the spacecraft as a partly reusable launch vehicle of which four have been built (Columbia, Challenger which perished in an accident on 28.1.1986, Discovery and Atlantis). Apart from information on launch and re-entry dates, the accompanying note gives the names of astronauts, name(s) of spacecraft launched, and recovery of satellite, if any.

This is a good reference source for libraries, universities, the aerospace industry and all aerospace organizations requiring information on space.

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Table III.I.5: India/Other

Name	Int.Des.	Launch	Re-entry	Notes
Aryabhata	1975 033A	19/ 4/75		Astronomy and ionospheric studies
Apple	1981 057B	19/ 6/81		Ariane Passenger Payload Experiment; experimental communications

Table III.I.6: Indonesia/Palapa

Domestic communications satellite system.

Name	Int.Des.	Launch	Re-entry	Notes
Palapa-1	1976 066A	8/ 7/76		
Palapa-2	1977 018A	10/ 3/77		
Palapa-3	1983 059C	18/ 6/83		
Palapa-4	1984 011D	3/ 2/84	16/11/84	Failed to achieve correct orbit, recovered and relaunched as Palapa-6
Palapa-5	1987 029A	20/ 3/87		
Palapa-6	1990 034A	13/ 4/90		Refurbished Palapa-4

Table III.I.7: Israel/Offeq

Technology satellites

Name	Int.Des.	Launch	Re-entry	Notes
Offeq-1	1988 087A	19/ 9/88	14/ 1/89	
Offeq-2	1990 027A	3/ 4/90	9/ 7/90	

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