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BOOK REVIEWS

Laws of chaos: Invariant measures and dynamical systems in one dimension by Abraham Boyarski and Pawel Gora, Birkhauser Verlag AG, Klosterberg 23, CH-4010 Basel, Switzerland, 1997, pp. 399, sFr. 108.

The main title of this book, *The laws of chaos*, makes one wonder if this is yet another book among the many flooding the 'science' shelves of all book stores, claiming to explain that wonderful discovery of recent times, 'chaos', with the usual invocations to Lorentz, Feigenbaum and other members of the chaos pantheon, and pictures of 'strange' attractors, fractals, etc. for the readers' visual pleasure. Well, it is not. It is a serious mathematical book, one with a difference. The most commonly studied aspects of chaotic systems (such as say, those dealing with Liapunov exponents) consider it as a branch of differentiable dynamics, with some topological dynamics thrown in for good measure. This book is among a few that take up these systems as measurable dynamics, dealing mainly with invariant measures and such. It is even more specialized; it takes up iterates of maps on an interval and concerns itself with a single issue: existence and properties of invariant measures that have densities with respect to the Lebesgue measure. Iterates of maps on an interval have among chaos researchers a status akin to that of *drosophila* in molecular biology. It is the simplest case which still has a sufficiently rich theory so as to serve as an ideal topic for aspiring chaos researchers to begin their 'journey into chaos' with. This is the explicit motivation for the book. It is monograph with a pedagogical twist, so that it can serve as a text for this aspect of the subject.

Specifically, it looks at piecewise continuous transformations on an interval, introduced right at the outset in the introduction along with some examples. The next two chapters are brief overviews of topics from real analysis and ergodic theory needed for later development. The real show begins with Chapter 4, dealing with the Frobenius–Perron operator, appropriately dubbed the real hero of the book. The next chapter gives the conditions for the existence of invariant densities and a counterexample to show that these cannot be relaxed in general. Some extensions appear in Chapter 6. Chapter 7 deals with the spectral theory of Frobenius–Perron operator and Chapter 8 with further properties of invariant densities which include an associated 'central limit theorem'. Chapter 9 takes up Markov transformations where the extra structure (e.g. in terms of the associated graph) buys a lot more. Chapters 10 and 11 contain some of the most useful results for applied chaotisists—approximation issues and robustness, respectively—with respect to small deterministic and stochastic perturbations of the dynamics. Chapter 13 concludes with several applications, e.g. to random number generators, control of chaotic systems, models of rotary drill and Hipp pendulum regulator, etc.

The book is written for students and as such is by and large well written with ample examples and exercises. While it deals, as already mentioned, with a single aspect of such dynamics, an important aspect often left out in most treatments of the subject, it fills in an important gap in literature. It should serve as an ideal stepping stone for the more advanced treatments such as *Chaos, fractals and noise* by A. Lasota and M. Mackey (2nd edn, Springer–Verlag, 1994)

There are, however, occasional problems, such as clumsy or undefined notation (proofs of Theorems 3.5.2 and 8.2.1, and Definition 9.7.1, for example). Another problem a student may face is that while adequate real analysis and ergodic theory has been covered in the early chapters, there are still other fairly advanced concepts like topological entropy that occasionally creep in with which one is expected to have prior familiarity. In fact, there are some sections such as Section 9.7 that deserve to be marked as

'advanced'. An index of notation would have also helped. The authors may bear this in mind while revising the volume.

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Noam Chomsky: a life in dissent by Robert F. Barsky, The MIT Press, 55, Hayward Street, Cambridge, Mass. 02142, USA, 1997, pp. 245, $14.

This is an unusual biography of an unusual person. The name of Noam Chomsky looms large on the intellectual landscape of this century. His revolutionary contributions to linguistics have marked him as one of the great original minds of all times. To quote from a review of one of his books (quoted by Barsky, p. 89), his work "... is one of the first attempts on the part of a linguist to construct within the tradition of scientific theory—construction (of) a comprehensive theory of language which may be understood in the same sense that a chemical biological theory is ordinarily understood in those fields." This was one of the early responses to his work, much of which is now staple diet for any student of linguistics.

But apart from Chomsky, the linguist, there is also Chomsky the political activist, equally intense and equally prolific. Chomsky's activism begins with his faith expressed in his remarks: "There are all sorts of people struggling to make the world—if not 'good', then a little better. And they desperately need help." (p. 33) And that's not all. He also says, "I knew that I just too intolerably self-indulgent merely to take a passive role in the struggles that were then going on. And I knew that signing petitions, sending money and showing up now and then at a meeting was not enough." (p.124) So he plunged into political activism with the same fervour and a clear, original mind as he exercised in his professional pursuits. The development of Chomsky as a scientist and as an activist cannot be separated—they were not parallel activities, but so completely intertwined with each other that they have to be seen together if one is to get any understanding of the man.

Then there is also Chomsky the man, with his own private life, family, etc. A conventional biography would focus more on this 'human element'. But to the credit of Barsky, and what makes this biography unusual, is the fact that he has avoided the standard format of biographies. Chomsky's personal life is very much there, but only as backdrop to his intellectual life. Equally remarkable is the subdivision of the book into two comparable parts: 'The milieu that formed Chomsky' and 'The milieu that Chomsky helped to create'.

These titles speak for themselves. The first part traces the early influences that went into the making of Chomsky, the intellectual. Growing up in the immigrant Jewish ethos of Philadelphia, he was surrounded by the fervent intellectual activity of his parents' social circle, with their left-libertarian ideas imported from a Europe in turmoil as well as the considerable intellectual baggage that goes with being part of the Jewish diaspora. Early education in a Deweyite experimental school also helped, an asset his later education in a more formal school could not undo. He was also in touch with various socio-political movements of the Jewish community, but characteristically, was involved without being conclusively tagged with any. Among his early influences were his teacher Zellig Harris and his reading of Orwell and Russell, to whose intellectual tradition he truly belongs.

Chomsky helped found the linguistics group at MIT, with which his name has been linked for several decades now. An early academic celebrity as a linguist, his forays into political activism were to bring him notoreity with the establishment and adulation of the small minority of activists across the world.

Prominent among these are his participation in the anti-Vietnam war protests, his outspoken views on Arab–Israel conflict in Palestine, his exposing of the genocide of East Timorese by US-backed Indonesian militia, and his support for the freedom of speech of the controversial French intellectual Faurisson.

What comes across most strikingly in all this is his ability to think about an issue independent of the specifics of the personalities or nations involved, with the same inexorable logic with which he would approach a problem in linguistics. His stand on any issue does not change if you interchange 'us' and 'them', a feat the best of the establishment intelligentia seem incapable of. He thinks without any prior doctrinal commitment, being concerned only with the ultimate basic human values. As he himself says, "The policies of governments should be judged by their effects and not by the reasons advanced to justify them." (p. 36) He defies traditional classification of intellectuals according to assorted 'isms' which in any case is an unwarranted consequence of the penchant of our 'scientific age' to classify everything into finite categories. The danger in such classification, particularly when self-imposed, is that it defines the perimeters of our thought and we are slaves to our labels. Chomsky has escaped this trap. Though he accepts classification as an anarchist in his political leanings and as a rationalist in his philosophical proclivities (p.106), these seem more of default options than anything. Not surprisingly, this 'free thinking' of his has got him on the wrong side of various intellectual establishments of every hue, leading to vicious personal attacks at best (in which even his science is sometimes sought to be maligned), to worse, systematic censorship of his views by a manipulated media. His book with Herman on 'Manufactured consent' and a film of the same name on him are pithy comments on media manipulation of public opinion, something he sees as a major threat of modern times.

What does all this amount to? In linguistics, the question hardly need be asked. In the arena of political activism, Chomsky's voice, despite the efforts to drown it out by contrary din, does register, at least in the minority subculture of struggling do-gooders who can draw inspiration from it. Barsky's book is no doubt adulatory, but justifiably so. It is a great source of 'Chomskyana' for Chomsky admirers, as well as a must read for those who want a glimpse of one of the greatest contemporary minds so that they may broaden their own, and hopefully reprogramme some of their own thought processes.

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Science of engineering materials, 2nd edition, by C. M. Srivastava and C. Srinivasan, New Age International (P) Limited, Publishers, 4835/24, Ansari Road, Daryaganj, New Delhi 110 002, 1997, pp. 486, Rs 165.

The second edition of the textbook, useful to students of materials science and solid-state chemistry, is a good addition to the scholastic material in this area. The contents are presented pleasantly in a logical sequence. The authors have many years of teaching experience at the Indian Institute of Technology, Mumbai, and the fact that the book has come up for a second edition is itself an adequate indication of the good reception accorded to the earlier edition by students and faculty.

A brief outline of the contents is in order before reviewing some aspects of the text. The first five chapters present the background material needed for understanding the correlations between structure and properties of materials. After a general introduction to this theme, the ideas of bonding in solids, crystal structures, chemical equilibria and equilibrium phase diagrams are discussed. The orientation is towards the use of these principles in materials science and so the style of presentation is to highlight the useful

ideas without worrying about rigorous derivations or subtle details. In some sense, this would be accepted by students as a good way of getting on quickly to the end goals rather than be bogged down in the procedures of analysis. In fact, even during the discussions of the general principles, one is introduced to some aspects of materials like covalent bonds leading to strong solids and Van der Waals bonds yielding soft solids.

The next dozen or so chapters deal with specific properties of various types of materials. The ideas of defects in otherwise perfect crystalline arrangements are introduced and their role in governing the mechanical properties of solids is discussed. From there the authors move on to explain the thermal behaviour of materials at low and at high temperatures. The electrochemical reactions among different materials are discussed in another chapter with applications to corrosion and fuel cells. The next theme is the electrical conductivity of solids, an understanding of which paves the way to appreciate the unusual features of super- and semiconductors which have ushered the ongoing electronics era. The authors then move to explain magnetic and dielectric materials, known for a long time but having a revival of interest currently. From here they move to a brief account of the ultrasonic and optical properties of materials. The next group of polymers is given a short description. Each one of these chapters is naturally a short summary of the vast literature of information often given in full monographs on these topics. Therefore, the presentation has to remain at an introductory level and cannot be exhaustive. The authors have remedied this deficiency by listing books for supplementary reading at the end of each chapter. Thus, it is churlish to point a finger at the omissions and inclusions, which has to be left to the judgement of the authors in relation to the students who are being taught.

In view of the importance of nuclear engineering and aerospace applications, the authors have added two short chapters on the materials of special interest to these areas. Similarly, a chapter on amorphous materials, especially metallic glasses, has been added. The final twentieth chapter is on the characterization of materials using a variety of modern techniques which could not be introduced in any of the earlier chapters, like X-ray techniques being introduced when dealing with crystal structures. The book ends with an appendix listing the physical properties of the 92 elements. A short subject index is also given at the end.

The authors make a mention of the discovery in 1986 of high-temperature oxide superconductors and incorporate an account of the hectic activity initiated in this area. Notwithstanding this, the book has a noticeable flaw. Among the many books suggested for supplementary reading very few are later than 1980 and indeed none is of recent origin. This includes the area of high-temperature superconductors where a very large literature has built up including some good readable books. This lack of intimate contact with the developments of the past 10 or 15 years has resulted in several gaps and omissions. Composites and ceramics which are moving to centre stage in modern technology are not discussed. Carbon fibres and fullerenes have opened new frontiers in the last decade. Dielectric and optical materials have new growth in nonlinear optical materials and devices. Multilayer capacitors are widely used now. Even in the research interests of the authors, magnetoresistance is mentioned but not the recent surging interest in giant magnetoresistance materials. In permanent magnets, neodymium iron boron is tops among the recent material development of the past decade. The appendix of elements stops at 92 Uranium without mentioning the transuranic elements going to 106. Among them, Plutonium 94 certainly deserves full treatment on account of its importance. This lack of contemporary information is a serious flaw which would be noticed by the better students.

However, the survey of the vast convas of materials has been done with considerable care at both the microscopic and the macroscopic level. Numerous figures, problems as also a list of supplementary books for further consultation at the end of each chapter, clear labeling of the equations and the subsections of each chapter and selected tables of data are all given, keeping the student's interest in mind. The success

of the first edition bears testimony to the teaching skills of the authors. The production is also done well with very few slips to be noticed. The book is modestly priced and is warmly recommended as a textbook.

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Structural design optimization by N. G. R. Iyengar and S. K. Gupta, East-West Press Pvt. Ltd, 104, Nirmal Tower, 26, Barakhamba Road, New Delhi 110 001, 1998, pp. 229, Rs 175.

This is a well-written book based on author's rich and varied experience in teaching and research.

It starts with emphasizing the need for structural optimization and compares it with other design methodologies. The book deals with optimization by deterministic approach using mathematical programming techniques for optimization. Four methods of mathematical programming—linear, nonlinear, geometric and dynamic—have been described with illustrations.

Linear programming is used when the optimization problem involves linear objective and constraint functions. It is also possible sometimes to cast nonlinear problems into equivalent linear problems. Simplex method, which is the widely used method, has been described in detail.

Nonlinear programming is the most useful method for structural optimization problems since it is more general in nature and does not impose restrictions on the nature of the objective and constraint functions or on the number of constraints and variables involved. This method has been dealt with in considerable detail. Technique for linearizing the nonlinear problem has been given. Search procedures such as Dichotomous search, Fibonacci, Golden section and Bisection which can be used for solving nonlinear unconstrained problems have been described. For solving constrained problems, well-known methods such as Simplex, Pattern search, Descent, Variable metric methods have been illustrated. Here, the constrained problem is converted into an equivalent unconstrained problem by exterior or interior penalty function approach. In this book, the interior penalty function method has been used which approaches the optimum from the feasible region ensuring a feasible solution at any instant in the search. Kuhn–Tucker conditions which ensure local optimum for a continuous variable problem with constraints have been described very well with illustration. Of the available constrained minimization techniques, such as sequential unconstrained minimization techniques (SUMT), gradient projection, feasible directions, etc., only SUMT is shown with illustrations.

Geometric programming applicable to a particular class of nonlinear problems involving posynomial functions has been dealt with next. Posynomials are generalised polynomials with positive coefficient and variables with arbitrary real exponents. The method computes the optimum value of the objective function first and then the optimum values of the variables. Thus, the method could be used to advantage for feasibility studies. Both unconstrained and constrained problems can be handled by this technique.

Dynamic programming based on multistage design process is considered next. The state of the system at a particular stage is solely dependent on the system state at the immediate previous state and the design is progressively improved at each state to arrive at the optimum. This technique is particularly useful where the objective and constraint functions are separable and in mechanical design process.

The illustrative examples are exhaustive covering a wide variety of problems. The problems chosen are useful for understanding the behaviour of the structural components used in aircraft design. A few examples come from civil engineering application. Some of the case studies described—walled columns with buckling constraints, multicell wings with strength and frequency constraints, wing structure optimization, laminated composite panel optimization under different loading conditions and constraints, cantilever beam with tip mass, etc. will be very useful for students and practising engineers. Where available, results from literature have been cited for comparison.

The book confines itself mainly to single objective optimization through deterministic methods using mathematical programming techniques. It will be useful for undergraduate and graduate students and also for practising engineers.

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Nanotechnology: Molecular speculations on global abundance edited by B. C. Crandall, The MIT Press, 55 Hayward Street, Cambridge, Mass. 02142, USA, 1996, pp. 214, $17.

As stated in the title of the book, this work is science fiction rather than science. The book speculates on the possibilities of manipulating molecules to design widely differing applications. Sensors, biological motors, use of biomolecules for computation, directed evolution, diamond jaws, etc. are just a few of the examples out of the plethora that have been mentioned in the book. Going through the book, one feels that it is a good science fiction work with (more often than not) little or no sound basis for what has been proposed. But that is probably what science fiction is all about.

The first chapter discusses introductory material. The dimensions of the atoms to those of galaxies, the nature of molecules and the development of the area of nanotechnology are discussed. This general introduction is necessary for a non-scientist. The book is then divided into three sections: (i) Mostly inside, (ii) Mostly outside, and (iii) Windows and environments. The section titles refer to applications basically within the human body (hence mostly inside) and outside it. The last section deals with a few other applications.

The first part deals with possibilities related to the use of nanotechnology in building an *in-vivo* nanoscope (Ch. 2), cosmetic surgery (Ch. 3) and diamond teeth (Ch. 4). While the possibilities are interesting, it appears that some of the applications are simply too trivial. It would have been better had these applications concerned some of the more serious problems facing humanity. Thus, for example, changing hair colour or eye colour or those related to baldness are good for wealthy individuals; it does not address many of the problems which require attention today. An *assembler* which is supposed to be a machine which assembles any molecule is discussed. Some of the astounding possibilities in the area of dental care are discussed.

The second part discusses applications that are not related to the human body. Chapter 5 deals with miscellaneous applications and Chapter 6 with personal computer. Other uses of nanotechnology are discussed in Chapters 7 and 8. Among the things discussed here are making small microscopic molecular robots which can do different types of work. These are termed nanomachines. Being small, such machines can exist in large numbers. The design of the very personal computer is discussed in detail and some useful applications are discussed for handicapped individuals.

The last part deals with two possibilities, namely, phased array optics (Ch. 9) and the utility fog (Ch. 10). The phased array optics has a possible application in constructing three-dimensional images from two-dimensional images. I quote from the last chapter: "Somewhere in your house there is a refrigerator, and within it stands a glass bottle of a beverage you wish to drink. Without getting up, or putting down this book, beckon with your hand. The door of the refrigerator will open, and the bottle will emerge, floating in the air. Simultaneously, a crystal goblet will appear in your hand. As the bottle approaches, the stopper will remove itself with a minimum of fuss. Enjoy your refreshment while the bottle floats serenely back to its place."

The last chapter deals with certain possibilities which seem more like magic since some of the proposals really seem like fiction.

Overall, it appears to be a book which would interest anybody who has an inclination to read science fiction. For a scientist, this book provides, at best, diverse possibilities in the area of nanotechnology by letting loose one's imagination wild.

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From imagination to reality: Mars exploration studies of the *Journal of the British Interplanetary Society*, Part I: Precursors and Early Piloted Exploration Missions: AAS Science and Technology Series, Vol. 91, edited by Robert M. Zubrin. Published for the American Astronautical Society and the British Interplanetary Society by Univelt, Inc., P. O. Box 28130, San Diego, California 92198, 1997, pp. 376, $ 70.

The title volume is a collection of 22 papers, published previously in the issues of the *Journal of the British Interplanetary Society* relating to exploration of Mars. It is divided into two sections—Precursors and Early Piloted Missions. Half of the papers grouped under the precursor section deal with the concepts for *in-situ* resource utilization while the other half discuss the exploration strategies on Mars.

Issues relating to making the case for Mars, getting there and being there, were discussed in the AAS Science and Technology Series, Vol. 86, which was reviewed earlier by the present reviewer. The topics presented in this volume are a step further in the studies of Mars. How to exploit the locally available *in-situ* resources on Mars, particularly as propellants for the return journey is a key issue. Because of the enormous distances involved (80 to 380 mkm) any chemical propellant if transported from Earth for the return flight from Mars, will cost over $50,000/kg. It would be beneficial if the same can be prepared utilizing Mars resources. Since Mars atmosphere contains about 95% CO_2, most of the suggestions pertain to the use of CO_2 to make *in-situ* propellants. Several papers discuss this issue. Methods suggested include breaking up of CO_2 to CO and O_2, reacting CO_2 with seed H_2 transported from the Earth and producing CH_4 and H_2O by the Sabatier process. H_2O could be electrolysed subsequently to produce O_2 and H_2, which could be used as propellants, or H_2 could be recycled to produce more CH_4. CH_4 and O_2 produced could be used as fuel and oxidizer, respectively, for the return flight. It is estimated that 1 kg of H_2 brought from the Earth could produce 18 kg of propellants. Other methods involve breaking the CO_2 using light metals brought from the Earth. CO_2/metal or CO_2/diborane are suggested for rockets working in a bipropellant mode. The *in-situ* propellant production (ISPP) method also includes the production of O_2 directly from Martian atmosphere by using a zirconia electrolyer to split CO_2 into O_2 and CO. Details of such a reactor are described. It is even proposed to launch an unmanned mission to

produce ISPP about 6 months in advance to the manned flight, and keep propellants ready for the return flight.

The presence of water on Mars is undisputed. It is present in polar caps, the regolith and the atmosphere. Methods suggested to utilize atmospheric water include adsorption process using molecular sieves. Another novel method proposed utilizes the Martian atmosphere constituents by temperature-swing adsorption. The process involves separating and compressing Mars atmospheric gases for *in-situ* resource utilization by a diurnal cycle: gases are separated by an adsorption-based separator at cold Martian night time temperature and are compressed at warmer daytime temperatures. The method could produce water, buffer gas, compressed CO_2 for applications such as scientific instrumentation, vaccum pumps, ISPP and life support.

This section also describes the design of a ground-penetrating radar (GPR) system capable of looking through the dust covering Mars, and probing the Martian subsurface in search for ice and geological information. It also introduces a proposal for a piloted double flyby Mars mission, named Athena which could be launched as early as 2001 at a cost of just $ 2 billion.

Papers included in the Early Piloted Missions section reveal that simulated studies covering a variety of aspects are required before sending human explorers to Mars. Of these, the crew health-related issues, both physiological and psychological, are most vital. The risk posed by increased exposure to space radiation and weightlessness could perhaps be reduced by deploying a faster propulsion system and artificial gravity. However, considering the very long exposure time—the suggested Mars trip time is about 3 years which includes a stay on Mars from a few days to as long as 550 days; the sprint class trajectory however would require about 14–16 months round trip, with a surface stay time of 20 days—more information is required. Using CH_4 and O_2 made from H_2 transported from the Earth and CO_2 on Mars as propellants for the return flight, a two-launch Mars Direct mission is discussed which appears feasible by combining near-term technologies. The data presented suggest a medium-energy conjunction class trajectory to be optimal for piloted missions. The optimal crew size is proposed to be a four-people crew—two 'Scottys' and two 'Spocks' in the 'Star Track' terminology.

To study other human factors (including long-term interaction among an international crew) in a cold isolated environment, an Antarctic research outpost as a model for planetary exploration is proposed. A planning of the instruments to be used in the astronauts' tool set to explore geological, biological and atmospheric aspects has been described. Suggestions have been made as regards the new designs of space suits and life-support systems for Mars exploration. An example scenario of daily activities of a four-planetary explorers team at a Mars base is also provided in this section.

Terraforming Mars, i.e. making it habitable for living, is an important factor once man reaches there. Certain aspects of the currently understood planetology relevant to terraforming are reviewed. To the question whether Mars can be terraformed to any extent at all, the answer is probably. But to find out for certain, we have to go there and look, and then 'yes'.

To summarize, the papers included in the volume are informative and interesting. The papers are all peer-reviewed and have already been published in *JBIS*. The expedition to Mars looks much closer to reality, and within the framework of the current technological feasibility. The day perhaps is not far off for the first manned flight to Mars. When that happens it will be another giant step for mankind. I am sure that Mars enthusiasts will like immensely to browse through these articles. The editor, Robert Zubrin, himself being an expert on Mars affairs, has done an excellent job in collecting relevant articles under appropriate groupings.

The volume bound in hard cover, as usual, has "Mars Base I", a painting depicting the Mars base set up in the course of 'Mars Direct'-type mission.

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From imagination to reality: Mars exploration studies of the *Journal of the British Interplanetary Society*, Part II: Base Building, Colonization and Terraformation. AAS Science and Technology Series, Vol. 92, edited by Robert M. Zubrin. Published for the American Astronautical Society and the British Interplanetary Society by Univelt, Inc. P. O. Box 28130, San Diego, California 92198, 1997, pp. 364, $ 70.

The title volume is a collection of a total of 19 papers published previously in the *Journal of the British Interplanetary Society*, 11 of which are grouped under Base building, and the remaining pertain to Colonization and terraforming of Mars.

Unlike the Moon, Mars is endowed with all the resources needed to support not only life but the development of a technological civilization. It has water frozen into its soil as permafrost, and vast amounts of carbon, hydrogen, nitrogen and oxygen, all in forms in which they could be readily accessible to utilization. Mars perhaps is the only extraterrestrial planet which may allow large-scale greenhouse agriculture lit by natural sunlight. It thus appears that Mars could be the new world for settlement. Approaches to reach Mars and utilize the *in-situ* resource were covered in Part I (Vol. 91) of the AAS Science and Technology series, reviewed by this reviewer. The present volume is a natural follower, and covers the next steps, namely, base building, colonization and terraformation.

The resources of Mars for human settlement are reviewed. The surface material contains chemical resources which can be converted to commodities, such as water, food, metals and fuels. Chemicals needed for manufacturing processes can also be produced from the soil. The *in-situ* propellant production from Mars resources was reviewed in Part I (Vol. 91) of this series. Energy resources considered for a human settlement are wind energy, solar and geothermal power. Although the atmospheric density of Mars is only 1/75 that of the Earth, estimated average wind speeds of over 14 m/s make wind energy useful for some applications such as oxygen or water production. Conceptual designs of the major components of a wind system have been proposed. The supply, collection and demand for solar power needed for a ten-person base are examined. The existence of geothermal hotspots on Mars is not certain, the prevailing view being that Mars is geologically dead and deep-frozen world. However, if hyperthermal areas exist, they might be profitably 'mined' for their heat.

Use of Martian resources in a controlled ecological life support system (CELSS) for crew life support on a Mars habitat is being studied. Methods for maintaining closed agricultural ecological system have been proposed. A concept design of a Mars settlement in the year 2057, consisting of habitat modules, a few hundred low-pressure greenhouses in which crops could be cultivated and big inflatable domes called Terraria used to breed livestock and fish, is presented. A solar-power satellite is proposed to supply energy to the habitats in the year 2057, the one hundredth anniversary of Sputnik orbiting the Earth. To achieve long-range mobility on the surface of Mars, alternative methods proposed include ground rovers, winged and lighter than air atmospheric vehicles and suborbital ballistic vehicles making use of rocket propulsion. Energy sources considered for such vehicles include batteries, fuel cells, radio isotope generators, solar photovoltaics, chemical combustion engines and nuclear reactors. Another paper included in the section considers the design aspects of an interplanetary transportation system to deliver 940 people to Mars using nuclear propulsion. The passengers are colonists to remain on Mars as permanent inhabitants and delivered on a one-way ticket. A lengthy exercise has been carried out but the idea seems to be far fetched for the present.

Terraforming (transforming for terrestrial life) Mars is a topic which has caught the imagination of several scientists. Ways to convert the cold and arid climate of Mars to cause a greenhouse effect include initial warming to drive the process. Means suggested for warming include stationing of orbiting mirrors, the importation of natural volatiles with high greenhouse capacity from the outer solar system and production of artificial halocarbon greenhouse gases on the Mars surface through *in-situ* industry. Another scheme involves the use of four 100-kg fusion warheads launched from a Mars orbiter, which will throw into air enough dust to cover the CO_2-rich South polar cap of Mars, darken it and cause it to subline through increased solar heating. The added atmospheric pressure will set off a runway greenhouse effect and partially terraform the planet, according to the author. Widespread growth of genetically engineered plants specifically designed for life on Mars, as a method of generating atmospheric oxygen, is suggested as yet another method of terraforming Mars. The use of genetically engineered microorganisms has also been envisaged for initial human colonization and ultimately the planetary engineering of Mars.

Most of the proposals mentioned so far for the ecopoeisis and terraformation, however, tend to treat the biological processes involved as a "black box" without specific detail to organisms and ecosystems. Only with detailed information about Martian environment and proposed terraforming organisms coupled with reliable models of communities that they form will accurate predictions of terraformation be possible. Right now, this information is not available. A question of environment ethics in using drastic measures for terraforming has also been discussed. The author of this article pertinently asks whether we should transform the planet into a life-bearing and habitable state or simply leave it alone, after taking into account ethical theories, i.e. homocentrisms, zoocentrism and biocentrism.

Overall, the papers presented make highly interesting reading. The issues discussed bring Mars closer to reality by exposing the fact that most of the problems involved are solvable by existing technologies. Mars appears to be within reach, and a real challenge for the next century. The decision to take up the challenge depends more on the prevailing political will power rather than urge of scientific enquiry. Whether it is worthwhile to spend billions of dollars on Mars or Earth is a debatable issue. The volume is recommended to space scientists and students. On the front cover, it has the same illustration of Mars base 1 as on volume 92-part I of this title.

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Some aspects of Brownian motion, Part II: Some recent martingale problems by Marc Yor, Birkhauser Verlag AG, Klosterberg-23, CH-4010 Basel, Switzerland, 1997, pp. 160, sFr. 32.

It is almost a century since the path-breaking papers of Bachelier and Einstein initiated a mathematical study of Brownian motion; a mathematically rigorous formulation of Brownian motion was achieved by Wiener in the 1920s. Ever since, Brownian motion has spawned its own offshoots: stochastic calculus, continuous martingales, continuous Markov processes, just to name a few. Einstein's work, among other things, indicated the connection of Brownian motion with the heat equation; much of the monumental work on the role of Brownian motion in statistical physics, theory of diffusion processes, etc. has been inspired by Einstein's work. On the other hand, Bachelier's derivation of the Brownian motion process from fluctuations in stock market prices initially did not attract much attention, though his work predated that of Einstein by three years; however, the recent spurt in financial mathematics is a testimony of Bachelier's foresight.

Stochastic calculus for general semimartingales, enlargement of filtrations, stopping times/random times, Wiener chaos representation are some of the 'technology' developed over the years to study a variety of probabilistic/analytic problems inspired by the Brownian motion process. Professor Yor points out that a number of very natural questions regarding these topics seem to have escaped attention till recently; the book under review concerns some of these natural but intricate aspects. It is of interest to note that some of the questions have arisen from applied probability, and some are of interest in mathematical finance. Also an interesting outcome of pursuing such questions is the emergence of the Azema–Emery martingales. This book, being Part II of a two-part volume, amplifies some of the computations of functionals carried out in Part I (Chapters 1–9 form Part I, while Chapters 10–18 form part II).

Coming to a brief chapterwise description, Chapter 10 has results relating principal values for Bessel processes and excursion theory. In Chapter 11, some connections between the Riemann Zeta function and the 3-dimensional Bessel processes are discussed. Some developments related to Part I are reported in Chapter 18. These three chapters essentially augment Part I.

Chapters 12–17 may be considered the main thrust of Part II, dealing with problems arising from martingale properties, filtrations, random times, etc.

An exposition of the difficult topic of the theory of enlargement of filtrations is presented in Chapter 12 (enlargement of filtrations is useful in defining certain anticipative stochastic integrals). Both initial as well as progressive enlargement of Brownian filtrations are studied; in both the cases, D. Williams' path decompositions and Pitman's theorem on the 3-dimensional Bessel process are obtained and extended.

Chapter 13 investigates the extension of Burkholder–Gundy inequalities when random times are considered in place of stopping times, whereas the next chapter discusses martingales which vanish on the zero set of the Brownian motion.

A remarkable class of martingales, due to Azema and Emery, are introduced in Chapter 15. These processes are also Markovian, enjoy Brownian scaling property, and in some cases also exhibit the Chaos representation property (the validity of the Chaos representation property in other cases of Azema–Emery martingales is an interesting open problem!). Some intertwining relations between Azema–Emery martingales and Brownian motion are sketched. Another open question is a representation of Azema–Emery martingales in terms of Brownian motion. Chapter 16 is about the filtration of truncated Brownian motion.

An important open problem concerning Brownian motion is: when is a filtration the natural augmented filtration of an one-dimensional Brownian motion? Chapter 17 presents discussions centred around this question. Some of the candidates tried out are: martingale representation property, filtration of Walsh's Brownian motion (In this context, one may see the article by Tsirel'son in the *Proceedings of the International Congress of Mathematicians*, Berlin, 1998, Vol. III for an update.).

To add an exotic touch to the book there are also Brownian snakes and spider martingales!

In spite of its slender look, this is a formidable book, and is meant for the specialist. Perhaps more detailed proofs would have been helpful.

For a brave reader, this book (together with Part I) can be very rewarding, imparting a very good insight into the subtelities of martingale theory and stochastic calculus.

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The complex WKB method for nonlinear equations I: Linear theory by Victor P. Maslov, Birkhauser Verlag AG, Klosterberg 23, CH-4010 Basel, Switzerland, 1994, pp. 308, sFr. 98.

The letters W, K and B in the title stand for Wentzel, Kramers and Brillouin, respectively. In their work done independently in 1920s, they have obtained asymptotic solutions to stationary Schrödinger equation in one dimension as Planck constant goes to zero. Even though such solutions were obtained earlier by others, the procedure is known in literature as WKB method. This method has been generalized to obtain asymptotic solutions to partial differential equations (both linear and nonlinear) involving a small parameter. Maslov is one of the pioneers who have made original contributions to this important area of development. His approach is geometrical.[1,2] The same method is taken up in this volume and generalized to the so-called complex case. In order to understand the issues involved and appreciate Maslov's contributions, it is necessary to start with the real case.

The general Ansatz for asymptotic solutions in WKB method is

$$u(x,t) = \exp\left\{\frac{iS(x,t)}{h}\right\}\phi(x,t). \tag{1}$$

Here, $h > 0$ is a small parameter. The phase function S and the amplitude ϕ are real-valued. As $h \to 0$, the above expression represents a function which oscillates on fine scales. The method consists of substituting (1) into the given equation in $\mathbb{R}^n$ and finding out S and ϕ. The function S is found to satisfy

$$\frac{\partial S}{\partial t} + H(\nabla S, x, t) = 0. \tag{2}$$

This is known as Hamilton–Jacobi equation where $H = H(p, q, t)$ is the Hamiltonian associated with the given equation. While (2) is nonlinear, ϕ satisfies a linear, first-order equation with variable coefficients called Transport equation which we do not write down.

It is known from classical mechanics that solution S of (2) is nothing but the action associated with the trajectories of the Hamiltonian system:

$$\begin{cases} \dfrac{dq}{dt} = H_p, \quad \dfrac{dp}{dt} = -H_q \\ q(0) = \alpha \quad p(0) = \dfrac{\partial S}{\partial x}(\alpha, 0). \end{cases} \tag{3}$$

Projections of trajectories onto configuration space are called rays. To find $S(x, t)$ and $\phi(x, t)$, we must solve

$$q(\alpha, t) = x \tag{4}$$

uniquely for α. Even if we admit that trajectories are globally defined, there are difficulties in the resolution of S and ϕ. It is true that the measure in phase space is conserved by trajectories but that is not the case in configuration space. Indeed, rays can focus on what are called caustics. At these spots, S becomes multivalued. The amplitude ϕ behaves like $J^{-\frac{1}{2}}$ (where $J(\alpha, t) = \det\frac{\partial_\alpha(\alpha, t)}{\partial\alpha}$) and hence blows up at caustics. Both these difficulties are overcome by an ingenious procedure of Maslov which is a quantization method of associating waves of the form (1) to Hamiltonian trajectories of (3). The first step is to consider what are called Lagrangian manifolds Λ_t inside phase space. They are nothing but the images of Λ_0 under the flow $\{g^t\}$ defined by (3), where Λ_0 is defined by

$$\Lambda_0 = \left\{ x = \alpha,\ p = \frac{\partial S}{\partial x}(\alpha, 0);\ \alpha \in \mathbb{R}^n \right\} \tag{5}$$

Assuming that Λ_t develops folds with several branches with respect to q-space, we see that there can be more than one point on Λ_t sitting over a fixed point x. This is the reason for multivaluedness of S. However, eqn (4) can be solved uniquely on each branch, an observation which enables us to define uniquely a 'lift' of S on Λ_t. To define $S(x, t)$, the idea is to add contributions coming from each branch.

To construct ϕ, we need to analyze how measure is transported by phase flow from Λ_0 to Λ_t. Phase flow can reverse orientation and consequently J can take positive and negative values on alternate branches. This makes $J^{-1/2}$ complex, in general. The associated phase factor depends on what is called Maslov index, an important topological invariant of the Lagrangian manifold Λ_t.

Since $J = 0$ at fold points, the above procedure breaks down. At these points, it is possible to make a change of variables $q \mapsto \left(q_I, p_{\bar{I}}\right), I \subseteq \{1,2,\ldots n\}, \bar{I} = \{1,2\ldots n\} / I$ such that

$$\left(Q_I(\alpha, t), p_{\bar{I}}(\alpha, t)\right) = x \tag{6}$$

can be uniquely solved for α (cf (4)) and at the same time $J \neq 0$ with respect to these new mixed variables. Following the method outlined above, we will be in a position to compute wave function with variables $(q_I, p_{\bar{I}})$. Fourier inversion with respect to $q_{\bar{I}}$ will then yield the required wave function in variable q.

Above is the gist of Maslov's method in the real case. In the present volume, the above method has been generalized to the case where the phase function S and ϕ in (1) are allowed to be complex-valued with

$$ImS \geq 0. \tag{7}$$

The above condition allows us to include dissipation effects in the wave propagation problems. As a result of dissipation, one may have strongly localized wave fields in the neighbourhood of a surface $\delta_{x,t}$ defined by $ImS = 0$ (e.g. laser beam where the above surface is one dimensional).

When S is real, i.e. $ImS = 0$, S and ϕ satisfy Hamilton–Jacobi equation and transport equations with zero right-hand sides. Thus, it is intuitively clear that where S is complex-valued, we will still have an asymptotic solution u if S and ϕ are allowed to satisfy same equations but with non-zero right-hand sides which are small when ImS is small. Such solutions S and ϕ are called *approximate solutions*. The book is primarily devoted to the construction of such solutions concentrated in the neighbourhood of k-dimensional surfaces $\delta_{x,t}$ with $0 \leq k \leq n$. It is proved that the initial beam propagates in the limit according to Hamiltonian mechanics and the behaviour of its neighbourhood is governed by the linearized Hamiltonian system. The first four chapters are devoted to these tasks.

The method followed in the construction is similar to the one which is followed in the real case, but of course, with important modifications due to the new parameter ImS. Fundamental geometric tools used are dissipative Lagrangian manifolds with complex germ. (The dissipativity condition is to ensure that the phase defined on them satisfies (7).) At the initial time, they are constructed from initial condition and for future times, phase flow is used. It is then quite clear that if the initial manifold is invariant under phase flow, the above construction will yield an eigenfunction of the stationary equation. This task begins in Chapter IV where initial surface is not closed. The case of closed curves (i.e. $k = 0$, 1) is considered in Chapter V. The natural stipulation that the phase function is single-valued gives the Maslov quantization condition on the invariant Lagrange manifold. This condition is well known in literature in the real case and the same is analyzed in the complex case. The final chapter is reserved for the application of the pre-

ceding theory to give a semiclassical description of eigenfunctions and eigenvalues to specific problems of quantum mechanics.

The main chapters of the book are supplemented with three appendices. The aim of Appendix A is similar to that of Chapter IV. It reports on some recent progress made in the case $k > 1$. Appendix B discusses the particular case where the phase is purely imaginary. Such problems arise in tunneling in quantum mechanics and in large deviations in probability theory. In Appendix C, the author compares the asymptotic solution obtained in previous chapters with the general problem of asymptotic behaviour of integrals using saddle point method. He also offers some heuristic solutions to overcome the difficulties associated with the latter problem.

Nowadays, there is a tremendous interest in the problem of quantization of classical trajectories, both regular and chaotic. The author is one of the first to offer a geometric approach to this problem. Several questions remain open in this area especially in the context of inhomogeneous media and singularities. This translation of the original version in Russian will, undoubtedly, help a wider mathematical community. It must be said that it is a tough book to read and typographical errors do not make the matters easy. Even though other books have appeared on the subject, I feel that it is always worthwhile to read the works of the author who is acknowledged to be a master in asymptotics.

References

1. MASLOV, V. P. *Théorie des perturbations et méthodes asymptotiques*, Dunod, Paris 1972.

2 MASLOV, V. P. AND FEDORYUK, M. V *Semiclassical approximation in quantum mechanics*, Reidel, 1981.

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University chemistry,
Limited, Publishers, 4835/2. 087,
Rs 75.

The volume under review is divided into three parts, viz. inorganic, organic and physical chemistry. It has a section on practical chemistry, and instruments and technique are broadly covered. A general introduction to pollutants or their impact on health and environment is also included.

The tone and tenor of the volume are that of a study guide or a companian volume to a proper textbook. Thus, it is written with an eye on examinations. Hence, the treatment of the topics is disjointed and is question-oriented in the form of notes, rather than as a comprehensive one.

Further, the level of presentation (at least of the sections in physical chemistry) is that of higher secondary course, though the range is extensive. Most of the problems in physical chemistry section are plug-in type and lack variety. No nomenclature is given. The portions covered in this volume are restricted to III year B. Sc. students of Andhra Pradesh Universities only.

Absorption spectroscopy is not covered adequately with sufficient examples. Characteristics and application of mass spectroscopy and NMR spectroscopy have not been included. However, electrochemistry has been covered in detail. Nuclear reactions and organic polymers, both synthetic and natural, have not been included though I am not aware if these have been covered in the first two volumes.

However, the style is quite lucid and readable. Once its limitation is recognized that it cannot replace a textbook and that it is at best a good study guide, it can be used profitably to prepare for examinations.

We have not had access to the first two volumes to give a detailed review of the series.

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Laboratory manual in microbiology by P. Gunasekaran, New Age International (P) Limited, Publishers, 4835/24, Ansari Road, Darya Ganj, New Delhi 110 002, 1996, pp. 138, Rs 65.

The manual is a handy and concise package of information. The book has been written for the students of both UG and PG courses in microbiology. The syllabi of any UG/PG course covers many aspects of microbiology in methodology and applications. The experiments included per se are informative, simple and within the reach of general laboratory infrastructure but all the experiments to be conducted according to the syllabi are not covered. Exercises 1 to 13, 17, 24, 25 and 26 are covered under UG courses and as such are redundant for PG courses.

The manual can be of help as a reference book for certain practical experiments. While dealing with microscopy, inclusion of the study of stereomicroscope and phase-contrast microscope with maintenance tips would be helpful, as they are routinely used by PG students. PG students have to conduct experiments in greater detail as compared with undergraduate students. Experiments related to measurement of growth or estimations of metabolic products, qualitative and quantitative analysis, assay procedures are conducted in greater detail using different types and species of microorganisms. Hence protocols should include instructions for differential analysis and study.

Apart from the above, many experiments in applied microbiology such as food, dairy, industrial, agricultural and medical are widely conducted. The manual is deficient in these. Albeit, experiments in genetics and genetic engineering are simple and convenient to conduct for PG students.

Undergraduate students being fresh and inexposed to practical methodologies in subjects like microbiology in preuniversity course need very specific, simple and mandatory instructions. The dos and donts in respect of operating basic equipment do not include autoclave, hot-air oven, U. V. light use, etc. which are required. Aseptic conditions are important for cultural operation to obtain contamination-free cultures; unfortunately this is missing in Experiments-I, III and IV.

The author could have used specific terms to indicate particular material or organism such as 'inoculumn-containing substance' instead of 'things' in experiment II. Additional information regarding colony morphology including pigmentation, opacity, size, texture, media composition, temperature, pH and age would help students to appreciate the significance of parameters in growth and identification. The general term 'microorganisms' in the titles of experiments 7 and 9 could be reworded to indicate bacteria and yeasts as they are used in the experiment.

Protocol-containing specific reagent in experiment 12 oxidase test (Step 2) should read oxidised TMPD, as commercially available TMPD is in reduced form; this avoids confusion in the minds of students and also the use of reagents mentioned in the second part.

It would help in value-based analysis of samples if test standard values for various kinds of water samples (potable, industrial, agricultural) are indicated for analytical experiments such as MPN.

Section-cutting is desired as an additional method of demonstrating the presence of Rhizobia, the relationship and anatomical details in root nodule study to make students understand the etiology of Rhizobial infection in experiment 27.

There are many typographical errors which could have been easily corrected.

The approach of covering individual experiments with principles based upon is commendable. In future editions it is recommended to cover the entire syllabi for better package to microbiology students or a manual exclusively on experiments in genetics and genetic engineering in the same simple-to-understand and easy-to-follow format would be welcome to microbiology and biotechnology students, as such manuals are not available for practical guidance to UG and PG students.

I congratulate the author for the coverage of topics in genetics experiments. This would broaden the learning and training of students in molecular biology and biotechnology which are the branches of keen interest and have profound application.

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