Selected Papers. Vol. 2 : Radiative Transfer and Negative Ion of Hydrogen
by S Chandrasekhar
The University of Chicago Press : Chicago, USA, 1989
622 pages ; price : US $ 34·50 (Paper) ; ISBN 0-226-10093-6

The equation of radiative transfer governs the transport of radiant energy in a medium absorbing, emitting and scattering radiation and its solution is of utmost importance in astrophysics. In the short period 1944-50 Professor S. Chandrasekhar made a lasting contribution to the solution of radiative transfer problems by his powerful mathematical techniques and his superb mathematical analysis. Papers included in the first three sections of Part 1 of this collection give the gradual evolution of his techniques and ideas.

In the starting paper of the first section, a new method is presented for solving the transfer equation for a semi-infinite plane-parallel atmosphere with isotropic scattering. The integro-differential equation for the intensity of radiation is converted into a set of coupled equations by using the Gaussian formula for numerical integration, the quadrature points in the n-th approximation being the zeroes of the Legendre polynomial P_{2n}. The solution of the required boundary value problem is obtained by the linear superposition of all the solutions of the coupled equations, the constant coefficients being determined by satisfying the boundary condition. The constants are eliminated in later works and the angular distribution of the emergent radiation is obtained in a closed form in terms of H-functions which are rational functions of the cosine of the angle. The exact Hopf-Bronstein relation, which gives the boundary temperature in terms of the effective temperature, is proved to be satisfied in any n-th order approximation. The method is subsequently applied with success to the spherical atmosphere, a stellar atmosphere in local thermodynamic equilibrium, the diffuse reflection by a semi-infinite plane-parallel atmosphere with general scattering laws and finally, the diffuse reflection and transmission by a plane-parallel atmosphere of finite optical thickness, in which case, the angular distributions of the emergent radiations are obtained in terms of the pair of rational functions X and Y.

The second section deals with more complicated problems which require the consideration of the polarisation of the radiation in addition to its intensity. Chandrasekhar first formulates here the general transfer equation allowing properly for the polarisation, in terms of the Stokes parameters, thus paving the way for the solution of a variety of interesting problems including the very important one of the illumination and polarisation of our sunlit sky. This formulation itself had

remained a fundamental problem. The new method of solution is equally applicable to these complicated problems.

In the third section Chandrasekhar, guided by Ambartsumian's basic ideas, applies the principle of invariance allowing for polarisation, to the problem of diffuse reflection by a semi-infinite plane-parallel atmosphere and obtains nonlinear integral equations for the scattering matrix which, though too complicated to be solved, can be reduced to simpler functions, also satisfying nonlinear integral equations. He then shows that the H-functions of his earlier work satisfy these equations when the order goes to infinity. Similarly, for a plane-parallel atmosphere of finite optical thickness, the scattering and transmission matrices can be expressed in terms of simpler functions satisfying one or more pairs of nonlinear integral equations and the X and Y functions occurring earlier turn out to be the solutions of these equations in the infinite approximation. An accurate evaluation of the exact H, X and Y functions now becomes possible by a rapid method of iteration of the integral equations using their values in a rational approximation of some high order, for the starting.

Part 1 has two more sections ; the fourth section includes three papers on miscellaneous astrophysical problems and another on mathematical boundary-value problem, while the last section contains two review articles on radiative transfer.

Part 2 is primarily devoted to Chandrasekhar's quantum mechanical calculations for a reliable determination of the absorptive power of H^-, negative hydrogen ion, for continuous radiation of varying wavelengths, it also includes his calculations of the accurate ground state energies of He, Li^+ and O^{6+} by the variational method.

The existing results of quantum mechanical calculations of the absorption coefficient of H^- for continuous radiation, have been in utter disagreement with the very reasonable suggestion of Rupert Wildt that the negative hydrogen ion plays the dominant role in the continuous absorption in the solar atmosphere. Chandrasekhar is thus led to consider the evaluation, with as high percision as possible, of the matrix element of the bound-free transition in which the H^- breaks into an outgoing electron and a hydrogen atom by interacting with the radiation field. After observing that, of the three alternative forms of interaction – the length, velocity and acceleration forms-the velocity form should yield the best result, he calculates the absorption cross section using the best available H^- wave function, the velocity form of interaction and improved continuous wnve function of the outgoing electron in the field of the hydrogen atom and obtains much better agreement. Further, calculations are done to estimate the absorption due to the free-free transition in which an electron initially moving with a certain velocity in the field of the hydrogen atom, finally moves with a changed velocity on absorbing

a radiation. The new results including the contributions of both bound-free and free-free transitions account closely for the absorption of continuous radiation in the solar atmosphere over the entire range of wavelength from 4000 to 25000 A.

Also included in Part 2 is 'the story of two atoms'—a lucid account of He and H^-, their discovery and the principal role of H^- in the absorption of different colours in the sun.

The present volume is immensely rich in elegant ideas and techniques with proved efficiency for a neat solution of extremely complicated problems and, as such, should be of general interest and use to all theoretical physicists ; to an astrophysicist it is indispensable as a source of reference. This volume should be in the possession of every good science library.

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Guidance on Radiation Received in Space Activities (NCRP Report No. 98)

NCRP : Bethesda, Maryland, 1989
227 pages : price : $17·00

The report provides latest assesments for radiation exposure limits and up-to-day risk estimates for astronauts. In this report, the working group considered new missions that are introduced and radiation protections presently adopted. Furthermore, additional data from Japanese atom bomb survivors and improved information on effect of radiation exposures on individual organs are taken into account.

Exposure of radiation in a space mission depends on many details viz. spacecraft trajectory and inclination, altitude, mission duration, nature and thickness of shielding of spacecraft (Bremsstrahlung radiation is produced by interactjons between electrons and wall materials of the craft). Exposure also depends on time of mission in solar cycle (movement of astronauts inside and outside the vehicle), energies of radiation and radiobiological effect. The report considered all new information, astronaut group and exposure details.

After giving a summary of the report in Chapter I, the work of the group set up for Assessment of Radiation Risks in Space by the National Academy of Science is considered in Chapter II. The working group examined the scientific and philosophical basis of radiation protection criteria for manned space flights.

Recommendations are made for the following : (1) guidelines for space travel, (2) the risk involved for both men and women, (3) risk in outer space and with special reference to SPE (Solar Particle Events) and HZE (High Z particle Energy) particles, (4) information and future research needed.

The effects of radiations in space are divided into three subdivisions : *early effects* occurring within sixty days, *late effects* occurring after early effect period. The cancer was the principal late effect. *Acute effects* which impair the performance and may threaten the complition of the mission.

It is shown in the report that except for protrated radiation exposures, radiation exposures in space are low compared to other risks involved in space flights. They are considerably lower than the terrestrial maximum permissible exposure levels.

It is pointed out that the radiation protection risk is an international concern and involves population on the earth as a whole.

In Chapter III, the radiation exposures in space are considered which are shown to be of three types : (1) trapped particle radiations, (2) galactic cosmic radiations, (3) solar particle radiations. The first type of radiations consists mainly of electrons, protons moving in close orbits in the earth's magnetic field. The galactic radiations consist mostly of protons with a small mixture of helium and even a smaller component of heavier particles. The solar particle radiations are composed mostly of protons with a small amount of helium ions and heavier particles. While for solar radiations the particle energies are high and sporadic in nature, for galactic radiations they are low and slowly varying.

It is shown in the report that it is not possible to predict which flare will produce energetic protons and reach the orbit of the earth. The date on which solar event will reach the orbit of the earth is not known. It is, however, possible to predict with some certainty whether a potential flame-producing region exists on the Sun. Once a solar flare occurs prediction of a subsequent SPE improves. The characteristics of the flare, such as the energy it releases in the form of X-rays or the amount and type of radio emissions, can be used to predict the SPE occurrance and its maximum fluence rate.

Lunar Mission :

For lunar trip, the total dose equivalent for exposure has been calculated after considering the transit through the Radiation Belts on both legs of the journey, transit from beyond the magnetosphere to moon and stay on moon. Calculations were also made to the increased dose equivalent if a large event occurs on Sun while the astronauts are on the lunar surface.

Mars Mission :

A rough estimate for exposure for mission to Mars was made. Assuming mission at solar minimum, a one-year flight to Mars would yield 0.45 Sv behind 2 g cm^{-2} Al shielding and 0.12 Sv on Mars below the 10 g cm^{-2} CO_2 shielding of the atmosphere of Mars. For a single three-year mission (one year for journey to Mars, one year stay on Mars and one year for return journey), the estimate is roughly 1 Sv total fo the BFO. (The calculation excludes exposure from onboard nuclear power sources and radiations from solar particle events. In case mission occur during solar minimum, the probability of having a large SPE is low. Some of the very large events may occur close to the solar minimum period within a few years.

In Chapter V, biological effects due to radiations in space are considered.

The electrons, protons and heavy ions have characteristic radiation exposure effects. For protons and heavy ions, the available information in human organs is insufficient. Hence one should consider experimental animal data. Neutrons should also be included because their exposure also occur in spacecrafts. However the contributions of neutrons to the total dose is small.

Electrons are small negative charged particles. Due to irradiations of matter with $X-$or γ-rays, electrons are set into motion and with sufficient energy ionise atoms. Thus, the biological effects of X-, γ-rays and electrons are similar. Only a few data of late effects of electron irradiation are available.

Protons loose energy as they pass through tissues mainly by interacting with atomic electrons. Secondary particles, such as, secondary protons, neutrons, pions, heavy particles and γ-rays are produced. As protons are slowed down the rate of energy increases. The depth dose distribution in tissue exposed to protons is given by Bragg curve which relates ionisations as a function of depth. The depth in tissue is dependent on the energy. The effects of protons of different energies have been studied. Proton-irradiated monkeys show that in females endometriosis appears after exposure to radiation. When exposed to 55 MeV protons, eight of 41 monkeys that had died, had glioplastomas.

The neutron is an uncharged particle and is therefore, very penetrating. Neutron interact with nuclei of atoms, whereas X-rays interact primarily with orbital electrons. By elastic scattering with atomic nucleus, neutrons are not slowed down to thermal energies.

Hydrogen, which is in abundance in tissues and having a large collision cross-section, interacts with neutrons producing large transfer of neutron energy and resulting in recoil protons. The latter loose energy by ionisation and excitation as they traverse the cells. As neutron and proton masses are essentially same, proton can acquire all neutron energy in a single head-on elastic collision with hydrogen. Again, interaction between neutrons and elements other than hydrogen

also produce recoiling heavy nuclei. The contributions of doses in the tissue are smaller than for interactions with hydrogen. Neutrons are not taken into account because of lack of relevant dose measurements and also because their contributions to the dose are assumed small. Neutron irradiations cause marked late effects and more severe effects than would be predicted from the acute response.

The three main models, are used to estimate cancer risks in man following exposure to low-LET radiations. They are classified as (1) the *linear model* in which effects are proportional to dose, (2) the *quadratic model* where effects are proportional to the square of dose, and (3) the so-called *linear-quadratic* model which is intermediate between the two models. At low doses and low-dose rates a linear component dominates and a quadratic component at high dose-rate exposure.

The report also gives the latent period influenced by the age at exposure. It varies between types of tumor, and may be greatly in excess of five years. For example, radiation-induced skin cancers usually do not appear for over 20 years after exposure.

Following radiation exposure, Leukemia is the most commonly reported cancer. There is a log-normal pattern of excess incidence over time which in two to four years the excess is apparent, peaks at six to eight years, and decreases about 25 years later. Chronic lymphocytic leukemia, had never been reported to be in excess in any radiation study.

The risk of radiation-induced breast cancer is high for women exposed in adolescence and it decreases with age.

Atom bomb survivors show that radiation causes stomach cancer. On the other hand, cervical cancer patients treated with radiation found no evidence for a radiation effect. Similarly, studies of women irradiated for benign gynecologic disease have been generally negative.

Radiation may cause particularly all types of cancer. There is little or no evidence for malignant lymphoma or chronic lymphocytic leukemia.

In Chapter VI protection from radiation are considered and recommendations are given.

The NCRP Report recommends that, except for exploratory circumstances in space (e.g. Mars mission), a career radiation risk limit of 3% for all ages and for both sexes be adopted.

The NCRP also recommends that in no circumstances should a pregnent female be a member of a crew in space. The special risks for embryo-fetus are small formation and mental retadation. The risk of cancer may be greater than that for adults.

The NCRP Report 98 gives a series of accurate, complete and useful new information of radiations in space. They provide wide and varied knowledge of space—its radiation environment, exposures, radiobiological effects and protections from radiation exposures. Although estimates carried out at present show that hazards to space travel are not high, but they can be so for space travel of long duration as in Mars mission. So the suggested recommendations should be carefully studied and followed. Also future research be undertaken.

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White Dwarfs (Lecture Notes in Physics, Vol 328)
(Proceedings of IAU Colloquium No. 114, held at Darthmouth College, Hanover, New Hampshire, USA, August 15-19, 1988)
edited by G Wegner

Springer-Verlag : Berlin-Heidelberg-New York-London-Paris-Tokyo, 1989
xiv+524 pages ; price : DM 102 (Hard cover) ; ISBN 3-540-51031-1

This book embodies the proceedings of IAU colloquium no. 114 held at Dartmouth College, Hanover, New Hampshire, USA, August 15-19, 1988. It is a collection of a large number of papers presented at the colloquium including a number of review papers (listed below). The book is meant for research workers and experts in the field. The purpose is to update the information available at the Delaware Workshop held in Montreal in June 1983. The review papers in the volume are listed below to give an idea about the subjects covered.

1. Mass distribution and Luminosity function of white dwarfs—V Weidemann and J W Yuan.
2. The Luminosity function of white dwarfs in the local disk and halo—J Liebert, C C Dahn and D G Monet.
3. Two new late-type degenerates : implications for the white dwarfs luminosity function—C C Dahn, D G Monet and H C Harris.
4. Pre-white dwarf evolution : upto planetary nebulae—J Mazzitelli.
5. Evolution of white dwarfs : starting from planetary nebulae—F D' Antona.
6. Transport processes and neutrino emission processes in the interior or white dwarfs—N Itoh.
7. White dwarf evolution in real time : what pulsating white dwarfs teach us about stellar evolution—S D Kawaler and C J Hansen.
8. Diffusion and metal abundances in hot white dwarfs—G Vanclair.

9. Chemical stratification in white dwarf atmospheres and envelopes—D Koester.
10. Gravitational redshifts and the mass-radius relation—G Wegner.
11. White dwarfs in globular clusters—G G Fahlman and H B Richer.
12. On the formation of close binary white dwarfs—I Iben and R F Webbink.
13. On the masses of the white dwarfs in classical nova system—J W Truran and M Livio.

In addition it has a paper : The coalescence of white dwarfs and type I supervovae—R Mochkovitch and M Livio.

The book will be useful to astrophysicists working on various aspects of white dwarfs.

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Journey into Light : Life and Science of C V Raman

by G Venkataraman

Bangalore : Indian Academy of Sciences, 1988
xviii+640 pages ; price : Rs. 175.00, $ 45·00 (Hard cover) ; ISBN 81-85324-00-x

Since this book was released by the Prime Minister in 1988 during the celebration of the birth centenary of C V Raman and the Diamond Jubilee of the discovery of Raman Effect held at the Indian Association for the Cultivation of Science, Calcutta, it has attracted vast number of appreciative readers. Quite a few reviews have also been published. The book is a delightful and very recommendable biography of one of the great scientists of India who influenced immensely the history of modern science in this country. The added attraction of the book is that Venkataraman provides the reader with an unusually good exposition of the Science Raman made, in a lucid fashion. The quality that makes Venkataraman unique amongst expositors of contemporary Indian Science is his depth of historical focus.

"The Background" on which Raman along with his contemporary scientists Saha and Bose worked, was pen-portraited to bring out the immense energy of these scientists to blossom in a hostile terrain. Backwardness of the society, shattered national economy under an oppressive colonial power, geographical isolation from the major centers of comtemporary science and many other diverse constraints could not deter these men from creating what one reviewer has called "Indigenous Science".

"The Early Years" of Raman, his birth, his family, his society and his schools were described in a picturesque style. Raman's keen passion for science, his capability of original thinking in early years, breaking of tradition even in marriage, all indicated an "extraordinary" man in the making.

Showing of early morning developed into beautiful sunshine all around in "Oh Calcutta". Calcutta gave Raman his second birth. An "Accountant General" was reborn as a "Nobel Laureate Physicist". Indian Association for the Cultivation of Science played the mother's womb. "Raman was given full use of the Association facilities and the freedom to come and go as he liked". Venkataraman writes "In fact Calcutta could claim to possess a school of Physics the like of which certainly did not exist in any other Indian University at that time and which was comparable with those existing in the best European and American Universities". All these were possible because of great personalities like Dr Mahendra Lal Sircar, Sir Asutosh Mookerjee, Sir Jagadish Chandra Bose and Acharya Prafulla Chandra Roy who were great visionaries and lived far ahead of their time.

The contribution of Dr Mahendra Lal Sircar and Sir Asutosh Mookerjee in Raman's making as great scientist cannot be underestimated though the former died three years before Raman entered IACS founded by him in 1876 and the latter died before Raman won the coveted prize. About Sir Asutosh Mookerjee's contribution towards Raman's achievement, the great statesman Rajaji said "but for him, Raman would have retired as a faultless Accountant General".

In the concluding section of this chapter on Raman's "Exit" from Calcutta, some of the authors' statements such as "Saha became furious" at Raman's expression that Krishnan was a better candidate for MLS Professorship of IACS and that in Allahabad "his (Saha's) life was miserable" have already been criticised by one reviewer as being "based on rumours" rather than on "documentary evidence". Many will however, subscribe to Venkataraman's final contention that the "Exit" happened as "there was not enough rooms for both the giants" in Calcutta.

The "Glimpses of the Golden Era" again tells us about Raman's Calcutta days. In author's own words "it is during this (period) one sees Raman at his creative best". His research in science covered wide variety of areas such as vibrations, musical instruments, optics and X-rays. His works on light scattering which led to the great discovery constitute a whole new chapter entitled "Elementary, My Dear Watson". Indeed all the Watsons before Raman saw the blue of the sea but it is he who succeeded to reason.

The chapter called "I say, What is this Raman Effect ?" is an exceedingly readable exposition of the science of Raman effect and it is where Venkataraman

shows his best in presenting science in a lucid fashion. Discovery of laser, a light source "Brighter than thousand Suns" has revolutionised the application of Raman scattering and has brought down Raman Spectroscopy to the level of a "tool" for science and industry. The message has been efficiently transmitted to the readers.

Raman lived more years of his life in Bangalore than in Calcutta. Naturally, the chapter "On to Bangalore" consume three times more number of pages than "Oh Calcutta". Raman's life and struggle in Bangalore and the science he did there have been treated more in a pensive mood than with flamboyance. "The transition to Bangalore did not end Raman's difficulties. Once again the forces rallied against him were able to dislodge him from a position of authority". In the next chapter "Son et Lumiere", though Venkataraman gets back his enthusiasm in dealing with "The Raman-Nath theory.....unquestionably the high point of Raman's work at the Indian Institute of Science", with his usual proficient language of science writing, he laments again on Raman's retirement from IISc. "The Raman we see leaving the Institute is a very different person that we saw earlier leaving Calcutta.....with fewer scientific triumphs to boast of".

"The Born-Raman Controversy" is on the science of lattice dynamics. Venkataraman's success in this chapter in not only in explaining the two scientific theories but also in bringing out that the two great scientists were also down to earth human beings with love, passion and anger.

"The Academy', one of Raman's gift to India" was established also through a high drama with angry Raman resigning from the Special Academy Committee formed to establish a National Science Academy. He formed "his own Academy". Happily today, both Indian Academy of Science and Indian National Science Academy are functioning harmoniously in their specified areas of activity to meet the need of Indian scientific community.

"The final years" of Raman is an ensemble of his deep commitment to science. He built the Raman Research Institute and after retirement from IISc, kept himself engaged in research, principally in Optics. Time and again Raman expressed his desire to live "a hundred percent active and productive life" and he did by all measures. Raman died on November 21, 1970.

Before conclusion "Looking Back", Venkataraman evaluates Raman as a scientist and as a man. He feels pain to say "Raman developed a mental block and refused to absorb the subtlities of new developments (in Quantum Mechanics)". But it did not deter Raman from his quest for science even in his late years. In early years in Calcutta, he was a Giant Scientist who made the mighty discovery indigeneously. As a man "Raman's ego is well known. His logic seems to have failed him at crucial times in later years". In spite of all these, he was "warm-hearted and without a trace of malice in his heart". He had "a child like simplicity about him which endeared him to" all.

Venkataraman presents a very lucid exposition of the contributions of a great physicist and gives very interesting details of his life. We see Raman as he was, a very human person who succeeded in turning weakness into strength. Venkataraman's scientific and psychological portrait suffused with love, pain, understanding and admiration succeeds in bringing Raman to life. Some unusally beautiful colour plates and many rare photographs of Raman enhance the value and the pleasure it gives. The book also contains extensive notes on the main text so that the inquisitive readers can pursue selected points in greater depth. The author has earned our gratitude.

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Quantum Probability-Quantum Logic (Lecture Notes in Physics, Vol 321)
by Itamar Pitowsky

Springer-Verlag : Berlin-Heidelberg-New York-London-Paris-Tokyo-Hong Kong, 1989
ix+209 pages ; price : DM 42 (Hard cover) ; ISBN 3-540-50679-9

In this 196 pages of the monograph, the author Itamar Pitowsky has organised his arguments in support of a new interpretation of quantum mechanics viz. non-classical hidden variable theory.

In Chapter 1, this objective is set in the proper context. The possible alternative candidates (e.g. the uncertainty principle or the principle of superposition) those in author's words can carry 'the burden of revolution (quantum revolution)', have been examined and found unsuitable. The best candidate in this respect is, in the opinion of the author, the concept of probability or more precisely that of correlation.

In Chapter 2, the classical correlation polytopes (including Bell-Wigner and Clauser-Horne polytopes) are discussed with their connections to the classical probability theory on the one hand and to the classical propositional logic on the other. It has been shown that the elements of correlation polytopes are the probabilities of suitable events. The fact that some of the Bell-inequalities are violated by the quantum frequencies, directs the author towards his own interpretation.

These violations are the matter of discussion in Chapter 3. Quantum correlation polytopes are defined and it is observed that they violate some of the Clauser-Horne inequalities and Bell-inequalities. In this chapter, Bohr's Copenhagen

interpretation, Van Fraassen's antirealist stand-point and the (classical) hidden variable interpretation have been briefly discussed.

Chapter 4 deals with quantum logic that has been developed formally (axiomatically). This allows two statements to be 'true' but their conjunction to be 'false' sometimes. By these logical rules of computing truth values, one gets the extremities of quantum correlation polytopes as in the case of classical logic, one gets the extremities of correlation polytopes. A few interpretations of this logic are given in this chapter.

Chapter 5 contains the alternative (non-classical) hidden variable theory. The main objection as raised by the author against the classical hidden variable theory lies in theorem 5-3 which states that 'there exists no classical local hidden variable theory'. In this programme to construct a 'hidden variable theory' that is also 'local', the author proposes the so called 'Kolmogorovian model of quantum probability'. We shall try to present here the crux of this approach.

1. To each physical system is associated a number $\lambda \epsilon [0, 1]$. The closed unit interval is thus the set of all hidden variable states.
2. With every physical property E which is an orthogonal projection on some closed subspace of a Hilbert space representing a physical system, is associated with a subset $A(E)$ of $[0, 1]$.
3. A statistical state is given by a function ρ on the subsets of $[0, 1]$ satisfying the conditions

   $$X \subset Y \Rightarrow \rho(X) \leqslant \rho(Y)$$

   and

   $$\underline{m}(X) \leqslant \rho(X) \leqslant \bar{m}(A)$$

   where $\underline{m}$ and $\bar{m}$ are the inner and outer measures defined in terms of the Lebesgue measure on $[0, 1]$.
4. If E_1 and E_2 comensurable properties i.e.

   $$\rho(A(E_1) \cup A(E_2)) + \rho(A(E_1) \cap A(E_2)) = \rho(A(E_1)) + \rho(A(E_2)),$$

   then the existence of both properties E_1 and E_2 can be simultaneously verified by a single experiment on a single sample. If however, E_1 and E_2 are not comensurable, we can not verify the existence of the properties E_1 and E_2 by a single experiment on a single sample, rather we can measure for the property E_1 on one sample and for E_2 on a different sample.
5. In a random sample of particles whose state (statistical) is given by ρ, the frequency of particles having property E approaches to $\rho(A(E))$ as the sample grows.

The main deviation from the classical theory lies in the item no. 3 above.

Thus it is established that this theory is local.

This book is addressed to physicists interested in the foundational issues, philosophers interested in the philosophy in science and mathematicians interested in applications and logic. I hope, readers of all these categories will find this book quite attractive although I am not quite sure about *practising* physicists. The content is well organised and lucidly presented. The author also mentions possible problems that might arise out of his own interpretation. For example, he points out that continuum hypothesis becomes essential to Kolmogorovian models but negation of this hypothesis is also consistent with the other axioms of set theory. He also puts forward the very pertinent question—'are hidden variable theories physically significant' ? The general philosophical remarks of the author and his discussions on the relation between quantum theory and the foundations of probability are also significant. One such remark is—'the dilemma is to chose between non-logical theories and the axioms of probability. Presently, no rational guideline for such a choice seems to be available'.

The author, however, seems to have done a little injustice to the antirealists. After all, they form a very strong group now and such a small account (Sections 3-10) is not adequate for a proper appraisal of this view point.

Apart from the bibliography, the 'notes and remarks' at the end of each chapter are much helpful to the reader.

Unfortunately, there are quite a number of spelling mistakes. In such a nice readable book those mistakes take away some of its pleasure.

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Biophysical Effects of Stready Magnetic Field (Springer Proceedings in Physics, Vol II)

(Proceedings of the Workshop, Les Houches, France, February 26-March 5, 1986)

edited by G Maret, J Kiepenheuer and N Boccara

Springer-Verlag : Berlin-Heidelberg-New York-London-Paris-Tokyo. 1986
xii + 231 pages, 129 figures ; price : DM 84 (Hard cover) ; ISBN 3-540-16992-x

This book is the proceedings of the workshop, Les Houches, France, held during Feb. 26-March 5, 1986.

The interaction of steady magnetic field with biological and macromolecular matter is of considerable importance. The orientation effects of polymers, viruses,

membranes, and ferrofluids have attracted considerable attention to the scientists of different branches of physics, chemistry, and biology. Besides these topics, this book also deals with the influence of weaker fields on photochemical reactions, surface temperatures of animals, other orientational, and navigational behaviour of bacteria, birds, and fishes. Physiological effects and some medical applications are also discussed.

The book contains four parts viz. diamagnetic orientation of macromolecules, ferrofluids, biological and chemical photoreactions, physiological effects and animal development, animal orientation and magnetoreception, and applications in NMR and medicine.

The most striking and useful reaction to magnetic fields at supermolecular level is the alignment of biopolymers, viruses, large assemblies such as retinal rods, and membranes when suspended in a solvent, usually water. The ease of alignment depends on the anisotropy of the diamagnetic susceptibility of the constituent groups and bonds. Here a strong field of the order of 1-10 T appears to be necessary, to achieve alignment. Long-range order as occurring in liquid crystals enhances magnetic susceptibility, and full orientation may be reached in about 1 T or even less. Various examples of how diamagnetic orientation can be used to study structural and dynamical properties of molecular fluids are discussed in part-1 of this book.

A new class of colloidal fluids responds to much smaller magnetic field, barely exceeding the earth's magnetic field strength, i.e. of the order of some millitesla, as they consists of suspension of usually monodomain ferromagnetic particles, several tens of nanometers in size, surrounded by a repelling polymeric coating preventing agglomeration. Such fluids called ferrofluids have very interesting applications in medical sciences as a drug carrier, for example. When coated with a specific drug-binding polymer the particles, and hence the drug, can be concentrated at a location in the body selected simply by a little magnet. Addition of very small amount of ferrofluids to liquid crystal (nematic, say) turns out to enhance the magnetic orientability of the whole liquid crystal by more than three orders of magnitude. The part-2 of this book deals with this ferrofluids.

In part-3, biological and chemical reactions have been shown to be affected by magnetic fields in the millitesla range. This is because the rates of photo-induced reactions involving non-zero spin intermediates are usually controlled in a zero magnetic field by nuclear hyperfine field and hence are changed in higher magnetic field. Based on this, a sensitive mechanism of magnetoreception has been proposed that is dependent on orientation and sensitive to the earths magnetic field.

Physiological effects of magnetic field as applied in NMR tomography are discussed in part-4. Here the underlying physical mechanism remains essentially unclear.

Other important applications in medical science have been discussed in part-6. They include NMR imaging, which is being used in many hospitals with the promise of novel developments such as high resolution imaging (down to some micrometers) and spectroscopy of phosphorous-31, the latter existing in many different chemical environments inside living cells. Furthermore, high field magnetic separation of magnetically different cells may have clinical and analytical applications as well.

The influence of the earth's magnetic field on the orientational behaviour of animals has been elaborated in part-5. The well-explained orientation process based on the earth's field is the so called magnetotactic behaviour of some bacteria and algae. It is based on chains of ferrimagnetic particles inside the organism providing just enough alignment in the earth's magnetic field against thermal agitation to force the organism passively to swim along the field lines of force. Although similar particles are known to exist in various higher animals like insects, birds, fishes and mammals, the definite role of these particles in the perceiving mechanism is still a matter of debate.

Because of the interdisciplinary nature of this workshop covering different topics of interdisciplinary researches, it is believed that this book would be highly demanded by many physicists, chemists, biologists, and medical practitioners, in general. This book will also be a useful document for experts as well for the newcomers to the field.

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Dynamical Problems in Solution Systems (Springer Series in Synergetics, Vol 30)
(Proceedings of the Seventh Kyoto Summer Institute, Kyoto, Japan, August 27-31, 1984)
edited by S Takeno
Springer-Verlag : Berlin-Heidelberg-New York-Tokyo, 1985
xiii+281 pages, 102 figures ; price : DM 89 (Hard cover) ; ISBN 3-540-15372-1

This volume contains most of the papers presented in the oral session of the 7-th Kyoto Summer Institute on Dynamical Problems in Soliton Systems, held in Kyoto from August 27 to 31, 1984.

It was August 1984 when John-Scott Russell first found and chased a solitary wave propagating in the canal near Edinburgh, Scotland. Zabusky and Kruskal discovered the novel and surprising nature of the solitary waves in the knowledge of de Vries equation. Its solitary waves behave like particles. They run, collide, and interact nonlinearly, but preserve their identities against mutual collisions. The solitary waves with particle properties was termed "soliton" by Zabusky and Kruskal. Solitons are essentially nonlinear phenomena. They are the elementary excitations in nonlinear dispersive systems. Now a days, the soliton concept is successfully applied to almost every field of physics, hydrodynamics, plasma physics, nonlinear optics, low temperature physics, solid state physics, elementary particle physics, astrophysics, biophysics etc.

Analytical methods, such as the inverse scattering method, Backlund transformations and Hirota's direct method, enable one to solve nonlinear evaluation equations exactly. It should be emphasized that the solvable methods, such as the sine-Gordon equation and Toda lattice, played an important role in the development of the soliton theory.

Physics in low dimensional materials has made remarkable progress. The soliton picture has also been applied to one dimensional organic materials, for instance, polyacetylene. In plasma physics and hydrodynamics various soliton phenomena have been predicted and observed. Even if systems are complicated, a soliton there is a macroscopic object. One can create, control and detect solitons. On the other hand, condensed matter physics deals with a soliton which is in most cases microscopic. Therefore, the identification of a soliton mode sometimes becomes controversial. A statistical description of soliton is often necessary. This is also true to the solitons in biological systems. The soliton concept in biophysics is also a fascinating field of research. The dynamics of Davydov solitons and solitons associated with open states in the DNA molecule have been studied theoretically.

There are some evidences where the soliton system has more than two independent variables. It is a challenging problem to ask whether in higher dimensional spaces the soliton picture should be altered or not. The soliton resonance found, for instance, in the Kadomtsev-Petviashvili equation is quite interesting. Due to the resonant interaction between solitons, there appears a spatial structure where 3-soliton branch away from a point in space.

Many of the investigative methods were presented in the book (viz. theoretical, computational and experimental). The subjects were divided into six parts :

(i) Mathematical theory of solitons such as Inverse Scattering methods, the Hirota theory, and the Painleve analysis.

(ii) Field theory and statistical mechanics of solitons.

(iii) Solitons in Hydrodynamics and Plasma Physics.
(iv) Solitons in Condensed Matter physics.
(v) Soliton in Biological systems.
(vi) Soliton and Chaos.

This book has given a coherent survey of current activity in the various fields of soliton physics. It is believed that this volume in Springer series in Synergetics would be highly useful to the theoretical as well to the experimental physicists.

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Measures of Complexity (Lecture Notes in Physics, Vol 314)
(Proceedings of the Conference, held in Rome, September 30-October 2, 1987)
edited by L Peliti and A Vulpiani
Springer-Verlag : Berlin-Heidelberg-New York-London-Paris-Tokyo-Hong Kong, 1988
vii+150 pages ; price : DM 55 (Hard cover) ; ISBN 3-540-50316-1

The present volume contains the Proceedings of an International Conference on 'Measures of Complexity' held in University of Rome, 1987. Complex systems that have been discussed in the Conference include dynamical systems exhibiting deterministic chaos, boolean networks which learn to compute, neural networks, hierarchial diffusion, random walks and random surfaces, complexity in biological or ecological systems etc. A major aspect of the study of complex systems is quantitative characterization of complexity in such systems. In the first article of the book Grassberger gives various definitions of complexity in physical systems. There is no universal measure of complexity applicable to all situations unlike entropy which is a measure of randomness. Complexity of an object is defined as the difficulty of some task associated with the object. The identification of a single relevant task is, however, seldom possible. To elucidate some of these issues Grassberger has discussed two different models in his article : left-right symbol sequences of quadratic maps and 0-1 sequences produced by a ld cellular automata after one single time step. Parisi in his article discusses the problems in defining complexity, classifying the configurations of a complex system and identifying the main features of the clasification scheme. Paternello and Carnevali consider a Boolean network which can learn to perform specific tasks. Learning processes constitute one of the most interesting complex systems. An important stage of learning is the associative process. Various physical models have been constructed to simulate the learning process. Krey and Poppel define a symmetric

spin glass model by which correlated patterns are recognized through association. Nadal discusses processing of temporal sequences in neural networks. Solution of the diffusion equation in ultrametric space which describes the space of spin glass states in mean field theory has been reviewed by Bachas. The article by Forcand *et al* treats random walks and random surfaces as complex objects. Enumeration of such objects, like the travelling salesman problem is a NP-complete problem. Both objects represent physical systems. For example random walks with self-avoiding constraint model polymers in dilute solution. The determination of asymptotic configurational properties involve both computational and configurational complexities. The article on complexity in large technological systems discusses how complexity arises in industrial plants and the different aspects of it. Bovet and Crescenzi gives an introduction to computational complexity in problems of computer science, e.g., parallel computers and artificial intelligence. There are two articles on complexity in biology and ecology in the last section of the book. The study of complexity in various branches of physical, engineering and life sciences currently constitute one of the most active areas of research. The book under discussion gives an overview of the work done so far in various areas and also serves as an introduction to complexity theory. The book is strongly recommended to those interested in learning about complexity in natural and man-made systems.

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Heavy Ion Interactions Around the Coulomb Barrier (Lecture Notes in Physics, Vol 317)
(Proceedings of a symposium held in Legnaro, Italy, June 1-4, 1988)
edited by C Signorini, S Skorka, P Spolaore and A Vitturi
Springer-Verlag : Berlin-Heidelberg-New York-London-Paris-Tokyo, 1988
x+329 pages, 210 figures ; price : DM 69 (Hard cover) ; ISBN 3-540-50578-4

This volume contains the proceedings of a symposium on Heavy Ion Interaction Around the Coulomb Barrier held in Legnaro, Italy, June 1-4, 1988. It is a collection of the invited talks and contributed papers. The articles of this volume have been divided in six chapters each containing different research works. The title of the chapters are sub and Near-Barrier Fusion, Fusion and Quasi-Elastic-Reactions, Spin Distribution, Elastic scattering and Threshold Anomaly, and Recoil Mass spectrometers. With the growing interest in Heavy Ion-Interactions at energies around Coulomb Barrier many sophisticated theoretical approaches and improved

experimental techniques with sufficient data are presented in this book which can be considered as a update of the developments in this field of research. Most of the articles here are devoted on sub and Near-Barrier Fusion whereas a few are on Elastic Scattering and Threshold anomaly. There are a few articles on Recoil Mass spectrometers also. All the works presented in the symposium have been nicely concluded in a Concluding Remarks. A broad area of the topic has been covered in this book as there are many workers who discussed their works in detail here. It is difficult to discuss each article individually. Undoubtedly, this book will be a helpful addition to any research library.

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Magnetic Properties of Free Radicals ; Nitroxide Radicals (Landolt-Börnstein, New Series, Group II, Volume 17, Part d, band 1)
edited by H Fischer
Springer-Verlag : Berlin-Heidelberg-New York-London-Paris-Tokyo-Hong Kong, 1989
ix+403 pages ; price : DM 1.110 (Hard cover) ; ISBN 3-540-19405-3

The rapid proliferation of the data on free radicals has necessitated the data on them to be split into several Landolt-Börnstein volumes. The author of this volume has surveyed a wide variety of nitroxide radicals ranging from those derived from amino acids, peptides, nucleic acid bases and a host of other sources. A list of recent reviews on nitroxide radicals have been included which will be useful to many workers. Any body interested in the method of generation and magnetic property of different nitroxide radicals will find this volume extremely helpful. For this, any science or engineering library will definitely like to have this volume.

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