J. Indian Inst. Sci. 66, Aug. 1986, pp. 573-582
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BOOK REVIEWS

Space safety and rescue–1984-1985 edited by Gloria W. Health. (Proceedings of the seventeenth and eighteenth symposia, Vol. 84, Science and Technology series), American Astronautical Society, 1986, pp. 388, $ 55.(Orders to Univelt, Inc., P.O. Box 28130, San Diego, Ca 92128, USA).

The subject of flight safety and rescue has acquired special significance in the contemporary space activities since it has come to influence the planning and execution of many a space mission. In the case of manned space missions, to which this discipline owes its birth, the scope spans across a whole spectrum of activities, including terrestrial recovery, launch and reentry covering a gamut of engineering, technological and operational functions, that contribute to the human safety while in space flight. Added to this, is the development of emergency and rescue systems, which can conceivably provide the safe return of the flight crew once an emergency has recurred.

A brief historical perspective about the development of the subject is appropriate in this context. Flight safety and rescue as a formal discipline within a space program came into existence in late sixties after the tragic Apollo 204 fire. Investigation of the accident from the flight safety angle, across many of the organizations involved in the manned space flight activities, revealed at that time that space safety was not a clearly defined, organized and functional discipline. This led NASA to take positive steps to correct the situation by establishing a flight safety organization across the entire government structure and the sub-contractors concerned. During this period, many concepts of flight safety evolved from almost sixty years of experience in aviation safety.

In the subsequent years, scope and content of the flight safety and rescue discipline gradually expanded to cover many more areas. One such aspect relates to the environmental considerations arising from the increased use of space and the associated risk factors to both earth and space. Issues such as collision hazards due to space debris as well as increased satellite populations in geosynchronous orbits come in this category. Earth safety and disaster/distress response employing space-based systems, towards detection and management of life-threatening occurrences on earth represents another dimension to the subject.

Recognizing the special significance of the space safety and rescue in respect of its crucial role in many facets of space activities, the Committee on Space Safety and Rescue Studies of the International Academy of Astronautics (IAA) has been holding annual symposia on the subject. The symposia deal with identifying new safety challenges in future space systems, demonstrated safety methodologies besides fostering the development of new safety concepts. A total of eighteen symposia had been held so far by IAA over the period 1968–1985.

The book under review covers the proceedings of the 1984 and 1985 symposia sessions. The 1984 proceedings include papers addressing broadly three categories of issues: the first relating to space debris and their impact on spacecraft collisions in orbit, second on manned space safety and rescue and third pertaining to earth safety disaster/distress response employing space-borne systems. The paper by Ulrich Thomas on the space debris at geostationary altitude is an excellent review of the subject providing a critical updated appraisal on the geostationary orbit crowding, collision probabilities and means of minimizing the problem in future by removal of inoperational satellites by orbit raising or returning to low-earth orbits. The paper on orbit-life-time prediction and safety consideration by Jean La Fontaine and Rolf Mamen is likewise a good informative review highlighting the present status of the accuracy of orbit-life-time predictions for low-earth orbiting spacecraft. The 'Thirty year perspective on manned space safety and rescue' by Francis X. Kane is a detailed treatment of the development of the techniques of space safety and rescue and provides some reasonable projections for the next decade based on the same. The papers dealing with earth safety, disaster/distress response employing space-borne systems provide details and description of individual systems, both space-based and ground-based, of different countries. These form a component of one or the other of the existing international systems, *i.e.*, Search and Rescue Satellite (SARSAT), International Maritime Satellite (INMARSAT), the Soviet (COSPAS) system or possible future variants of these. The papers cover both the maritime and aircraft search and rescue systems.

The 1985 proceedings contain nine additional papers on the subject of SARSAT, COSPAS and INMARSAT earth safety, disaster/distress response employing space-borne systems. Two of the papers, one on 'Development and implementation of the future global maritime distress and safety system', by V. Bagdanov and the other by I. L. Fear on 'INMARSAT' role in the future global maritime distress and safety system' provide excellent reviews of the subject of maritime search and rescue. The paper by Ronald Wallace on 'Proposed new concept for an advanced search and rescue satellite system' makes an interesting reading in its ability to provide new ideas/concepts to reduce the response time in search and rescue situations. The analysis includes both the use of geostationary satellites as well as redundant polar stations for relaying the search and rescue information to SAR forces. The remaining eight papers in the 1985 proceedings deal with space station-related safety issues, manned manoeuvring systems for on-orbit rescue operations, and environmental implications of the solar power satellite concept. The ideas developed in these papers are of preliminary nature, and likely to undergo considerable evolution in future, since the systems concerned are futuristic and concrete configurations are yet to emerge. However, these papers provide considerable food for future thought. The paper by Peter E. Glazer on the Solar power satellite provides a very good review and addresses a number of key environmental issues that include effects on human health and safety, on the ecosystems and on astronomy. Further, legal issues are also discussed in the context of the need for evolving policies, international agreements and a consensus on the future course of development.

On the whole the proceedings present a highly readable set of papers that not only provide an excellent update on the main subject matter but also offers to the reader

excellent reviews on a variety of topics such as orbit-life-time predictions, geostationary-orbit crowding, SARSAT/COSPAS systems, Solar power satellite and aspects of manned systems.

The contents of the book are relevant to research workers, teachers, managers, policy-makers and specialists in space law. The book is recommended to every library interested in having a section on space research.

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Space station beyond IOC (Advances in Astronautical Sciences, Vol. 59) edited by M. Jack Friedenthal. American Astronautical Society, 1986, pp. 176, $ 40. Orders to Univelt, Inc., P.O. Box 28130, San Diego, California 92128.

The volume presents the proceedings of the 32nd Annual AAS International Conference held at Los Angeles, California, in November 1985. The conference being restricted to panel discussions only, without presentation of formal papers, the volume consists of the short abstracts of the material, submitted by the authors, or developed based on transcribed recordings.

The title concerns the decision of the United States in January 1984 to establish in space a permanent manned station. Since then the space station beyond initial orbital capability has been a subject of much discussion. The present volume considers the scientific, technological and application aspects of space station evolution. The introduction part comprises of the luncheon and the banquet addresses, which provide an outline of the space station program and the opportunities it offers, including the manned flights to Mars. Other headings under which the various topics have been divided are; space station evolution: the aerospace technology impact, the science potential, the planetary exploration potential, the application and commercialization potential, international cooperation in space station era and an abstract on humans and machines, the future. Overall, there are 26 abstracts covering these topics.

The major missions of the space station currently proposed are in the areas of solar and astrophysics, materials processing in micro-g environment, earth and life sciences, communication research and planetary manned explorations. The program envisages evolution of newer technologies in space transportation and electrical power systems for space station. It is also anticipated that the station will usher in a new era of space facilities and capabilities. The facilities, such as a permanent manned launch site, a manned service centre and both manned and unmanned facilities for scientific observations and experiments, and commercial products in space, will undoubtedly help in gaining a deeper understanding of the universe as well as our own earth – particularly the interconnections of sea, surface and atmosphere. The material spin-offs of the space station are also immense; these include evolution of improved metals, alloys, glasses and ceramics, and electronic materials; development of biotechnology, etc.

It is obvious that the design of a space station which could effectively accomplish the missions mentioned above has to be an immensely complex task and a technological challenge in itself. The program also envisages international cooperation – with Europe, Canada, and Japan – in accomplishing this gigantic project. In this context, the volume presents some of the preliminary ideas concerning the design philosophy of the station, to accomplish the missions mentioned above. However, since only the short abstracts of the discussions are presented, the volume has neither the rigour of a technical book nor the seriousness of the proceedings of a research conference. Furthermore, it is very likely that the actual system will be a substantially different version of the one conceived in 1985 which will depend upon the prevailing priorities and technologies. In this sense the book is of transient value only. The volume may provide some general information, at the best, to the workers presently engaged in the space station program, as it mentions in a nutshell some of the high stakes, and technological challenges involved in this venture. The volume is bound in hardcover but considering its contents, and transient use, is priced too high.

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Space exploitation and utilization (AAS Science and Technology Series, Vol. 60) edited by Gayle L. May *et al.* American Astronautical Society, 1986, pp. 724, Hard cover $ 70, Soft cover $ 55. Orders to Univelt, Inc., P.O. Box 28130, San Diego, Ca 92128, USA.

The volume presents proceedings of the First AAS/JRS Symposium organised by the American Astronautical Society and the Japan Rocket Society held in Honolulu, Hawaii during December 5-11, 1985. It includes six invited talks, 45 technical papers and five abstracts presented during the sessions on: national/international space programs, advanced space-based communication systems; remote sensing of the Earth; earth resources satellite technology; future trends in the development of launch vehicle technology; space-based manufacturing; future use of robotic technology for space applications; and astrodynamics. The papers are well presented and cover a wide range of topics.

The first two sections include comprehensive overview of space programs in Japan, U.S.A., Canada, China and Australia. Programmes of future cooperation are also discussed. The next set of papers deals with development of telecommunication facilities in the Pacific Basin including satellite based as well as submarine and terrestrial communication. Multibeam antenna satellites, fiber optics systems, mobile communication network for more efficient systems are suggested. Japanese innovative approach is apparent from the papers.

Under the section on remote sensing of the Earth, successful use of observations from LANDSAT for radiation temperature measurements, Earth's surface roughness, cirrus and snow fields are presented in three papers which are followed by a paper on Japanese meteorological satellite observations. A method is also proposed for removal of

atmospheric effects from remotely sensed data. Some hardware and software aspects of remote sensing satellite technology are discussed in the next four papers. Some of these papers should prove to be valuable source of information for persons involved in remote sensing.

The section on future trends in the development of launch vehicle technology presents some details of the present and the next generation of Japanese and U.S. launch vehicles. Some interesting and thought-provoking concepts on massive reusable vehicles for the future are also proposed. The new concepts include a two-stage air-breathing rocket TSTO/HTOHL, a heavy lift launch vehicle, and phoenix.

Space-based manufacturing and commercialisation will be an area of significant importance during the coming years. Interest of Japanese industry, manned role in space-based material processing, and industrial use of space resources are presented in detail in three papers on the topic. The last paper discusses many interesting proposals.

Robotics has generated considerable interest during the last few years. A set of six papers deal with future use of robotic technology for space applications. Concepts, design and development of robots for use in space stations are discussed. One paper considers robot plantation on the moon. One presentation deals with the U.S. Congressional view on robotics for space station.

The presentations, in general, concentrate on design considerations, mission planning, technological issues and therefore are descriptive in nature. The last section on astrodynamics, however, departs from this trend and includes ten research papers with analytical details and simulation results. The topics covered include: parameter identification in distributed space structures, effect of solar radiation pressure, deployment and slewing of flexible structures, atmospheric effects on rockets, optimal control laws, dispersion studies using Monte-Carlo methods.

The volume is informative and is a valuable reference document particularly for designers of systems in the Pacific region.

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Eingenvalue distributions of compact operators by H. König. Volume 16 in Operator theory–Advances and applications, Birkhäuser Verlag, CH-4010, Basel, Switzerland, 1986, pp.262, SFr 68. Indian orders to Allied Publishers Pvt. Ltd., New Delhi 110 002.

The central theme of the book is the asymptotic distribution of eigenvalues of Riesz operators on Banach spaces. Classical results pertain to the works of Fredholm, Shur, Carleman, Hilbert-Schmidt, and Hille-Tamarkin. Gohberg-Krein's book appeared in 1969. Birman-Solmjak in their 1977 survey paper treated the case of weighted kernel operators on unbounded domain.

In late 1940s Schatten p-classes were introduced. Most results after 1949 are based on

Weyl's inequality. Nuclear operators on Banach spaces were studied by Grothendieck (1955). Other significant contributions were the two volumes of J. Lindenstrauss and L. Tzafriri in the years 1977 and 1979 respectively. Two more significant books by A. Pietsch are available. The first one is on Nuclear locally convex spaces, (Springer, 1972) and the second one is about Operator ideals (North Holland, 1980), in which the general theory of operator ideals is presented. In 1974, A. Pietsch introduced the concept of s-numbers $[s_n(T)]$ of operators in Banach spaces as an axiomatic generalization of the singular numbers of Hilbert space maps. $\pi_{p,q}(X,Y)$ denotes the (p,q) summing operators. For $p = q$ we get the p-summing operators, π_p. Asymptotically optimal results on the distribution of the s-numbers of π_p, $\pi_{p,q}$, S_p operators in Banach spaces were proved by (i) W. B. Johnson, H. König, B. Maurey, and J. R. Rutherford (1979), (ii) H. König, (1980), (iii) H. König, J. R. Rutherford, and N. Tomczak-Jaegerman (1980).

In the first chapter, the Riesz-Schauder theory of compact operators is reviewed, in the more general setting of power-compact operators and Weyl's inequality for the eigenvalues of compact operators on Hilbert spaces is proved and Schatten p-classes are introduced. For integral operators to be in Schatten p-classes for $p \neq 2$, easy characterizations are not available. The s-number ideals S_p, Banach spaces with extension property are treated and Khinchine's inequality is proved. The Lorentz spaces $l_{p,q}$ provide an important class of [illegible] spaces. The Pietsch representation theorem and Pietsch factorization theorems are proved. This enables us to reduce the eigenvalue estimates for operators on Banach spaces to operators on Hilbert spaces. The π_p and $\pi_{p,q}$ operators are characterized for $1 \leq p < \infty$. Pietsch extended the concept of singular numbers of operators on Hilbert spaces to operators on Banach spaces. The approximation numbers, Weyl numbers, Gelfand numbers and entropy numbers are defined and shown to be multiplicative, and other properties are proved. Classical approximation theory yields estimates for the approximation numbers of integral operators with differentiable kernels. The Weyl numbers of integral operators with some summability conditions are later estimated.

The operators in N_q, π_q and $\pi_{q,2}$ and the ideals S_q^a and S_q^s form extensions of Schatten classes to operator ideals on Banach spaces. The main topic of the second chapter is the natural question: "What is the optimal order of summability of the eigenvalues of the above classes of operators on Banach spaces? Weyl's inequality is extended to the above operator ideals on Banach spaces. The key result concerns S_p^s or $S_{p,q}^s$. Pietsch proved that the maps in S_p^s have p-th power summable eigenvalues. Weyl number ideals are large enough to allow a flexible approach in applications. The Weyl ideals are natural and most useful. It can, therefore, be concluded that eigenvalue theory in Banach spaces is no longer a 'zoo' as Simon still seems to feel. Next, some interpolation results for the Weyl-number ideals are derived and these are needed for applications to integral operators on function spaces. Estimates of eigenvalues of single Riesz operator by entropy numbers are considered. All estimates are 'upper'. 'Lower' estimates are difficult to obtain. Motivated by some arguments of König, Weyl numbers in the more general setting were introduced by Pietsch. Applications in chapter III show that the order of decay of eigenvalues of $\pi_{p,2}$ operators is optimal in general. It is shown that S_p^s,

$\subset \pi_{p,2} \subset S^q_{p,\infty}$. Optimal asymptotic estimates for the eigenvalues of π_p and nuclear operators are derived. The order of decay of nuclear operators depends on the geometry of the Banach spaces. For $1 \leq p < \infty$ and $q = \max(2,p)$ a π_p operator is shown to be a Riesz-operator with q-summable eigenvalues. Pietsch's proof is presented.

Real interpolation theory has been used for eigenvalue estimates in Banach and Hilbert spaces. Interpolation theory of the ideals $S_p(H)$ was presented by Gohberg and Krein. The more important theorems proved here are the reiteration theorem and the s-number theorem of König and Pietsch.

By estimating entropy numbers of diagonal maps it is shown that a stronger version of an important result of Carl (comparing eigenvalues and entropy numbers) is the best possible. A generalization of the spectral radius formula is obtained.

The purpose of chapter three is to determine the asymptotic distribution of the eigenvalues of integral operators in function spaces. Two different types of conditions are imposed on the kernel k. If the conditions are stronger, eigenvalues will tend to zero faster. The main aim is to illustrate the usefulness of the results of the previous chapter rather than to present the results in the most general case. In more complicated situations involving many indices of Besov spaces the estimates of s-numbers get more tedious, but the same basic scheme applies. Pietsch treats up to 10 indices when the kernels belong to vector-valued weighted Besov spaces. Summability conditions on the kernel are imposed, Hille-Tamarkin kernels are considered. The estimates are often shown to be asymptotically best possible. The author next considers more regular kernels which are elements of vector-valued Sobolev or vector-valued Besov spaces. Interpolation spaces between L_p-spaces and Sobolev spaces are next characterized. Minimally smooth open sets are defined and results are generalised. Moduli of continuity are used to define equivalent norms on $B^{\lambda}_{p,q}(\Omega,X)$. Standard imbedding and extension theorems for scalar-valued Sobolev spaces are needed to estimate the Weyl numbers of Sobolev imbedding maps. Results on piecewise polynomial approximation and discretization techniques are used and operators with values in smoother B-spline spaces are considered, to prove general s-number estimates of Sobolev imbedding maps. The main result here concerns Weyl numbers of Sobolev and Besov imbeddings.

The result due to Pietsch asymptotic distribution of eigenvalues of integral operators defined by differentiable kernels belonging to Sobolev or Besov spaces is optimal and an application to convolution kernels yields optimal estimates for the Fourier coefficient of functions in Besov spaces. Weekly singular operators with general kernels are studied. Eigenvalue theorem for vector-valued Besov kernels is the main result. Similar results for unbounded domains, assuming the kernel and its derivative decaying fast at ∞, can be proved. Pietsch proved optimal asymptotic eigenvalue estimates in some cases of his 10 indices involving logarithmic terms. The entropy numbers are used to derive some results. The Sobolev spaces satisfy $W^s_u(\Omega) \subset B^s_{u,v}(\Omega)$. Result about vector-valued interpolation can be extended to Sobolev spaces. Extensions to unbounded domains are proved. These asymptotic estimates are used to treat convolution kernels in Besov spaces. We get asymptotic estimates for Fourier coefficients of Besov functions. Two examples are presented to show that these results cannot be improved. Finally results on general metric spaces are mentioned.

Applications of results about eigenvalues of Riesz operators to the problems in the theory of Banach spaces are presented in the last chapter. One of the important questions is of the existence of trace of an infinite dimensional Riesz operator. Hilbert spaces are characterized by the absolute summability of the nuclear operators. Constructions of projections of minimum norm on to finite dimensional subspaces are presented.

The important notion of trace for finite rank operators on infinite dimensional Banach spaces can be defined. This matrix trace is equal to spectral trace. For Banach spaces with approximation property trace can be defined for nuclear maps. There are Banach spaces without approximation property (Enflo). The main problem is that eigenvalues are, not in general, absolutely summable, but only square summable. Quasi-Banach ideals and uniform Riesz type I ideals are defined and examples presented. Lidskii's theorem about trace formula is presented. Banach spaces with unconditional basis are discussed. Using Lindenstrauss-Tzafrari theorem, it is proved that *only on* Hilbert spaces, nuclear operators have absolutely summable eigenvalues. The estimates of Kadets-Snober about the projection constant of n-dimensional subspaces is shown to be asymptotically best possible. The complemented subspace theorem is presented.

The author's claims that the book is self-contained and readable by any mathematician with basic knowledge of functional analysis and that it could be useful as a text are more or less true. I feel that it could be useful for a course at the M.Phil. level in good Indian universities. For a person with strong desire to get a feel of operator theory and particularly those who wish to see applications to eigenvalues of integral operators, this book would be a pleasant reading.

The book is well-planned and the author has succeeded in amply demonstrating the importance of methods from geometric theory of Banach spaces to prove asymptotic estimates for the eigenvalues of certain Riesz operators. With 130 references cited, it will serve as a valuable reference source. The citations are very up-to-date. In addition to several references up to 1984, there is one from 1985, another from 1986 and one more of the author's own papers which is to appear in an Israel journal.

Only one final remark. Many results are contributions of A. Pietsch. The author has seen a manuscript of his forthcoming book treating similar and other topics. *Is it really* necessary to have two books at advanced level which are so close to each other in spirit? Would it not have been better to have a combined one?

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Ergodic theory of random transformations by Yuri Kifer. Birkhauser Verlag, P.O. Box 133, CH–4010, Basel, Switzerland, 1986, pp. 210, SFr. 68.

In the classical sense, ergodic theory consists of studying the asymptotic behaviour of the sequence $T, T^2, \ldots, T^n, \ldots$ of transformations obtained by repeated application of a single

transformation T of a space X, the latter being equipped with a measure structure preserved by T. The individual ergodic theorem (asserting that the time averages $n^{-1}\sum_{j=0}^{n-1} f\circ T^j$, where f is an integrable function, converge almost everywhere to the space averages $\int f$, under a natural condition called ergodicity to be satisfied by T > spectral analysis of ergodic systems, the notion of entropy are some of the main features of the theory. The ergodic theorem also culminated into the multiplicative ergodic theorem which involves studying asymptotic behaviour of the 'size' of the product of the n matrices $f(x), f\circ T(x),\ldots, f\circ T^{n-1}(x)$, where f is a function whose values are nonsingular matrices; the theorem plays an important role in studying various physical systems.

Relatively recently ergodic theorists have also studied similar questions for actions of groups of transformations, especially for amenable locally compact groups. Philosophically, this amounts to a more general notion of 'time'; however, the transformations involved or 'the process' is still deterministic.

In contrast to this, one may consider a sequence of transformations T_1, $T_2\circ T_1,\ldots$, $T_n\circ T_{n-1}\circ\ldots\circ T_1,\ldots$, where each successive element is obtained by applying to the previous one a transformation chosen 'at random' from a class $\mathcal{C}$ of transformations of the space X. (The randomness being with respect to a fixed distribution on $\mathcal{C}$). For instance, one could have all T_is to be small (independent) random perturbations of a fixed transformation T, in which case the study throws light on accumulation of errors after repeated application. On the other hand, the set up generalises the study of random walks, popularly exemplified by drunkard's walk.

We can then ask to what extent the deterministic theory generalizes to the above set up. Though there have been papers dealing with various specific questions falling in this category, the book under review may be considered the first comprehensive treatment of the subject. After briefly introducing the necessary background material (some details are included in appendices) the author goes on to give appropriate generalisations of the ergodic theorems, notion and properties of entropy (both metrical and topological), pressure, characteristic (Lyapunov) exponents, etc., and then a random version of the multiplicative ergodic theorem, which may be considered a high point of the theory. It is also shown that, under certain natural conditions, no randomness is left in the limit (in a certain natural sense of which we will not go into the details). This has implications to asymptotic stability under independent random perturbations mentioned above. There are also applications to various physical systems. In the concluding chapter the author applies the theory to random diffeomorphisms and stochastic flows.

It is imperative that such a work involve considerable technical machinery both from probability theory and (conventional) ergodic theory. The author clarifies in the introduction that the book is addressed to mathematicians working in these areas but adds that it can also be read by graduate students with some background in them. Inevitably the book is difficult to understand; unfortunately, this feature is only

enhanced by the author's choice of notation, style, etc., However, it caters to a flourishing area of research and would serve as a very useful reference.

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Published by T.K.S. Iyengar, Executive Editor, Journal of the Indian Institute of Science, Bangalore 560 012.
Typeset and printed at Phoenix Printing Company Pvt Ltd, Attibele Indl Area, Bangalore 562 107.