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Book Reviews

Culture, excitement and relevance of mathematics by V. Krishnamurthy. Wiley Eastern Ltd, 4835/24, Ansari Road, Daryaganj, New Delhi 110 002, 1990, pp 327, Rs. 300.

This is an unusual book There is no better way to give a flavour of what it is all about than to quote from the opening paragraphs of the author's preface—"The largest clientele of undergraduate courses in mathematics consists of those who will ultimately graduate in subjects other than mathematics. But their undergraduate curriculum . never reaches that much of sophistication or depth to give them any idea of what lies beyond. They forever miss the culture that runs through the fascinating branches of 20th century mathematics. It is the conviction of the author that this large clientele, before they fork away from the foundation courses into their own discipline specialization, or before they graduate, should be exposed to a bird's eye view of 20th century mathematics, its culture, the structural interconnections of much that is called advanced mathematics, the excitement attendant with many of the 'unsolved' problems, the relevance of even apparently very abstract mathematics and the undercurrent of unity of a large part of modern mathematics, though camouflaged by the innumerable techniques that are doled out to the user." As for the state of affairs depicted at the beginning of this quote, the present reviewer (an engineering graduate) can vouch for its veracity, having had to rediscover his high school interest in mathematics during his Ph D days after having all but lost it thanks to the cookbook-style mathematics that passes by the name of engineering mathematics

With this noble aim in mind, the author embarks upon the daunting task of giving a perspective of twentieth century mathematics to a literate non-mathematician The first chapter is historical in nature, predictably beginning with ancient astronomy as mother of mathematics and quickly racing through the centuries that led to modern mathematics. The next chapter, titled 'The nineteenth century revolution in geometry', has a section on the parallel postulate of Euclid and the controversies surrounding it, and one on non-Euclidean geometries The third chapter describes the foundations of set theory and the controversies and drama that surrounded it early this century It has an interesting digression on Nicholas Bourbaki, the *enfant terrible* of modern mathematics Chapter IV, on counting and enumeration, describes the 'necklace problem' and goes on to describe applications of combinatorics to chemical isomers and DNA sequence recovery. Chapter V on modern algebra introduces finite fields and algebraic coding theory. Chapter VI on topology opens with a nice historical section on the great problems of low-dimensional topology, aptly titled 'From Poincare to Donaldson' After a brief account of the basic concepts of topology, it goes on to discuss at length the Euler–Poincare characteristic, probably the unique choice of most topologists as the show piece of their subject for the lay public. The last section gives a short account of homotopy theory Chapter VII describes the developments surrounding the much-publicized four-colour map problem, culminating in its controversial computer-assisted solution. Chapter VIII, titled 'Srinivasa Ramanujan', gives a brief biography of the genius and describes the aspects of number theory which bear a lasting imprint of the man's contributions. Chapter IX is titled 'Power of generalization and abstraction: functional analysis'. It begins with a digression on Ramsay theory, inserted to motivate the tendency to generalize in mathematics. Functional analysis is quoted as a prime instance of this and is briefly introduced, particularly in connection with quantum mechanics to which it owes its explosive growth A short overview of some prime areas of functional analysis concludes the chapter. The final chapter concludes with two sections—one on the Fields medal, the equivalent of Nobel Prize in mathematics (in prestige, though not in money) and one on some topics not covered in the book.

There are many things about this book that one can rave about. The foremost is its lucid style, without which the venture would have fallen flat on its face (I have not heard the author lecture, but he must be a great teacher) I also liked the two-layered arrangement of the material There are extensive and reasonably detailed accounts of some of the more accessible ideas, interspersed with less detailed, semihistorical accounts of what lies beyond The level of the book is above that of an ultra-popular sort like Court's *Mathematics in fun and in earnest,* but below that of the more technical accounts such as the 3-volume *Mathematics its content, methods and meaning,* edited by Aleksandrov, Kolmogorov and Lavrent'ev It is also quite distinct in its flavour and organization from other books in similar spirit, such as *What is mathematics?* by Courant and Robbins and *Mathematics and logic* by Kac and Ulam An extensive bibliography is an additional asset of the book

Another positive aspect of this book merits a comment. Mathematics is a lonely and strenuous exercise and the relative merits of works of mathematics are not always obvious (except perhaps in case of the exceptionally good and the exceptionally bad ones) This makes mathematicians egocentric, prone to critically 'evaluate' other mathematicians and branches of mathematics other than their own. This almost always leaves some overtones in 'general' books written by mathematicians, be it an autobiography or a popular treatment. (Pathological instances are Halmos's *I want to be a mathematician* and Diudonne's *A panorama of pure mathematics*) The book under review is exceptional in not being so The author comes across as an admirer of mathematics forever in awe of the subject, rather than as a self-styled judge sitting on top of it, passing judgements on all and sundry

A book of this type obviously entails some selection among the topics that can be covered and this will naturally be dictated by the author's own interests The book, as the sketch of contents given above suggests, is heavy on algebraic/combinatoric mathematics (even the chapter on topology is dominated by algebraic topology) with functional analysis coming a close second As the jacket indicates, these are precisely the author's research interests. Omissions are many and any mathematician reading the book is likely to remark on omission of some subject or the other dear to him Thus, while granting that writing a book like this covering the entire gamut of modern mathematics is impossible in this day and age, I would like to register a mild disappointment over two omissions — dynamical systems theory with its high profile spin-offs such as 'chaos' and 'strange attractors', and my own bread and butter, probability theory

Negative points are few. There are occasional typographical errors that need to be weeded out in subsequent editions. Also, an occasional sentence jars, particularly early in the book, because it conveys nothing unless the reader already has more familiarity with the subject than what he is supposed to have This is perhaps unavoidable to some extent given the delicate act of balancing the author is attempting between the popular and the technical, and can definitely be amended by supplementary discussion in any course based on this book I also found a bit odd the choice of Ramsay theory to illustrate the power of abstraction and generalization that led to functional analysis. An example from functional analysis itself would have been more appropriate, with Ramsay theory being discussed separately.

To conclude, this book gives a kind of course on modern mathematics which I would have loved to have gone through as a student. Those who did are lucky Those who didn't, should read this book

Department of Electrical Engineering V S. BORKAR
Indian Institute of Science
Bangalore 560 012

Huygens and Barrow, Newton and Hooke by V. I. Arnold. Birkhauser Verlag, CH-4010, Basel, Switzerland, 1990, pp 118, SFr 118. Indian orders to Springer Books (India) Pvt Ltd, 6, Community Centre, Panchasheel Park, New Delhi 110 017.

Newton agreed to take on the position of President of the Royal Society only after the death of Hooke in 1703 One of the first acts of Newton in this position was to destroy all the instruments of the late Hooke and also his papers and portraits. So the Royal Society now has portraits of all its members except

Hooke Not one drawing of Hooke, who was a member, Curator (for forty years) and Secretary of the Royal Society, was preserved A recent portrait in the folder of Hooke's biography had to be made up by the methods of modern crime detection from verbal descriptions of Hooke! This speaks of the enemity Newton nurtured towards Hooke Why was this? How did Newton and Hooke come into conflict? Hooke was a very skilful experimenter On suggestion from Newton he performed experiments to find the trajectories of falling bodies on the earth He found that Newton's arguments regarding the trajectories of a falling ball were not very correct He wrote a letter to Newton about this matter Apart from the account of his experiments, this letter of Hooke contained the following important words "My supposition is that the attraction always is in duplicate proportion to the distance from the centre reciprocal, and consequently that the velocity will be in subduplicate proportion to the attraction and consequently as Kepler supposes reciprocal to the distance . " From this letter, which is reproduced in detail in this book, Arnold argues that the inverse square law is apparently the Hooke theory of attraction that he mentioned in his earlier letter (also reproduced in the book) to Newton Not only this, in this second letter Hooke had even suggested to Newton that he with his superior methods can check that Kepler's first law also follows from the inverse square law Newton did not reply to this letter. Nearly after six years in 1686 he wrote *Principia Mathematica* which was essentially written to solve the one-off problem, namely, the problem of motion in a force field inversely proportional to the square of distance from an attracting centre Arnold points out that Hooke's first letter to Newton on November 24, 1679, was essentially the start of the history of the law of universal gravitation *Principia* thus arose from the conflicts and scientific interactions between Hooke and Newton. Did Newton refer to Hooke's letters in *Principia*? There was no mention of Hooke or any acknowledgement to his letters anywhere. The history of Newton's *Principia* contained in the story of Newton and Hooke forms the first part of the book.

The beginning of mathematical analysis coincides with the time of publication of *Principia.* Newton expressed the laws of nature by the differential equations and discovered powerful techniques to solve these equations The main mathematical discoveries in analysis made by Newton had their roots in his training in mathematics from his teacher Issac Barrow, who was lecturing in mathematics at Trinity College, Cambridge Barrow's book, based on his lectures, appears to be actually devoted to the Newton–Leibniz formula which Barrow could not have known, since this happened twenty years before their first publications. The first publication on analysis in 1684, however, was due not to Newton since he did not publish his discoveries in this field, but to Leibniz. A very interesting section about the rivalry between Newton and Leibniz is written in the second chapter Newton was very seriously concerned with questions of priority Somewhat earlier he had stated the following principle: each person must one day make a choice — either to publish nothing or to devote all his life to the struggle for priority For himself Newton apparently also made his decision on this, choosing both policies together: he published hardly anything, and he was constantly struggling for priority. As for the invention of analysis, here the first publications were due to Leibniz, who said that he developed his differential and integral calculus independent of Barrow and Newton Nevertheless, discussion on this point gave rise to a very ugly dispute between Newton and Leibniz Leaving the sad episode of priority of invention of analysis among Newton, Leibniz and Bernoulli, a pupil of Leibniz, Arnold goes on to discuss very interesting geometrical works of Huygens in solving essentially the same problem as Barrow and Newton that led to the creation of analysis

The last part of the book is devoted to discussion on the main concrete achievements presented in the *Principia* and series of triumphs for the law of universal gravitation in the development of celestial mechanics The history of origin and the contents of *Principia* will not be complete without looking at remarkable mathematical contributions made by Newton. In the *Principia* there are two purely mathematical pages containing an astonishingly modern topological proof of a remarkable theorem on the transcendence of Abelian integrals. These theorems are discussed in the last chapter.

The book ends with interesting notes on all the references made in the text.

Arnold, in this short and very engaging book, relates the story of the history of *Principia* to the readers. No doubt, the main role in this story is played by Newton but the roles of Hooke, Barrow and Huygens cannot be forgotten. In not acknowledging this fact, Newton no doubt behaved less scrupulously in his dealings with his co-workers and contemporaries

This book will be very useful in the study of history of science It can be read both by scientists and non-experts with equal enthusiasm and interest. It certainly manages to leave the readers awed by the combination of an inferior personality and a super mind

Department of Mathematics
Indian Institute of Science
Bangalore 560 012

C UBEROI

The case for Mars III: Strategies for exploration — General interest and overview (C. Stoker, ed). **The case for Mars III: Strategies for exploration — Technical** (C. Stoker, ed.), American Astronautical Society Science and Technology Series, 1989, Vol. 74, pp 743, $ 75 and Vol. 75, pp 646, $ 70. Orders to Univelt Inc., P.O. Box 28130, San Diego, California 92128, USA.

These volumes represent the proceedings of the Case for Mars III Conference, the third in the series, held on July 18–22, 1987, at Boulder, Colorado, USA

Space policy marketing is proposed to vigorously project the case for Mars to the elements of a participatory democracy noting that the US Congress would definitely play a major role in the decision to go ahead with a manned Mars mission (MMM). A separate workshop on space policy marketing was held to decide on and implement a strategy to vigorously market the space policy. It is suggested that the 500th anniversary of the discovery of America (1992) should be the proper time to decide on the MMM programme.

Educational perspectives are also stressed considering that a focal theme such as *Mars exploration* could probably help the Americans to overcome the crisis in education currently being felt in their universities and colleges Realizing that the future belongs to students, NASA and the aerospace industry are planning to organize a large number of interdisciplinary courses including some about Mars

The social implications of MMM are outlined by Hofgard The Apollo missions cost $ 30 billion The MMM is expected to cost $ 189 billion till 2030. Funding from various participating nations is optimally proposed, or alternatively an endowment type of fund-raising method is also suggested. Political considerations for going to Mars are given a good deal of priority. Byerly Jr considers the major decisions already taken and concludes that 'we need to make a decision through a process of open debate' Apart from the Space Station, there is no other major programme in the 1990s, hence 'NASA should go all out to develop another major initiative' White and Staehle suggest that NASA should examine options and make ready the groundwork for future missions Economic issues for financing a Mars programme are covered in three papers Smith feels that there should 'be a clear national objective and White House support'. Leonard *et al* feel that the possibility of finding volatiles such as carbon, water and nitrogen on Phobos and Deimos, the two Martian moons, could reduce the expense of exploration. Their paper estimates the cost of shipping volatiles from Phobos/Deimos (Ph/D) to low-Earth-orbit (LEO) compared to that of shipping from Earth and finds the former less expensive They feel that a 10% return on capital could be realized Since most of the technologies needed to mine Ph/D are already developed, the Ph/D approach to Mars is considered important Cordell proposes that a mission to Ph/D should be implemented *first* He points out the several advantages of a Ph/D manned mission apart from the cost advantage accruing due to mining and propellant production on Ph/D and stresses the need for creating public awareness of this mission: 'The primary aim of a Ph/D mission is the exploration of the surface of Mars'. The added advantage of doing Mars science studies from Ph/D is that the ecology of Mars would not be tampered with. Ph/D are more accessible every two years almost as accessible as geostationary earth orbit (in terms of propulsive requirements) Further, the chemically propelled Mars lander version requires two times more weight in LEO than a manned Ph/D spacecraft. Unlike the missions to the Mars surface, Ph/D missions will contribute even more to the larger development of space exploration of the solar system. O'Leary suggests use of the 1999 opportunity (of maximum accessibility) as a year ideal for the Ph/D mission using the Shuttle cryogenic tank He feels that a space industrial infrastructure could more easily develop in this scenario than in other scenarios. It appears that Deimos is the better target, marginally preferred for early science missions, because of its orbit around Mars If an early manned sortie to the equatorial regions of Mars is planned, Phobos is better. The recommendations of the Ph/D workshop were that (1) An unmanned sample return mission to Ph/D should be executed before the end of the 1990s, (2) More research into propellant production utilizing carbonaceous chondrite materials is needed, (3) The environmental challenges in dusty environments should be studied, and (4) A robotic propellant plant based on the moons should be studied, amongst other recommendations The Ph/D path to Mars exploration should be considered in view of its advantages

The deliberations on international cooperation are summarized by Michaud who advises against the 'mad dash' or 'one-shot' model but is undecided whether the decision should be first political or technical The consensus arrived at is that both the sides (the US and the USSR) could go parallely without technology transfers, but in separate space vehicles, to take care of the most serious problem of technology transfer This could include contacts on the ground on mission planning, etc , and thereby ensure cooperation for complementary, parallel, coordinated and mutually supportive missions to Mars Data could be exchanged and a division of labour could be worked out, but the spacecraft would not be jointly built or crewed: for example, two Soviet spacecraft could fly parallely with two US spacecraft One of the best ways is to use the US National Security Space Programme which is a major ($23 billion in 1987) programme, already developing several of the technologies required An MMM would require ten times more weight to be launched into LEO than at present. The Advanced Launch System programme, already underway in the US can take care of this, with the SP–100 power system development Environmental hazard studies (against cosmic rays, etc.) already in progress can be made use of Various other friendly countries could also be included, depending on the funding they wish to give based on their percentage of the gross global product

The scientific goals for going to Mars are covered in detail Levine *et al* point out that the results and interpretation of the Viking lander data which had negatived the possibility of life at the lander sites, are subject to ambiguity, and although the search for life and Mars does not have the priority it had two decades ago, the search is still on They propose a search using either spectrometric measurements from a Mars orbiter or *in situ* measurements from a Mars rover, for the presence of specific trace gases which could be present only due to microbial life. Precursor missions have been proposed prior to the MMM for 'precursor science'. Precursor missions and rover technology are mainly related to the Mars rover/ sample return mission. O'Donnell *et al* describe the energy considerations for a robotic Mars surface sampler. The use of lunar-derived propellants is considered important for MMM. Lunar base operations have been covered in detail by a separate working group In this approach, a lunar oxygen supply of 1100 tonnes from the mined regolith from 71,000 tonnes of lunar mare would have to be mined to generate oxygen and delivered to the libration point L1. This approach is cost effective compared to the use of Earth-supplied oxygen and may save up to 200 tonnes of oxygen per year. Alternative transportation techniques in Earth–lunar space may reduce the Earth lift-off mass The evolution of the present space station (Freedom) has been considered and a separate space station for quarantine has been proposed. Software considerations on flight dynamics, Mars mission opportunities and computer support requirements for the MMM have been discussed. A wide range of science problems can be studied on Mars. The planet has had a long and complex history similar to that of the Earth, but the origin and evolution of the atmosphere are different to that of the Earth. Life may have started early in the planet's history and may have then become extinct In the end, the most important lessons that Mars may teach us will only be found when we live and work on Mars by looking for traces of prebiotic evolution on Mars with additional observations from roves and an equatorial Mars Observer Mission.

The mission strategy for the MMM is considered in several papers. French points out that CFM I and II had recommended a permanent Mars base. Earlier, chemical propulsion had been proposed for the vehicles, which required large masses launched into the Earth orbit Mars resource utilization for propellant generation and habitat use is an important method for minimizing costs (a 25% reduction by fuelling at

Mars of payload weight to LEO). This subject has been treated in depth Drawings of a gaseous extractor which pulls in Martian air, compresses it and provides breathable air and rocket fuel are given Ash *et al* provide the design for the Mars oxygen processor Nuclear rockets using Martian propellants, for reducing the mass required in LEO, can refuel themselves every time they land on Mars Solar energy can be used on the Martian surface in spite of the dust, by photovoltaic power conversion if a method can be found to overcome the problem of dust accumulation on solar cell surfaces. The use of robots on a large scale is advocated to assist humans on the surface of Mars, including 'Bootstrap robots' (which can even extract materials from the surface and convert them into finished products).

Mobility on Mars is considered, with a proposal for a Martian aeroplane The use of carbon monoxide from Martian resources for propulsion of the takeoff engines providing a 285 s specific impulse (Isp) could allow a hyperbolic escape trajectory, and sufficient spare weight to allow thermal protection tiles to be fitted for aerobraking on earth return Details are given of a 6000- and a 16,000-lb vehicle fuel cell power supply system for manned transportation

Human habitat concepts on Mars are described in detail and designs are given in several papers. A modular system is proposed, with a provision for fire safety A static Mars modular habitat is preferred to a lander/rover habitation due to the advantages of the former. Locally available materials, combined with water to form 'Duricretes' and inflatable structures are proposed as building materials on Mars. Recovery and utilization of carbon monoxide and oxygen from the Martian atmosphere for propellant production for Mars exploration by land rovers, aeroplanes and rocket engines and the use of Martian soil are described, even going into details like fire protection and tool and equipment requirements A piloted Mars vehicle is proposed as a low-thrust nuclear-powered vehicle with at least a two-year round-trip travel time, on a conservative basis. This is the interplanetary transfer vehicle with a 10-MW nuclear power system and propellants from LEO or the lunar surface. A vehicle condition-monitoring system is also proposed for the piloted Mars vehicle. It is suggested that all the transfer vehicles rendezvous and dock in LEO Communications with Mars is considered as a vital issue due to the time delay from Mars to Earth in various scenarios Designs for such communications systems are given. The concept of time has also been addressed: Mars habitat may require a metric time Power systems are required to be developed for the MMM. One of the innovative ideas is DeYoung *et al*'s suggestion of a solar-pumped laser power transmission station orbiting around Mars for power, materials processing, habitat needs, power for surface rovers and surface launch.

Nuclear propulsion is advocated since chemical propulsion systems are limited in their Isp and thus the 'delta V' requirements for short (200-day round trip) missions (necessary because of biomedical and human factors) cannot be met by such propulsion techniques. Nuclear propulsion had been advocated much earlier by the late John F. Kennedy in 1961, parallely with the announcement of the Apollo missions The NERVA rocket technology programme, subsequently dropped because of budgetary constraints in 1973, could give 825 s Isp, more than twice that of chemical propulsion systems at that time and capable of delivering 900 s Isp with a little development, sufficient for a 200-day round-trip mission, which could provide important benefits for the Mars mission structure Nuclear propulsion is a powerful technology and should be kept in mind whatever scenario or strategy is chosen because it enables the reduction of mass into LEO by a factor of five or more and allows enough power for the generation of artificial gravity in the Mars transit vehicle, thus providing a great deal of flexibility. Two advanced propulsion programmes are the USAF's nuclear thermal rocket and a new NASA initiative in electric propulsion for cargo transport Other promising non-chemical options exist (the fission rocket engine, plasma Wakefield accelerator (PWFA), anti-proton propulsion, laser propulsion, etc.), some of which are described. One of the promising concepts is that of the PWFA, which can generate very high fields (10 GV/m) for short times to accelerate the ions, with a capability to generate an Isp two orders of magnitude higher than conventional sources An Isp of 65,000 s can be achieved. The PWFA can also be optimally 'tuned' to obtain a suitable specific impulse for various mission scenarios/stages It is therefore necessary to carry out research in advanced propulsion technologies keeping in view the possibility of reduced ship-mass and/or reduced transit time for missions, from two-year to ninety-day round-trip missions over the ensuing forty-year time frame up to 2030, by which time a permanent Mars manned outpost should be in operation.

A large number of artistic illustrations of the various technological elements of the Mars rover/sample return mission and the MMM, including heavy lift vehicles and propulsion systems are given to convey some idea of their design Several engineering details and drawings/sketches also form part of the presentations, hence, the volumes can be considered as useful reference material. The two-volume set is definitely an asset for general scientific enrichment and as a reference for aerospace scientists, technologists and programme planners for the advanced technologies required. Perhaps the driving theme is best illustrated by the statement made by two high school students at the Conference. *We are the stewards of Mars. Watching it for a Universe that created us both. In that sense Mars is ours.* I am sure that readers of these volumes will get the same feeling

Laboratory for Electro-Optics Systems
(A Division of ISAC)
A5-6 Peenya Industrial Estate
Bangalore 560 058

RAMANI SESHAMANI

Guidance and control 1990 (Volume 72 in Advances in Astronautical Sciences) edited by Robert D. Culp and Arlo Gravseth. American Astronautical Society, 1990, pp 660, $95. Orders to Univelt, Inc., P.O. Box 28130, San Diego, CA 92128.

Like its predecessor volumes, this record of proceedings of the Thirteenth Annual Guidance and Control Conference of the Rocky Mountain Section of the American Astronautical Society is a 'yearbook' of the achievements of the massive American endeavour in astronautical and certain related sciences. The Conference, held at Keystone, Colorado, USA, during February 3–7, 1990, had five technical sessions, with an average of about seven papers in each session. In addition, the proceedings contain a sixth section devoted to aerospace human factors, with a tutorial and a series of invited papers

The first section of the volume is devoted to its title theme advances in aerospace navigation, guidance and control. A very novel idea in this area is presented right in the first article: the concept of a highly accurate roll control method for spacecraft without the use of a rate gyro. Normally, such a concept would have been considered outlandish But, then, the spacecraft to be so controlled is not a 'normal' one. it is a test bed for the revolutionary Stanford relativity gyroscope Such a mission poses very special restrictions on the spacecraft a precise and steady roll rate must be maintained, the roll phase at any instant must be precisely known, and the spacecraft should not carry any rotating machinery on board, which precludes the use of conventional rate gyros The Stanford group describes in its paper a special technique for achieving these objectives The technique consists of scanning a ring of space using a body-mounted narrow-field optical sensor Due to the distribution of stars in the ring, a time record of starlight intensities is obtained, which repeats itself with every rotation of the body. Correlating this with a stored or 'reference' record of stellar intensities, highly accurate roll rate and phase information can be obtained The authors show that there is enough information redundancy in the intensity record to achieve the required correlation accuracies even when the data are grossly quantized—to a one-bit level

An equally significant concept is the image navigation and registration (INR) system being developed for the GOES-I geostationary meteorological satellite system. Normally, it is assumed that application satellites, such as the meteorological and communication satellites, are somehow maintained in the proper orbital position and attitude by independent means, and only serve as platforms for the instruments and equipment they carry. Breaking this convention, the INR system envisages to generate orbital and attitudinal misalignment utilizing the observation of stars and earth landmarks made by the meteorological sensors (*e g.*, the imager and sounder instruments) themselves. Another novel aspect of the scheme is that the image misalignment information is used not to physically correct the satellite position and attitude as such (*i.e.*, for satellite station keeping), but to modify the parameters of the instruments themselves (*i.e.*, mirror scan program, mirror motion compensation, etc.) to obtain images nearly like those from perfectly aligned instruments exactly in position.

Other important ideas and developments presented in this section include studies on 'aerocapture' for a possible mission to Mars in the late 90s to land a rover on its surface and to acquire and return surface samples to the Earth The use of Martian 'air'-braking, partially to reduce the approach speed of the spacecraft to orbital speeds, should save on braking fuel requirement, and reduce effective vehicle mass by 20–30% An article on precision star trackers for the coming decade provides an insight into the use of advanced mosaic detectors for accurate star-tracking applications The practical problem of model-order-reduction flexible structures is also dealt with in this section

The second section is on guidance and control storyboard displays Here, the development of a laser-pointing-and-tracking system for cooperative dynamic targets in space is described Also presented is a high-isolation magnetic suspension system for fine-steering mirrors. The classical function of horizon-sensing in satellites has been raised to a higher status in an article that discusses the use of artificial intelligence, early vision, and processing techniques for precision horizon location in scanning horizon sensors Elsewhere, a simpler horizon-sensing method using a linear pyroelectric sensor array is presented

Two computer applications are presented in this section one for the intelligent health monitoring and autonomous decision-making abilities of spacecraft, and another for the teaching and application of the quaternion approach to satellite-attitude maneuvers. A third computer application considers the simulation of the flexible arm controls experiment (FACE) in relation to the space shuttle.

The third section deals with another important topic in space operation· On-orbit alignment and calibration of satellites This topic gains extra emphasis for many of the futuristic missions which aim at unprecedented levels of accuracy in observation An example is the concept of a large space-based optical interferometer, capable of mapping the skies to a small fraction of a milliarcsecond Such a goal presents extraordinary levels of challenge in areas of optics, meteorology, structure, dynamics and control Many of these goals can be achieved only through a continuous or frequent on-orbit calibration process which is the subject matter of the first paper Other papers in the section deal with the inflight estimation of attitude sensor alignment, calibration of the tracking sensors of the space-based laser-Zenith star satellite, astrometric calibration of the famous Hubble space telescope fine guidance sensors, and the end-to-end control system verification of the space shuttle-based STARLAB experiment There is an interesting paper on the structural control sensors for the CASES (control, astrophysics and structures experiment in space) experiment, to be carried on the space shuttle This offers a good look at a futuristic area of activity generally dealing with adaptive control of structural systems

As space missions become more complex, distant, hazardous, and beyond human endurance, attention is focussed more intensely on autonomous and adaptive control of spacecraft, space missions, and space devices This forms the subject matter of the fourth section of the volume. The first article in this section concerns an autonomous landing on Mars Long communication times between the Earth and Mars require autonomous landing capabilities The paper discusses landing strategies based on orbital imagery for a Martian landing site selection and surface-relative navigation Another paper discusses adaptive control for advanced launch vehicles Other papers in the section deal with magnetometer-based autonomous satellite navigation (MAGNAV), adaptive robust control of flexible beam systems, telerobotic control, and on-board autonomous control of the infrared space observatory (ISO). There is also a generic paper discussing the contribution of artificial intelligence (AI) to spacecraft autonomy.

The section on Recent experiences is always an important section of the Guidance and Control Series as it discusses the actual missions. The encounter of two Voyager spacecraft with the planet Neptune and its satellites had made newspaper headlines in the later half of 1989. The first article in this section by a JPL group calls this encounter 'guidance and control's finest hour' and discusses some of the challenges of the mission. Other articles describe early mission characterization of the Galileo attitude control subsystem, system performance of a kinetic energy weapon (KEW), and lessons learned from engineering evaluation tests of the solar maximum mission.

The last section of the volume concentrates on aerospace human factors The section starts with a tutorial, slide-based article on the topic, using the setting of the parameters of artificial gravity as an example. In this article are listed the side variety of human-related factors that are relevant directly to the success and efficiency of space projects and missions. In some of the remaining articles, the topic of 'telescience' is emphasized. 'Telescience' involves remote-coaching of astronauts by scientists and principal investigators (of spaceborne experiments/tasks) on the ground This is a topic of increasing importance, as space tasks are becoming more and more complex, specialized, and diverse to the point that they cannot be effectively conducted by one or a few crew members of space missions based only on prior training before launch. Telescience, as an operational concept, will provide the space science community a more direct involvement with the goings-on in the space mission. This is a topic that includes in its fold the interaction between communication, display, and human perception, assimilation and reaction aspects Articles on other topics such as human–computer interaction, operator–machine interaction, and telerobotics are also included in this section

For those who follow the Guidance and Control Series through the years, the inexorable march of space science and technology towards ever-increasing technical sophistication is clear. The present volume reflects this trend in a great measure by devoting much of its attention to aspects of automated and intelligent operation by non-human entities. That a major driving force in many of the more sophisticated missions is the strategic defence initiative (SDI) is also apparent. However, the one thing this volume has in common with its predecessors is its cutting-edge reporting of the most exciting and novel of all that is happening in space systems

Department of Aerospace Engineering
Indian Institute of Science
Bangalore 560 012

P R MAHAPATRA

Orbital mechanics and machine design edited by Jerome Teles, Vol. 69 in Advances in Astronautical Sciences Series, American Astronautical Society, San Diego, CA, 1989, pp 862, $95. Orders to Univelt, Inc., P.O. Box 28130, San Diego, CA 92128, USA.

The successful operation of space shuttle fleet, maintenance of space station Mir over a long period of time, launch of interplanetary spacecraft and deployment of Hubble telescope are the pointers to the things to come during this decade and beyond into the next century A total of 53 papers and two abstracts are presented in four sessions on Low-Earth orbit mechanics, Earth, Sun, Moon regime, Navigation, and Lunar and planetary sessions at AAS/NASA International Symposium held at NASA Goddard Space Flight Center, Greenbelt, Maryland, during April 24–27, 1989. The proceedings of the symposium cover many aspects of mission design and orbital mechanics comprising motion of the Earth satellites, transfer orbits and rendezvous, and geosynchronous orbits, libration point, lunar/planetary/cometary missions including trajectory design and orbit determination

The session on Low-Earth orbit mechanics contains nine papers on solutions to equations of motion, rendezvous and docking, launch and orbit mission analysis The adaptive Cowell's method is basically a finite difference scheme, while Poincaré–Lindstedt solution uses orthogonal functions of Poisson Series. Both the methods, though provide fairly accurate solution, are very cumbersome to use Nearly half of the papers in this session are related to rendezvous and docking (RVD) operation or missions that make use of these operations The survey paper which is basically on terminal RVD gives overview of RVD approach techniques, autonomous *vs* manned docking and a set of constraints/problems embedded in such operations RVD is a process of bringing a secondary spacecraft on to the primary one Both impulsive and continuous low-thrust propulsion systems are dealt with Some of the issues considered in the generation of RVD guidance logic are: path constraints, glide slope/terminal attitude profile specifications against minimum fuel expenditure during the terminal phase, following of optimal reference trajectory which is computed with constraints due to plume impingement, visibility, safety, etc , time of transfer/RVD operation. Rendezvous to space stations in near-Earth and geostationary orbits are mainly discussed. The impulsive (two or more) transfer considered in the latter case is useful when the time of transfer is at a premium The possibility of using small launch vehicle (of sounding rocket class) for orbiting miniature satellites is a very interesting concept specially from the view point of developing countries On the other hand, elaborate planning is required for a large launcher such as Japanese H-I launch vehicle Moving further, the injection of cluster of four satellites into geostationary transfer orbit by the next generation expendable rocket Ariane-5 is an example of what the technology can deliver in the Nineties

Navigation is the most important discipline for successfully using any spacecraft Most of the navigation systems can be put under inertial systems, or telecom-based systems, or combination of these two NASA's tracking and data relay satellite system (TDRSS) is capable of providing accurate navigational information at low cost In order to minimize the effect of measurement, transmission and process noise, a square-root filter is often used Astronomers have long been using the interferometric principle for over a couple of centuries. It has been suggested that very long baseline interferometry (VLBI) can be used as a large aperture radio telescope Then, it will be possible to track one or more satellites using differential interferometry On the other hand, inertial navigation uses mostly autonomous (onboard) sensors and determines its position and velocity vectors through the solution of appropriate motion model The spacecraft of future are likely to use both the modes of navigation system

Curiosity about the constitution of the Moon and planetary systems around the Sun has been disturbing the minds of the humanoids from time immemorial With the advent of rocketry, the lunar and interplanetary missions naturally took pride of place in the space technology Space transportation to interplanetary space using only expendable fuel would be prohibitive in terms of practical realization with the present-day technology Successful space missions such as Voyager and Galileo are results of indigenous trajectory design that also made use of gravity pull from terrestrial bodies to alter the orbital energy Moon being the nearest terrestrial body can be used for designing some of the optimal space trajectories. Utility of a particular planet for a given gravity-assist trajectory depends on the launch schedule of the space probe, relative position of the planet with respect to the Earth, and other celestial bodies The two of nine-satellite ISTP (International Solar Terrestrial Physics) program will use extensively double lunar swing by orbits for scientific observations in the Sun's geomagnetic tail and front-field regions of the Earth The five papers presented in the session on 'Earth, Sun, Moon regime' provide elaborate descriptions of Geotail, Wind, MVSE-A, and SOHO missions

Apollo landing on the Moon heralded a new era of space adventure In years to come, one will see many lunar and planetary missions which is apparent from the 21 papers presented on this theme These papers contain description of missions to Mars, Venus and Mercury They give details pertaining to spacecraft description, interplanetary orbit determination, guidance and control, planetary/terminal orbit control/station keeping, planetary landing and return and navigation The lunar missions will consist of two complementary spacecraft-carrying instruments for global mapping and penetrators to make seismic and heat-flow measurement network The Venus mission will probe the fundamental process of interaction and interaction between the Venusian atmosphere and solar wind Among these space programs, manned mission to Mars is certainly the most challenging in terms of technology development and man's endurance in outer space Unlike the planets and their natural satellites, comets have invoked a lot of interest as their study is believed to help in better understanding of origin and evolution of universe Many of them are thought to have come from outer space and got trapped into the solar system The earlier comet missions had limited capability and flew past them at large distances International Cometary Explorer (ICE) probes the Giacobini-Zinner Comet, GIOTTO from ESA which initially had rendezvous with Comet Halley will later retarget to Comet Grigg-Skjellerup on July 10, 1992, Rosetta is a comet nucleus sample return mission, while CRAF (comet rendezvous asteroid flyby) aims to study the development of Comet Coma and tail under the influence of sunlight The mission details are elaborated without resorting to mathematical juggleries

The proceedings contains details of many interesting space missions which exemplifies the ever-increasing capabilities of space technology and advancement of science The presentations are mostly narrative and hence are easily readable by general scientific and engineering community Various missions described here can raise the imagination of many young and old alike, and lure them into the challenging as well as fascinating world of aerospace engineering .

Department of Aerospace Engineering
Indian Institute of Science
Bangalore 560 012, India

M. SEETHARAMA BHAT

Space safety and rescue 1986–1987 edited by Gloria W. Heath. Proceedings of the 19th and 20th International Symposia, Vol. 70 in Science and Technology Series, American Astronautical Society, 1988, pp 360, $55. Orders to Univelt, Inc., P.O. Box 28130, San Diego, California, 92128, USA.

Space Safety and Rescue Symposia are held annually during the International Astronautics Federation Congress This volume contains the proceedings of the 1986 and 1987 Symposia A total of 31 papers are presented in five sessions on· Interdisciplinary assessment of space stations, Space safety and rescue 1986, 1987, Earth safety and disaster/distress response employing space-borne systems, 1986, 1987.

With the advent of space transportation systems, like space shuttle and proton vehicle, and the establishment of Mir space station under permanent/semipermanent orbit operations, the safety of humanoids in space (*i e.*, during transportation as well as on orbit residence) assumes great significance. The five papers presented under interdisciplinary assessment of space stations describe multifarious aspects of risk assessment, various human factors, study of effects of subgravity conditions on man, and planning of space station from the safety point of view.

Over the next decade and further, the safety of the future vehicles in space will be threatened greatly by the increasing population of man-made space debris unless certain control/protection measures are undertaken A large number of papers (16) deals extensively on build-up of space debris (man-made and extra-terrestrial), characterization of debris population, proposal to remove debris and to increase protection against collision damage. The management of debris calls for establishment of a catalog of debris, understanding of their orbital decay, determination of zones of large concentration of debris in various toroidal space around the Earth, distribution of debris *vs* size and location Suggested methods to reduce the risk include the identification of debris and determination of possible rendezvous/intercept with such a debris, and use of non-expendable transportation system It is projected that during the next decade or so, the number of spacecraft in low-Earth orbit (LEO) is likely to proliferate by two orders of magnitude as more and more nations come forward in building/hiring multi-objective, multi-mission satellites However, in future, the vulnerability of these satellites against collision will limit the number of satellites that can simultaneously operate at a given moment. The situation will be nearly the same for the spacecraft in geostationary Earth orbit (GEO) The need for transportation from LEO to GEO with transatmospheric space vehicles will increase the problem further. Since the complete scenario involving debris cloud is nondeterministic, the risk analysis can at best be carried out by probabilistic/stochastic methods

The safety of future missions also requires to design required hardware and software and to prevent collision with another spacecraft or debris, accidents like fire, explosions and depressurization, radiation and toxic contamination, biologial hazards, etc. In order to build robust and safe space systems, the study of breakup of Kosmos 1275, subsequent disintegration and tracking of nearly 200 fragments, will be useful. This will also help in setting up of proper simulation experiments for risk analysis and fabrication of suitable preventive measures.

Equally important theme covered in this proceedings relates to space applications for disaster mitigation and management, many of the related papers coming from the 1986 conference The problems addressed here are the counterpart of the issues discussed earlier, in the sense that they are concerned with the best use of satellites for early warning of impending disasters on the earth Different aspects of disaster management with a number of case studies as well as a few-disaster warning systems are presented To sum up, the editor Gloria W Heath quotes the remarks of Y S Rajan and U R Rao of ISRO that "the challenge of space technology no longer lies in conquering space, but in deriving the benefits for the poorest and most handicapped segments of humanity Using low-cost mobile terminals, many disasters such as recurring of droughts in countries of Africa, for example, can be contained efficiently and effectively "

The above discussion gives an idea of the breadth of coverage of this proceedings It contains a wealth of information that will be useful for many practising engineers and scientists in aerospace and related areas Most of the papers included are descriptive in nature making it very readable and usable even as a good source of pastime

Department of Aerospace Engineering
Indian Institute of Science
Bangalore 560 012

M SEETHRAMA BHAT

Working in orbit and beyond: The challenges for space medicine edited by David Lorr and Victoria Garshnek. Univelt, Inc., P.O. Box 28130, San Diego, California 92128, 1989, pp 182, $45.

The challenges in space medicine have brought together the scientific community all over the world in a bigger way in various fora. This volume, number 72 in this series, is based on serious deliberations conducted in such fora by eminent scientists in different specialities It is a nicely bound collection of scientific papers with numerical and author indices.

A total of 30 photographs from the high frontier of space medicine depicting actual experimental conditions presented in Appendix B makes the book interesting, informative and realistic

The book aptly concerns itself with four areas of current interest in space medicine: problems connected with zero gravity and adaptations to such condition, special hazards to life and effect on efficiency in space, measures to counteract the adverse effects and future challenges, in addition to the existing problems in space medicine

Thus this volume has satisfied three main objectives (i) It brings together current state of knowledge in space medicine, (ii) offers appropriate methods to address problem areas, and (iii) provides a source for further information like medical aspects of Space Phoenix programme (AAS 87-155)

The significant fact to note is that literature concerning both the Soviet and American space programmes finds a place in this volume which will benefit readers interested in the field Human exploration of the Martian surface and proper readaptation on return to Earth is a challenge ahead for the aerospace medicine Significant contributions made by Soviet and NASA scientists in this direction to proceed ahead to tackle such problems have aptly been referred to

Finally, a scholarly account on aerospace medicine presented lucidly and effectively by the editors needs high appreciation

The book can be of immense help to students as well as professionals connected with aerospace medicine and as such is recommended as a reference book for institutions conducting courses or research in this field.

Department of Aviation Neuropsychiatry
Institute of Aerospace Medicine
Bangalore 560 017

A. K. SENGUPTA

Astrodynamics, 1989, Vol. 71 in Advances in Astronautical Sciences, edited by C. L. Thornton, R. J. Proulx, J. E. Prussing and F. R. Hoots, published for the American Astronautical Society by Univelt, Inc., P.O. Box 28130, San Diego, CA 92128, USA, 1990, pp 1437, $200.

This volume, in two parts, contains exhaustive collection of 87 papers and 30 abstracts from the proceedings of the 1989 Astrodynamics Conference The Conference was held from August 7 to 10, 1989, at

Vermont under the auspices of the American Astronautical Society and the American Institute of Aeronautics and Astronautics. The volume aptly begins with a lucid keynote address on Adventures in celestial mechanics. Technical papers are presented in 16 theme sessions on Trajectory computation techniques, Geocentric satellite orbit determination, Attitude determination and control, Satellite dynamics, Orbiting debris, Earth orbiter mission analysis, Trajectory optimization applications, Planetary spacecraft orbit determination, Satellite orbit control, Neutral upper atmosphere density, Dynamics and control of large flexible structures, Guidance analysis, Planetary mission design and analysis, Trajectory analysis, Dynamics and control of space structures or multibody systems, and Estimation/identification techniques Thus, it is a compendium of almost all aspects of modern astrodynamics and related aspects.

The dynamics of a spacecraft can be described in terms of orbital motion, attitude motion and structural motion/vibration. The dynamics, estimation (navigation) and control problems of the spacecraft dynamics is the key issue contained in this proceedings Also, dealt with are related issues like earth satellite and planetary mission analysis, and upper atmospheric study. These issues have much utility value.

The orbital motion of the heavenly bodies has caught the imagination of humanoids for several centuries, with serious and scientific study extending over three hundred years Following the successful launch of Sputnik in October, 1957, the accumulated know-how on celestial mechanics is put to use in understanding artificial Earth satellite orbit mechanics after appropriate refinements Since then, great strides have been made which can match or to some extent surpass the earlier achievements, mainly due to technological innovations Trajectory analysis (5 papers plus one abstract) is one such topic which is useful for ever-increasing space program In future, satellite positions in their orbits are required to be controlled very precisely to derive maximum benefit out of them For example, it is shown that the orbital perturbation due to oblateness of the Earth, if accounted for properly, can improve the accuracy of orbit determination However, the methods of orbit determination presented here are extensions of existing well-known procedures which are time tested for reliability.

The orbit control mainly consists of orbit/station keeping, rendezvous and interplanatery trajectory shaping The main strength of the present proceedings comes from important contributions in this field. For the successful operation of multi-satellite global positioning system (GPS) and other satellite constellations, the orbit control is needed to nullify the effect of disturbances due to the oblateness of the Earth, luni-solar perturbation, atmospheric drag, etc. It is interesting to see that by changing the altitude of GPS system by a small factor, it is possible to minimize the influence from external disturbances The other equally useful spacecraft constellation relates to a combination of three communication satellites which are put into a highly eccentric and inclined orbit so as to service the high latitude zone of the Earth. On the other hand, rendezvous is a trajectory control problem wherein a secondary spacecraft is taken to a target spacecraft/satellite in an Earth orbit or to move it to a specified destination in interplanetary space Such a trajectory may comprise powered phase and coast/orbit phase in any combination depending upon the rendezvous strategy.

With increase in space activity, the Earth orbits are getting saturated. These orbiting satellites eventually complete the operational life time The orbiting debris which mainly comes from dead satellites or final stages of launch vehicles and also those from cosmic origin are capable of inflicting fatal damages on safe functioning of the operational satellites. A total of seven papers on the subject can certainly help to refine modeling aspects and analysis of space debris

Accurate attitude control over a long period of operations extending several years is the requirement of the present- and future-generation spacecraft. This calls for improvements in attitude determination accuracy, so also better attitude control system The autonomous attitude determination algorithms presented here are of the state of art and may soon find applications in many satellites. Real-time corrections for sensor bias and infrared radiance variations (hitherto done heuristically) using Kalman filter enhance the accuracy of attitude determination Few attiutude control system for specific missions is also discussed The attitude control system is designed with emphasis on pointing accuracy, the only design constraint being that the level of structural vibration be low (*i e.*, stable motion) The analysis of control-structure interaction is largely limited to extensive analytical and numerical simulation studies.

With increasing trend towards building large flexible structures, the control-structure interactions become stronger, due to lowering of structural vibration frequency and increase in control bandwidth Therefore, along with attitude control, it is necessary to have structural vibration damping/control The four important issues related to dynamics and control of large flexible structure/spacecraft are modeling, model order selection, design/selection and optimal location of sensors and actuators, and control law design Vibration damping/shape control enhances the operational life of the spacecraft, apart from helping to maintain better attitude-pointing accuracy The fourteen papers and five abstracts presented in two sessions are interesting. They try to address some of the above-mentioned issues in a limited manner Though the amount of research and development activities related to development of large flexible structure is enormous, the current proceedings does not contain high-quality papers as in earlier themes *vis-a-vis* the state-of-the-art developments taking place globally at present

It is satisfying to see that the proceedings under review dwells on the state-of-the-art technologies on modern astrodynamics in a brief but effective manner. The papers are mostly descriptive in nature and those interested in finer mathematical details can always look into the vast references cited. The proceedings is useful not only to aerospace engineers and scientists in industry and academic institutions, but to others who can draw upon the vast experience embodied here into their own disciplines

Department of Aerospace Engineering
Indian Institute of Science
Bangalore 560 012.

M Seetharama Bhat

The 21st century in space, Vol. 70 in Advances in the Astronautical Sciences, edited by George V. Butler. Published for the American Astronautical Society by Univelt, Inc., P. O. Box 28130, San Diego, CA 92128, 1990, pp 433+12, $90.

At the stroke of 12 on the midnight of December 31, 1999, the world enters the 21st century The end of the millennium and the beginning of the 21st century will be abrupt. In contrast, the breakthroughs in science and technology stand on the shoulders of past achievements and technological developments are gradual Space technology has emerged as a major milestone in human civilization in the latter half of the 20th century as a result of materialization of dreams and imaginations by systematic and hard work The proceedings of the 35th Annual AAS Conference held from October 24 to 26, 1988, at St Louis, Missouri, presents a set of practical dreams It is practical because these can be materialized in the early part of the 21st century if the current trend in technological development is any indication. However, it would be naive to predict about all future innovations at the present juncture The AAS Conference had an introductory and ten business sessions The papers presented at the Conference discuss the programs of NASA in collaboration with other laboratories of US allies The discussions are centered around NASA space station Freedom, large space structure, space transportation systems, utility services and space sciences

It is very educating to go through the evolution of the space station Freedom over the years What is more significant is that such an evolution takes care of user and industry view points at every stage of development Probably, one will definitely find more sophisticated space platforms in future, but at the same time, a sound tradition has already been built in designing Freedom Concept of large space structure is a logical continuation of the above space station, in which the in-site manufacturing of the station is the central theme. Manufacturing technology presented in this proceedings looks a little crude, but it is expected to sharpen as the time passes by. In-site manufacturing is expected to be undertaken by either human operators or robots. The space robots envisaged here try to mimic the functioning of living ones on earth such as spider and human being. The critical issue for the success of any large space structure/station lies in the development of proper material and structural systems. Structure, by definition, takes the load and is made up of advanced light-weight materials for space applications, but, unfortunately, these issues get only a cursory look and interested readers may have to look to other sources of reference

Prominent applications of large space platforms are believed to be in the field of communications, manufacturing of special materials at low 'g', and space and biological science experiments. It may also be possible to advance genetic engineering to new heights that cannot be reached by earth-based research Possibilities are many, and 21st century will see much more than what we can imagine at the present juncture

The section on Space utilization and applications appears outdated compared to the advanced missions of the early 21st century Likewise, papers on manned Mars mission and hypervelocity vehicles, though futuristic, are slightly outside the main theme of the Conference Understandably, therefore, these are presented in separate sessions

The papers presented here are largely descriptive and discuss specific issues in generic terms. It forms a useful reading material for aerospace community as well as general public

Department of Aerospace Engineering — M. SEETHARAMA BHAT
Indian Institute of Science
Bangalore 560 012

What every engineer should know about microcomputers (2nd edition) by William S. Bennett, Carl F. Evert Jr and Leslie C. Lander. Marcel Dekker, Inc., 270, Madison Avenue, New York, NY 10016, 1989, pp 476, $107 50.

This is a very elementary introduction to the world of hardware and software design using microcomputers. This book is in the 'What every engineer should know' series of books and fulfills its role in introducing this subject to an audience that has no previous experience of the subject.

The pedagogy adopted is that of self-learning and the subject material is presented gradually with many examples and figures As an overarching structure, the book introduces a real problem (measuring the amount of liquid in a tank with a float on the end of an arm that moves up and down as the liquid level does) and develops the complete solution (both the complete hardware required and the Ada program for controlling the hardware). The hardware and the transducers needed for interfacing with the microcomputer are introduced at a rather slow pace For example, the following concepts are introduced assuming no foreknowledge: digital signals, level detectors, clocks, integrators, registers, table-lookup, seven-segment displays, binary and decimal representations, assembly language, I/O devices and programming, etc For introducing the concepts of programming, recourse is made to 'Warnier-Orr' diagrams but this does not seem appropriate: first, it is non-standard; secondly, another competing way of describing an algorithm, flowcharting, is introduced abruptly without explanation (p. 191) The Motorola MC6800 is used for introducing microcomputers and the Ada language for introducing programming The various aspects of microcomputers are discussed in detail (for example, interrupts, ALU, control registers, etc). The discussion on Ada is creditably done and it is quite conceivable that a person introduced to this book first might have a better perspective on computation and how a program involving I/O programming and interrupts is to be written in a high-level language. Ada concepts like packages, tasks, rendezvous, and concepts like time-slicing, overhead when programming in Ada, interrupt vectors, etc , are all discussed from first principles

The discussion of designing a digital system has been competently addressed by many authors (for example, Peatman) but very few books have dealt with programming a digital system using a high-level language, especially a complex language like Ada This is where this somewhat elementary book has distinguished itself. The author recommends this book to high-school students who want to learn about digital systems, to scientific personnel like lab assistants without previous experience with digital systems and also to those who are curious about using Ada for control applications. One major drawback of this book is its price which makes it too costly for causual interested readers, the intended audience

Department of Computer Science and Automation — K GOPINATH
Indian Institute of Science
Bangalore 560 012

The logic of architecture — Design, computation and cognition by William J. Mitchell The MIT Press, 55, Hayward Street, Cambridge, MA 02142, USA, 1990, pp xi+292, $19.95. Indian orders to Affiliated East-West Press Pvt Ltd, 25 Dr. Muniappa Road, Kilpauk, Madras 600 010.

Architecture is an art of distinctions within the continuum of space So the means of architecture are basically given by one's capabilities to make and sense physical distinctions in space It is with sensitivity to the dimensions, nuances, and subtleties of spatial distinction that the abilities to understand, to be moved by, and eventually to create architecture originate The book *The logic of architecture* which grew out of the seminars conducted at Harvard, UCLA, Carnegie–Mellon and Cambridge by the author successfully explains the concepts in a lucid way

There are ten chapters, each with a summary at the end, notes and an up-to-date bibliography. The first chapter on building descriptions establishes the basics on which the second chapter on architectural form is discussed The next chapter on design worlds establishes some domain of formal possibilities for a designer to explore. This is followed by a discussion on how expressions in critical languages are interpreted in design worlds and how designs in design worlds are realised in construction worlds

After briefly touching upon reasoning about designs, explaining the types and vocabularies, the author explains the design operations. A set of shape possibilities are established This is followed by the languages of architectural form The rules of an architectural grammar should provide a well-formed representation of a class of buildings in the construction world The languages specified attempt to include a depiction of every possible building in the class The chapter on function describes why the performance of elements and subsystems must be evaluated relative to the program since the function of a building as a whole is established by its program The last chapter on functionally motivated design includes functional adequacy and equivalence, conditions for the same, element selection as well as design, etc.

The book is well written and the illustrative sketches make the reading interesting and simple

Department of Civil Engineering
Indian Institute of Science
Bangalore 560 012.

N S PANDIAN

Hadronic physics with multi-GeV electrons edited by B. Desplanques and D. Coutte. Nova Science Publishers, Inc., 283, Commack Road, Suite 300, Commack, NY 11725–3401, 1990, pp 360, $ 84.

There have arisen in recent times several new meeting grounds for nuclear physicists and particle physicists. Particle phenomenologists are taking a closer look at quark and gluons in nuclear environments from the point of view of deep inelastic reactions after recent results on the so-called EMC effect and the phenomenon of shadowing. Nuclear physics specialists are paying greater attention to the role played by quark and gluon dynamics in the structure of the nucleon In the context, the book under review is very welcome, since it reviews topics of interest to both categories of people.

The book contains the proceedings of the winter workshop held at Les Houches during February 6–15, 1990, which was largely motivated by the advent of a new generation of electron accelerators aiming to study the nucleus and its constituents. These accelerators are characterized by high-energy (0·8 GeV to a few GeV) and high-duty cycle beams The choice and level of the lectures were governed by the wish to familiarize the international nuclear physics community with the electromagnetic probe There were also theoretical lectures which dealt with traditional aspects of nuclear physics, as well as various newer models of the nucleon This book will serve as a useful reference for high-energy physicists wanting a review of nuclear structure at high energies.

The book largely does justice to the professed aim of introducing the theory of high-energy electron scattering as a probe of hadron structure through fairly thorough papers by J. Martino and C Ciofi degli Atti, though they overlap considerably in content. They cover between them, elastic and inelastic scattering, nucleons and nuclei, with and without polarization measurement. They discuss the formalism, as also models for electromagnetic properties, and some experimental results.

The papers on traditional nuclear physics do an adequate job of reviewing topics like mesons and nucleons in nuclei (J -F. Mathiot), few-nucleon systems (N.d'Hose) and relativity in nuclei (J. A. Tjon) At the same time, there is also a discussion in Mothiot's paper on effects arising at large momentum transfer and at large densities, which may take one outside the standard scenario

The set of contributions on newer models of nuclear structure begin with an introduction to quantum chromodynamics (QCD), the gauge theory of quark-gluon interaction. QCD is in itself a growing field, and the paper of M Fontannaz does a superb job of summarizing the essentials, while refering to standard works for details This, however, is a treatment of perturbative QCD, and the problem of colour confinement is left to the authors of the subsequent papers. Confinement being as yet an incompletely understood phenomenon, these papers expound various models of hadrons incorporating confinement. The paper of Ferrando and Vento is a neat and compact review of different quark models, like potential, bag and Skyrmion models The other two papers in the category of models are more in the nature of research contributions. One would have preferred expanded versions of the brief reviews in Ferrando and Vento's paper containing more detailed comparison with experiment

The rest of the book contains a varied fare of assorted topics, most of them of considerable importance Some are treated in painstaking detail (*e.g* , shadowing, by Covolan and Predazzi), while, others, no less interesting, are presented as brief reports (including topics like electroweak parity violation and hypernuclei)

All in all, the book contains an amazing amount of stuff, and taking into account what is said, as well as what is unsaid but pointed out to through the references, this is an excellent reference book on the topics of nucleon and nuclear structure especially as seen by an electromagnetic probe. As mentioned earlier, there is something in it even for particle physicists Having said this it might be appropriate to point out a few shortcomings

A somewhat better pre-editing could have made the contributions less overlapping in content, and covering more uniformly certain areas touched only cursorily. I would have preferred a clear division into a review section and a research article section rather than a mix of the two. Though a less rigorous style of English should be tolerated of contributors to whom English is a foreign language (as it is to me), typing and slipshod notation in some articles detracts from reading pleasure, and could have been weeded out by the editors

Despite these drawbacks, I consider the book an important asset for reference libraries.

Physical Research Laboratory
Ahmedabad 380 009

S. D. RINDANI

Quantum mechanics by Leslie E. Ballentine. Simon and Schuster International Group, 66, Wood Lane End, Hemel Hempstead, Hertfordshire, HP2 4RG, England, 1990, pp 486, $20.95. Indian orders to Prentice-Hall of India Pvt Ltd, M-97, Connaught Circus, New Delhi 110 001.

Quantum mechanics is now generally believed to be the correct framework theory of all physical phenomena; but a theory that is based on a substratum of which we may not make a mental image. Given this and the 'unreasonable effectiveness' of quantum mechanics in all experimental situations, two distinct, rather extremal attitudes, have developed as reflected in books on quantum mechanics. Thus, there are the standard textbooks on quantum mechanics that more or less present quantum theory as a prescribed set of rules, a calculational recipe, and then quickly proceed to the pressing matter of applying these rules to various physical problems of interest. They do refer to the rather abstract underpinnings of quantum mechanics in the introductory chapters, but somewhat apologetically Then there are the forbidding treatises that take on the deep philosophical and the abstract mathematical foundations of quantum mechanics that is mostly inaccessible to all but the preoccupied mind *Quantum mechanics* by Leslie E Ballentine is a refreshing and a user-friendly text that bridges this attitudinal gap, both in terms of its content as well as its presentation The guiding motivation of the book is to make the reader realize that the abstract ideas of quantum mechanics should be and can be readily appreciated in the operational sense and that they are efficiently related to our working knowledge of its principles in practical matters Without a proper understanding of these abstract ideas we can become vague The chapter on State preparation and determination is a most welcome addition usually missing from standard texts So is the chapter on Bell's inequalities with its highly contemporary significance and interest The author's choice of contents is very refreshing and contemporaneous The chapter on photon statistics (correlation and coherence) and kinematics and dynamics (space-time symmetries and quantization) are the other cases in point There is a fairly comprehensive chapter on Potential scattering. As announced, this book can be profitably used as an advanced text for a graduate-level course It has a rich selection of problems with solutions. It should also serve as a user-friendly reference book for researchers in physics and practitioners of quantum mechanics.

Occasionally, I do find the presentation unnecessarily incomplete Thus, in discussing the problem of bound states in a continuum, the reader is left wondering if these are an oddity—having found one such state by construction, are these more for the same potential, are these states stable, and if so in what sense A few general (without proof) remarks would have clarified these points.

All in all, I consider *Quantum mechanics* by Prof Ballentine an excellent and much needed book that fills a gap. Strongly recommended for science libraries.

Department of Physics
Indian Institute of Science
Bangalore 560 012.

N KUMAR