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"BIGNAN KUTIR"

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INDIAN JOURNAL
OF
THEORETICAL PHYSICS

[Founder President : Late Prof. K. C. Kar, D. Sc.]

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"BIGNAN KUTIR"
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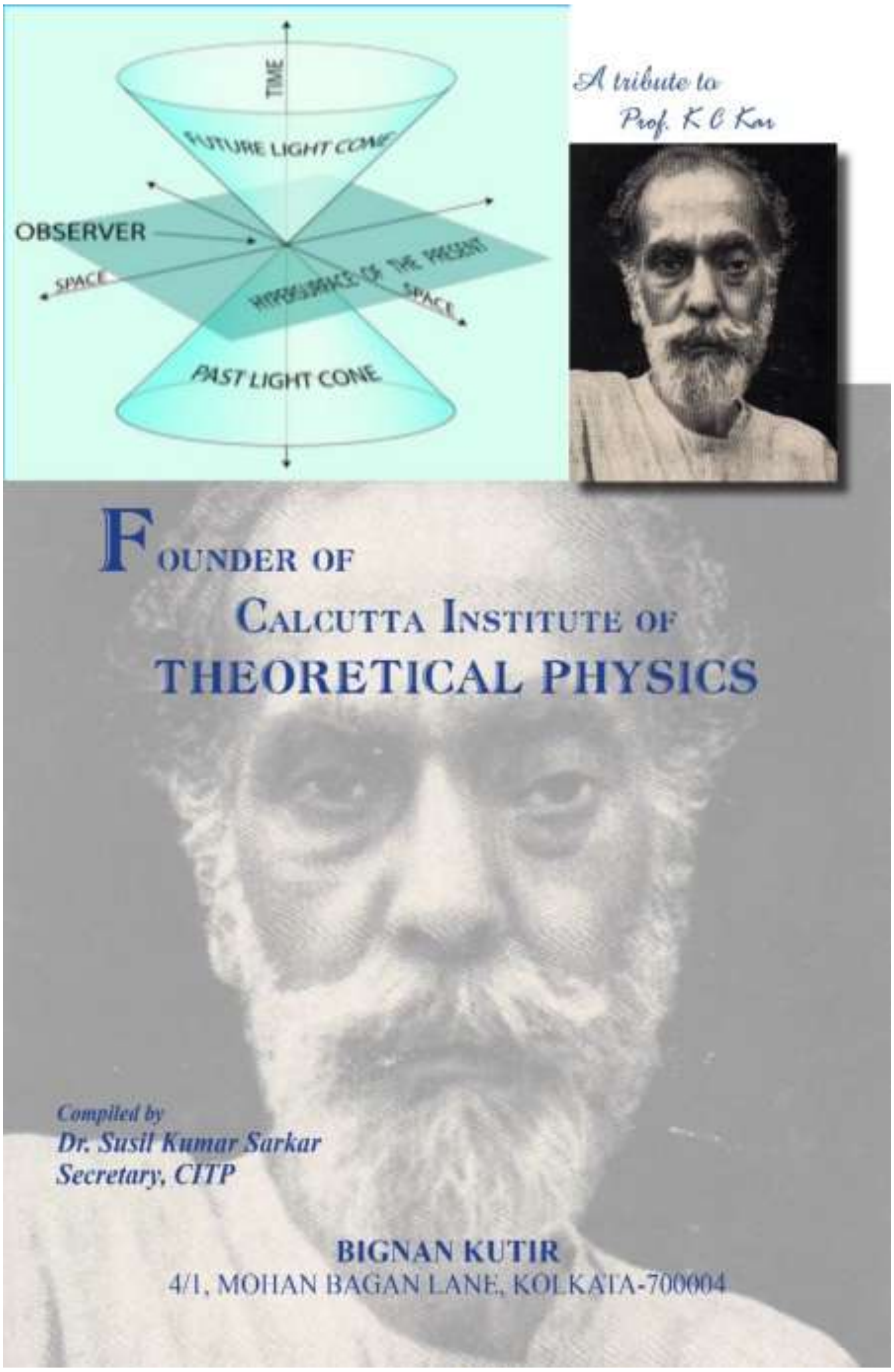
TIME
FUTURE LIGHT CONE
OBSERVER
SPACE
SPACE
PAST LIGHT CONE
A tribute to
Prof. K C Kar
FOUNDER OF
CALCUTTA INSTITUTE OF
THEORETICAL PHYSICS
Compiled by
Dr. Susil Kumar Sarkar
Secretary, CITP
BIGNAN KUTIR
4/1, MOHAN BAGAN LANE, KOLKATA-700004


A GALAXY OF EDUCATIONISTS & SCIENTISTS IN CALCUTTA
Dr. M. L. Sircar
P. C. Ray
J. C. Bose
Asutosh Mukherjee
C. V. RAMAN
M. N. Saha
S. N. Bose
K. C. Kar

Foreword

Prof. Kulesh Chandra Kar was an outstanding theoretical physicist and an eminent and dedicated educationalist, who had spent most of his formal working period as a teacher in Presidency College, Calcutta, with some short stints at Scottish Church College, Calcutta, Serampore College and Rajshahi College. This part of his life spanned three decades of the twentieth century extending from the early twenties to the mid-fifties. His active life, however, extended well beyond that. He actually converted his residence to a small working institution which he named “Institute of Theoretical Physics” and initiated the publication of a journal titled “Indian Journal of Theoretical Physics”. The institute that he founded is still functional and is now known as “Calcutta Institute of Theoretical Physics”. Prof. Kar had been an inspiring figure for generations of aspiring physicists and certainly one of that elite group of Bengali scientists who made science in Bengal competitive with the rest of the world at times which can best be described as “difficult”. In this article about Prof. K C Kar, the author Dr. Susil Kumar Sarkar (formerly of Vidyasagar College, Kolkata and who himself has been an untiring dispenser of the knowledge of physics to all those who chose to learn) looks back at the life and times of Prof. Kar. It is ardently hoped that this will inspire some of the readers to consider dispensing knowledge as a profession, however pointless it may seem to be. Imparting correct education, in the long run, should help build the character of a society, if not of the nation as a whole.

Prof. Jayanta Kumar Bhattacharjee
Distinguished Emeritus Professor of Physics, IACS, Kolkata
&
Director, CITP, 4/1, Mohan Bagan Lane, Kolkata-700004

A tribute to

Prof. K. C. Kar : Founder of Calcutta Institute of Theoretical Physics

***Susil Kumar Sarkar,** Secretary, CITP

4/1 Mohan Bagan Lane, Kolkata-700004

1. Introduction

First organized Science Movement in the Eastern part of India was initiated by Dr. Mahendralal Sircar (1833-1904) and carried out by Indian Association for the Cultivation of Science (1876), oldest research institute in India from the middle of the nineteenth century to early twentieth century. Sir Asutosh Mookherjee (1864-1924), a versatile genius with a special fascination for Physical and Mathematical Sciences worked in IACS during 1887-1890 as a lecturer and researcher. Mookherjee's connection with

* Former Associate Professor in Physics, Vidyasagar College, Kolkata

IACS, his personal bond with Sircar and Rev. Father Lafont (1837-1908), and other socio-economic factors influenced him strongly. Almost naturally, the next phase of science movement was led in a big way by Mookherjee. The establishment of the Calcutta School of Physics by Sir Asutosh was successful realization of his dreams. Earlier, Presidency College of Calcutta witnessed the scientific researches of Sir J C Bose (1858-1937) and Sir P C Ray (1861-1944) in Physics and Chemistry respectively. Sir Asutosh Mookherjee encouraged young researchers in their pursuits which eventually culminated in the achievement of Sir C V Raman (1888-1970), Prof. S N Bose (1894-1974), Prof M N Saha (1893-1956) and other knowledge seekers. The close interaction between Calcutta University and IACS continued for many years, under the leadership of C V Raman. In fact, IACS continued as a training centre for research scholars and young faculty members of University College of Science (1914). The objective was to stimulate research in Physics, and to afford post graduate students the fullest opportunities to acquaint themselves with original investigation in progress. We are fortunate to have a savant of Physics in the person of Prof. Kulesh Chandra Kar who continued the teaching and research works of his predecessors. The present monograph is aiming at unraveling the creative contributions of Prof. K C Kar in the area of Physical Science.

2. Family History and Education

Kulesh Chandra Kar was born on 1st October, 1899 in Burrbazar in the district of Manbhum, Bihar, East India during British Raj. His father, Umacharan Kar was a district judge. Kulesh's mother, Mokshada Sundari Debi was a pious lady. His ancestral home was located in the village Sahapur, in the district of Burdwan. His grandfather, Hara Chandra Kar happened to be an affluent landlord. Dr. Sitesh Chandra Kar, the elder brother of Kulesh Chandra Kar was an extraordinary mathematician with exposure to German trends and thoughts. He was Principal of Bangabashi College, Kolkata. He was also associated with the department of Applied Mathematics, CU as a guest lecturer and an active member of Editorial Board of Indian Journal of Theoretical Physics published by Institute of Theoretical Physics. Kulesh was the fourth son of his parents. Right from his school days, he proved to be a meritorious student. He was exceptionally good in Mathematics. In 1916 he passed the Matriculation Examination from Hare School with a merit scholarship and a gold medal for standing first in Mathematics. Then he studied at Presidency College, Kolkata and passed the I. Sc. Examination in 1918.Kulesh chose Physics as honours subject and passed the B.Sc. Examination with first class in 1920 from the Calcutta University, for which he was awarded a jubilee scholarship. In 1922 he passed the M.Sc. Examination in Physics standing first in the first class and won gold medal. He had the good fortune of being taught by eminent teacher, Prof. C V Raman (Palit Professor of Physics, Calcutta University), who had already attained international recognition as an authority on acoustical science.

S C Kar

3. Teaching and Research

Soon after passing M.Sc. Examination K C Kar joined the Scottish Church College, Kolkata as a demonstrator in the department of Physics. He taught there for about one year. In 1924 he joined the Serampore College as a lecturer in Physics and immediately made his mark as a brilliant teacher. He served the Presidency College, Kolkata as a lecturer in Physics in 1927 and attracted wide attention. He was known as an ideal teacher and a lucid expositor. He always delivered lectures without any written notes and worked out intricate mathematical formula on the blackboard without slightest hesitation. He believed that mathematics should be considered as a language for expressing physical concepts more precisely. He used advanced techniques of Applied Mathematics to understand the basic theories of Mechanics, Waves and Vibration. Fourier Analysis was one of his favourite techniques. It is interesting that the Fourier series gave rise to generalized functions treated by Lighthill and others. K C Kar's ideas on the special theory of relativity was another thought-provoking approach as a generalization of Lorentz transformation. He was transferred to the Rajsahi College in 1945, where he had to spend four years of his professional career. He returned to the Presidency College in 1949 and continued there as a professor and head of the department of physics till his retirement in 1955. Thereafter he was appointed Emeritus Professor of Physics at the Presidency College.

K C Kar was very much interested in research work. He came in contact with Professor C V Raman from whom he received encouragement to carry out research on Indian Musical Instruments. When he was a 1st year M.Sc. student, K C Kar wrote an article entitled "The action of the bow in stringed instruments" which was published in Physical Review, Vol 20, p.148,1922. Next he turned his attention towards statistical mechanics and soon attained mastery over the subject. His researches in theoretical physics covered a wide spectrum of subjects (Acoustic Physics, Wave Statistics, Nuclear and Particle Physics, and

Theory of Relativity). During his career he published 123 scientific papers in different journals of national and international repute. Of his own, he learnt French and German languages. Many of his papers were published in the German Journal "Physikalsche Zeitschrift" and "Philosophical Magazine" of London. For his outstanding research work, he obtained D.Sc. degree from the University of Calcutta in 1925. Few men in India have obtained distinction over such a wide range of subjects as Dr. K C Kar. He was a talented mathematical physicist, who used his physics to guide his mathematics and his mathematics to give precision to his physics. Citation profile of Prof. Kar shows that out of his 123 papers, 44 papers received 86 citations. Kar's most cited paper 'The statistical theory of spontaneous fluctuations in energy, pressure and density' published in Physical Review, Vol.21, p.672, 1923 received 6 citations. This paper had been cited first in 1925 and last cited in 2012. According to the geographical distribution of citations received by K C Kar, 34 papers were cited from India, 24 from USA, 7 from Germany, 6 from UK, and 5 from Poland. Kar worked with 28 collaborators but he published 60 single and only 63 multi-authored papers. The citation profile of a scientist signifies the substantial growth in terms of quantifiable outputs with the clear perception about his work. Citation to the scientific contributions of the scientist highlights usage of the publications. Besides publication of papers, he trained a galaxy of young men for effective research work in Theoretical Physics. Among his many talented students and collaborators, who achieved distinction in their subsequent careers for independent research works, are M Ghosh, K K Mukherjee, A Ganguly, R C Mazumdar, D Basu, R R Roy, S Sengupta, M L Chaudhury, S Sanatani, P P Chattarji, Mrs. A Basu, S P Banerjee, R K Bhattacharyya, N K Datta, B N Paria, Mrs. C Dutta, A K Bhattacharyya and others. Dr. Kar was a profound thinker. Each of his theories was the result of months and years of stubbornly pursuing what he called ‘Idealized experiments’. Pencil and paper were his scientific equipment his mind was his laboratory. There was hardly any year without any publication and few without many. It was typical of Dr. Kar, that he continued his research work until the end of his days, at the same tireless pace to which he had grown accustomed in his earlier life. He was a person who could never tolerate illness or incapacitation and in spite of the serious handicap of near sightlessness during the fag end of his life, his creative activities remained unimpaired till the very end.

Dr. Kar strongly felt that more writing of scientific papers would not foster the development of true scientific knowledge among the student community in India. For this purpose, he emphasized that the distinguished teachers in the country should be persuaded to write appropriate text books on their special subjects. Accordingly, he wrote the following five books on Physics for advanced learners.

1. **Statistical Mechanics Vols. I & II, 1953**

   The different statistical methods are the first time classified under five heads. The book is more exhaustive than the existing treatises on the subject and is useful to advanced students of theoretical physics (including physical chemistry).

2. **Introduction to Theoretical Physics Vol. I, 1955**

   Mechanics of particle (including relativity), rigid body, deformable body, fluid, statistical mechanics and thermodynamics.

   Useful to students of higher physics. Special emphasis is given to the physical side of each problem. An important feature of the book is that certain examples in particle and rigid dynamics which are important for the study of higher physics are worked out by different important methods.

3. **Introduction to Theoretical Physics Vol II, (Acoustics), 1958**

   Theories of different problems of acoustics are discussed emphasizing throughout their physical aspects. Many new problems on forced vibration and the vibration of string are discussed for the first time. The book is useful to students of higher acoustics and is a standard treatise on the subjects.

4. **Wave Statistics, 1966**

   The book has been written to present the theories developed by the author and his collaborators, for the first time in a connected form. High Velocity problem e.g. X-ray scattering in the Klein Nishina region, radiative scattering and pair production are discussed in detail. Special emphasis is given to the physical sides of the different problems discussed. A special feature of the book is that certain questions which are never discussed in books on quantum mechanics, are for the first time clearly explained by the author. The questions are – (1) Why Schrodinger equation gives correct eigen values? (2) Why XX* gives the probability? (3) What is the nature of Heisenberg exchange force? What is the basis of the selection rule? and so on. It is hoped the book will be useful to Post graduate and research students. The author is the first and the only Indian Physicist to write a comprehensive book on his extensive theory.

5. **A New Approach to the Theory of Relativity, 1970**

   In this book the relativistic problems have been discussed from new standpoints. Author's new theory of gravitation has been presented. In this theory it is explained why the gravitational field is always attractive and is never repulsive. On the basis of this theory Einstein's formula for perihelion motion of planets and the bending of light have been deduced with the help of simple theory of relativity. Einstein's complicated general theory, or his assumption of space-time curvature has not been used at any stage. Thus there is nothing as special or general theory of relativity. There is only one theory which is the simple theory of relativity. The phenomenon of red-shift which is an outcome of general theory of relativity, has been discussed as a purely non-relativistic effect. It is due to action of the gravitational field on the photon mass $h\nu/c^2$.

It is hoped the book will be useful to the Post graduate and advanced students who want to have a clear grasp of the fundamentals of relativity.

These books were published by Institute of Theoretical Physics.

Probably Dr. Kar was a pioneer in India, who volunteered to write five of his original scientific papers in his native language (Bengali).

1. আপেক্ষিক তাত্ত্বিক হ্যামিল্টন সূত্রর একঘাতকরণ– Ind.Jour.Theo.Phys.Vol.12,p.1, 1964
2. তরঙ্গ বেগের পরিমাপিকা রূপ, (measurable form of wave velocity), Ind.Jour.Theo. Phys. Vol.13,p.69, 1965

3. সমষ্টি তরঙ্গবাদের মূলনীতি (The fundamentals of wave statistics), Ind. Jour. Theo. Phys. Vol.14,p.1, 1966.
4. সমষ্টি তরঙ্গবাদের মূলনীতি (আপেক্ষিক তত্ত্বের দিক থেকে)– (Fundamentals of Wave statistics (relativistic) Ind. Jour. Theo. Phys. Vol.15,p.57, 1967
5. আইনস্টাইনের সাধারণ আপেক্ষিক তত্ত্বে কয়েকটি গুরুত্বপূর্ণ: ত্রুটি। (Some serious defects in Einstein's generalised theory of relativity), Ind. Jour. Theo.Phys. Vol.23(3), P-115, 1975.

4. Establishment of Calcutta Institute of Theoretical Physics

(Formerly Institute of Theoretical Physics)

Theoretical Physics was very much in the air in the early decades of twentieth century and Calcutta University, with its beginning of academic dimension could well take on establishing an initial forte of Theoretical Physics. As is well-known the then Departments of Mixed (Applied) Mathematics and Physics (Pure) could well grapple with that. Any history of pursuits in Physics, ought to identify this phase as a landmark, reflected both in teaching and research. The consolidation, of course, on classical areas was not glossed over. Presumably, studies on mechanics could find physicists and applied mathematicians as allies of mutuality. Presidency College could affordably rest on its oars in respect of classical areas of Physics, besides other disciplines. Presidency College, in its long history, has seldom allowed its academic pursuits to go by default on such scores. One can then situate the rationale of the inception of Institute of Theoretical Physics under the leadership of Professor Kulesh Chandra Kar, outside the precincts of Presidency College.

Professor Kar, needless to add, was basically a leading personality of Physics with as much openness as one could have expected from a physicist of his period. Prof. Kar could not at all abjure the emerging developments in the domain of Physics. But at the same time, he could rally around him mathematicians and theoreticians, whoever they may be, even his colleagues to build up afresh the edifice of academically well-knit classical physics. Professor Bidhubhusan Sen, an applied mathematician and his colleague at Presidency College did find in Professor Kar an extraordinary pursuer in classical directions.

In 1953, before his retirement from Presidency College, Prof. K C Kar, a theoretical physicist of broad vision founded Institute of Theoretical Physics, at his dwelling house (4/1 Mohan Bagan lane, Calcutta 700 004), which he had christened as “SCIENCE COTTAGE” or BIGNANA KUTIR. In 2013, after registration (Reg. S/2L No. 9125) under West Bengal Society Act 1961, the institute is renamed Calcutta Institute of Theoretical Physics. Kar bestowed all his belongings and ancestral property to the institute forming a Public Trust in 1967, for the dissemination of new frontiers of Physics and allied subjects. This institute had become his dream-child.

Prof. Kar and his brother, Paresh Chandra Kar donated agricultural lands of 10.23 acres to the Institute of Theoretical Physics, represented by Secretary, Dr. Chinmoyee Dutta, and members, Sri Jyotirmoy Biswas and Sri Amal Kumar Bhattacharyya. Mutation of the said lands was done in 2017. The details of the land are given below:

Mouza	Block	District	P.S.	J.L. No.	Khatian No.	Land Area	Total Plots
Sahapur	Jamalpur	Burdwan	Jamalpur	102	1964	5.77 acres	34
Itla	Jamalpur	Burdwan	Jamalpur	099	1555	4.86 acres	02

Members of Board of Trustees (1967)

(1) Prof. K C Kar, President (2) Ms C Dutta, Scientist, Member (3) J Biswas, Lecturer, B K C College, Kolkata, Member (4) A K Bhattacharyya, Lecturer, Asutosh College, Kolkata, Member, (5) Ms Anita Dutta, Homeopath Doctor, Member (6) S Dutta, Homeopath Doctor, Member (7) Sm. Sujata Pal, House Wife, Member.

5. Foundation of Indian Journal of Theoretical Physics

The year 1953 also witnessed the foundation of the Indian Journal of Theoretical Physics, brain-child of Prof. K C Kar. He sponsored the publication of this journal, the first of its kind in India, out of his personal resources. During his tenure as a Professor of Physics at the Presidency College, Calcutta, Dr. Kar had gathered around him a band of devoted workers, who worked for the fun of doing research work without any kind of remuneration. Among them, the most conspicuous were M Ghosh, K K Mukherjee, A Ganguli, D Basu, R R Roy, S Sanatani, S Sengupta and others. Many of them came up above the horizon in their lives. Their combined efforts prepared the ground for a new sort of growth in the field of Theoretical Physics in India. Their early papers used to be published in foreign journals like Philosophical Magazine, Zeitschrift fur Physik, Physikalische Zeitschrift, Physical Review etc. But such a procedure turned out to be a time-consuming affair. Gradually the number of papers was transformed from a mere trickle into a spate and the local journals like the Indian Journal of Physics and the Bulletin of the Calcutta Mathematical Society could not cope with the situation, to ensure quicker publication. This led Professor K C Kar to think seriously about starting a new journal of his own, devoted entirely to

Theoretical Physics. To begin with, he formed a small committee consisting of M Ghosh, S P Banerjee and himself to go into details for such a venture.

The first issue of the journal was published by the Editorial Secretary. Subsequent issues were quarterly published by the Institute of Theoretical Physics.

First Board of Editors

Dr. S C Kar, Ph. D	Dr. K C Kar, D. Sc.
Dr. B B Sen, D. Sc.	Dr. M Ghosh, D. Sc. (Hon. Secretary)

Emerging from its preliminary teething troubles, the Indian Journal of Theoretical Physics gradually grew up in stature. Its sphere of circulation widened. It is now widely subscribed by universities and research institutes scattered all over India and abroad. Published papers were abstracted in Science Abstracts and Nuclear Science Abstracts upto 1995. Now these published papers are being indexed in Indian Citation Index (ICI) data base. This journal covers research on various branches of Physics, Applied Mathematics and other related fields. All the submitted papers are reviewed by eminent experts in the concerned fields as proposed by the board of Editors of the journal.

We feel pride that the following scientists were associated with the institute as eminent members of International Advisory Board of IJTP for more than 25 years.

Prof. A K Raychoudhuri (1976 -2005): Eminent Theoretical Physicist and senior Professor of Physics, Presidency College, Kolkata. He is known for his most significant contribution, the eponymous Raychoudhuri equation in the field of general theory of relativity and cosmology.

Prof. D. K. Sinha (1975 –2006): Eminent Mathematician and Professor of Mathematics, Jadavpur University, Sir Rash Behari Ghose Professor of Applied Mathematics, Calcutta University and VC of Visva Bharati University. He had published a number of scientific papers in IJTP.

Current International Board of Editorial Advisors

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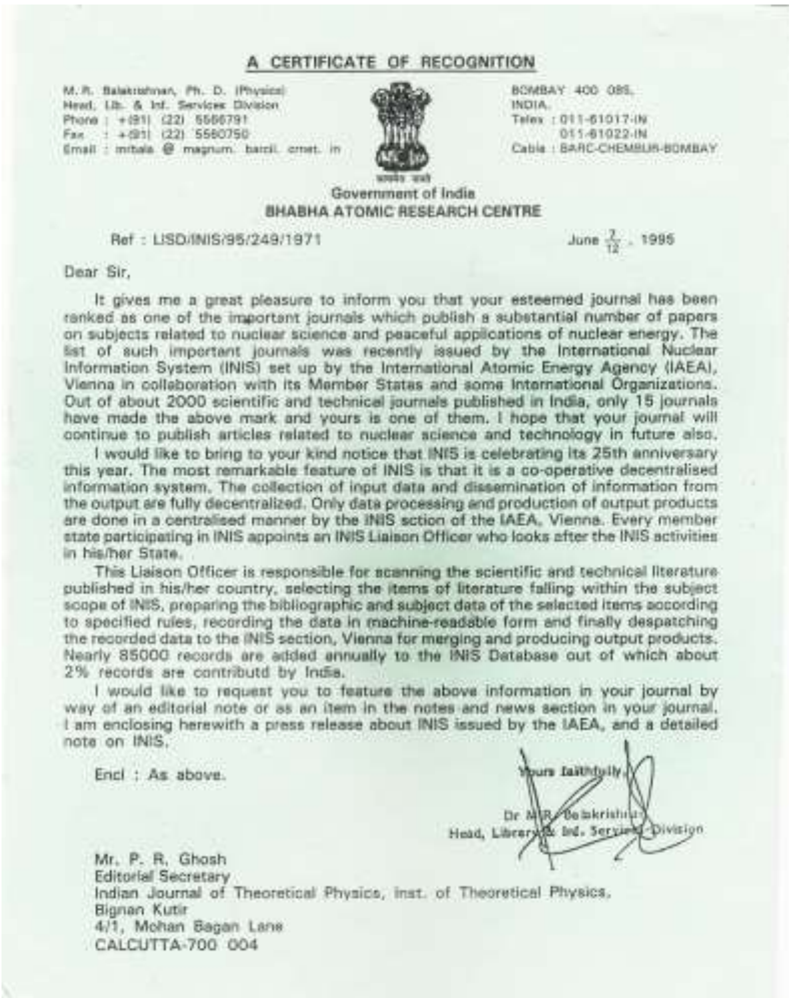
Serving the scientific community all these years, the journal has been one of the standard journals published in India. It is noteworthy that during 1995, the International Nuclear Information System (INIS) set by the IAEA, Vienna in collaboration with its member states and some international organization had issued a list of important journals which published a substantial number of papers on subjects related to nuclear science and peaceful application of nuclear energy. Out of 2000 scientific and technical journals published in India during that time, only 15 journals had been ranked and ours was one of them.



A CERTIFICATE OF RECOGNITION

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Government of India
BHABHA ATOMIC RESEARCH CENTRE

Ref : LISD/INIS/95/249/1971 June 7/12, 1995

Dear Sir,

It gives me a great pleasure to inform you that your esteemed journal has been ranked as one of the important journals which publish a substantial number of papers on subjects related to nuclear science and peaceful applications of nuclear energy. The list of such important journals was recently issued by the International Nuclear Information System (INIS) set up by the International Atomic Energy Agency (IAEA), Vienna in collaboration with its Member States and some International Organizations. Out of about 2000 scientific and technical journals published in India, only 15 journals have made the above mark and yours is one of them. I hope that your journal will continue to publish articles related to nuclear science and technology in future also.

I would like to bring to your kind notice that INIS is celebrating its 25th anniversary this year. The most remarkable feature of INIS is that it is a co-operative decentralised information system. The collection of input data and dissemination of information from the output are fully decentralized. Only data processing and production of output products are done in a centralised manner by the INIS section of the IAEA, Vienna. Every member state participating in INIS appoints an INIS Liaison Officer who looks after the INIS activities in his/her State.

This Liaison Officer is responsible for scanning the scientific and technical literature published in his/her country, selecting the items of literature falling within the subject scope of INIS, preparing the bibliographic and subject data of the selected items according to specified rules, recording the data in machine-readable form and finally despatching the recorded data to the INIS section, Vienna for merging and producing output products. Nearly 85000 records are added annually to the INIS Database out of which about 2% records are contributd by India.

I would like to request you to feature the above information in your journal by way of an editorial note or as an item in the notes and news section in your journal. I am enclosing herewith a press release about INIS issued by the IAEA, and a detailed note on INIS.

Encl : As above.

Yours faithfully,

Dr M. R. Balakrishnan
Head, Library & Inf. Services Division

Mr. P. R. Ghosh
Editorial Secretary
Indian Journal of Theoretical Physics, Inst. of Theoretical Physics,
Bignan Kutir
4/1, Mohan Bagan Lane
CALCUTTA-700 004

32th revision of the INIS: Authority list of journal titles (IAEA-INIS-II) has included Indian Journal of Theoretical Physics ISSN0019-5693 IJTPAL. This list is published annually and includes the titles of all journals which contain articles submitted to INIS at the time of publication. It was last updated in February, 2006.The list of scholarly articles published in IJTP (Google Scholar) during 1980 to 2005 is given below.

(i). "MHD free convective flow of viscous fluid through a porous medium bounded by oscillating porous plate in slip flow regime with mass transfer"-P. Singh et al. Vol. 53(2), p.111-120,2005. Cited by 34

(ii). "Unsteady MHD flow of stratified fluid through porous medium over a moving plate in slip flow regime"-A K Khandelwal et al. Vol. 53(1) p.25-35,2005. Cited by 14

(iii). "Steady free convection MHD flow past a vertical porous moving surface"-P R Sharma et al. Vol.50(1),p.5-13,2002.Cited by 17

(iv). "MC^2 = BVL Coulomb: Gravitational and electromagnetic interaction energies in dual resonance"- J I Jacobson Vol.34(3), p.231-239,1986. Cited by 14, last cited in 2021

(v). "Gravitation and the theory of the physical vacuum"-M F Podlaha Vol. 28(1), p.19-30,1980. Cited by 16

(vi). "Effects of mass transfer on unsteady MHD flow and heat transfer past an infinite porous vertical moving plane"-P R Sharma et al. Vol.50(2), p.109-115,2002. Cited by 11 (vii). "Local solutions of an MHD free convection and mass transfer flow with thermal diffusion"- M Mahmud Alam et al. Vol.47(10, p.35-42,1999. Cited by 9

(viii)."Unsteady free convection MHD flow between two heated vertical parallel plates in induced magnetic field"-S Chakraborty et al. Vol.47(1), p.43-60,1999. Cited by 6

(ix). "Radiation-medium-curvature interactions" Simaciu, Ion et al. Vol.41(1), p.129-140, 1993.Citedby 6

(x). "MHD flow and heat transfer of a dusty visco-elastic liquid down an inclined channel in porous medium" - A K Singh et al. Vol.43(4), p.293-302.1995. Cited by 5.

It is noteworthy that on the recommendation of ICI our journal was included to the list of UGC approved journals. Unfortunately after March, 2019 our journal was found excluded from the UGC CARE LIST of Journals. We are now committed to making our journal available online and also ensure that at least one article which focuses on absolutely recent developments from a pedagogic point of view appears in each issue of the journal. With these two added features, we believe that the journal will be of significant use to young faculty members and university students across the country

Silver Jubilee Celebration of IJTP was held in 1977 and a special volume, Silver Jubilee (1953-1977) was published on this occasion.

Another academic activity of the institute is to organize seminars and memorial lectures where eminent academicians are invited to deliver lectures on recent trends in Physics and Applied Mathematics. CITP organises four memorial lectures every year and memorial lectures are generally published in IJTP.

I. Prof. K C Kar Memorial Lecture

Professor Kulesh Chandra Kar, Eminent Theoretical Physicist and Founder Director of CITP.

II. Prof. S D Chatterjee Memorial Lecture

Prof. Shyamadas Chatterjee was a versatile experimental physicist who followed the tradition of instrument building set up by pioneers of modern science in India. He was successful in initiating research in many diverse fields in the country with very modest resources.

Prof. Chatterjee earned his D. Sc in 1946 from Calcutta University. His areas of specialization were Nuclear Physics, Cosmic rays, andSolid State Physics. He was a Professor of Physics, J.U. Kolkata (1956-69), visiting Professor, Technical University, Munich, Germany (1963-66), a Senior Scientist, IACS, Kolkata (1970-77), Emeritus Professor (1977) and a Visiting Scientist at BARC, Kolkata.

Prof. Chatterjee discovered the spontaneous fission of Uranium simultaneously with and independently of Petrazhak and Flerov. He isolated ^{60}Co chemically for the first time from inactive neutron-irradiated ^{59}Co and extracted and purified He- gas (99.98%) and other noble gases from natural gas emanating from thermal springs of India. He also fabricated B10F3 –filled (at high pressure) ionization chamber and proportional counter and suggested possibilities of Mossbauer effect by cooling in liquid helium. Shyamadas Chatterjee was truly an innovator and initiated research in many fields throughout his lifelong passion for science. He pioneered the measurement of environmental radioactivity and radiocarbon dating in India. He was one of the notable students of Prof. D M Bose, former Director of Bose Institute and was associated with Institute of Theoretical Physics as **Secretary** (1978 – 1994).

Shyama Das got the inspiration to study radon and helium emanation at Bakreswar hot springs, from Prof. S N Bose who was asked by the C M of WB, Dr B C Roy to investigate the hot springs. Shyamadas and his group found that the gas emanating from the hot spring contained copious amount of radon and the water also had dissolved radon.

Dr. Chatterjee started the S D Chatterjee Research Foundation in Kolkata and was its Director (1985 – 95). He was a life member of Royal Institution(UK), American Physical Society, Instrumentation and measurement Society (USA), and Laser and Electro Optics Society (USA).

Awards and Honours: Recipient of Woodburn Medal of IACS (1948), the M N Saha Memorial Medal of Asiatic Society (1982), Institute of Electrical and Electronics Engineering Centenary Plaque(1984) and M N Saha Memorial Plaque of Indian Science News Association(1984).He was also a Fellow of New York Academy of Sciences.

Born:1909, Died: 27.05.1995

III. Prof. S Ghosh Memorial Lecture

Suddhodan had brilliant academic career. He passed the Matriculation Examination in 1914 and Joint Intermediate Examination in 1916, securing highest marks in Mathematics. He studied at Presidency College Calcutta.

He stood first with first class in the B.Sc. (with Mathematics Honours) examination of the Calcutta University in 1918 and awarded the University Gold Medal for his brilliant performance. He joined the University College of Science and Technology as a post-graduate student of Mixed Mathematics. He studied mathematical theory of Elasticity with Professor S N Bose, who was then lecturer in the department. He passed the M.Sc. examination in 1920 standing first in first class, obtaining 90% marks and earned the University Gold Medal.

Next, he worked as a research scholar under the guidance of Professor Nikhil Ranjan Sen, then Sir Rash Behari Ghose Professor of Applied Mathematics. In 1925 he competed for and won the Premchand Roychand studentship prize of the Calcutta University- the most coveted award at the disposal of the University. He also won the prestigious Sir Asutosh Mookherjee Gold Medal of the Calcutta University for his outstanding researches in Mathematics.

Suddhodan Ghosh obtained D.Sc. degree from Calcutta University in 1928. He was persuaded by Professor S N Bose to join Dacca University as lecturer in Mathematics. After a brief stay at Dacca he returned to his alma mater and joined the department of Mixed Mathematics. Soon he was acclaimed as a great lecturer and top academician by his pupils and colleagues.

In 1953, Calcutta University selected Dr. Suddhodan Ghosh as the first Reader in the department of Applied Mathematics. He was the unique distinction of becoming the Head of the departments of both Pure and Applied Mathematics, a rare and unique privilege.

An ardent student of Professor S N Bose, Suddhodan Ghosh was irresistibly drawn towards Mathematical Theory of Elasticity. He developed a research interest in the subject even as a student of post-graduate class and published his first paper before joining the department of Mixed Mathematics as Ghosh Research Scholar. As his research activities widened, encompassing fields of both Pure and Applied Mathematics, many research associates, mostly honorary congregated around him. He guided them in their doctoral theses. However, he never wrote a paper jointly with any student working under him for a doctoral degree. This was indeed a rare quality. Ghosh's research works comprise essentially two fields: Fluid dynamics and problems of Elasticity. Dr Ghosh made significant contributions in Mathematics and Mechanics. He introduced 'Theory of Number' in Pure Mathematics. He also taught Analysis there.

Dr. Ghosh rendered, inestimable service to the Calcutta Mathematical Society, and helped to sustain it when it was on the verge of collapse. For a long time, he served the Society as its (honorary) Editorial Secretary.

Prof. Ghosh remained bachelor for his life. After his demise in 1976, all the gold medals he received for the brilliant academic careers were handed over to the Calcutta University in deference to his wishes, for the creation of an endowment for providing financial aid to the poor and meritorious students of the department of Applied Mathematics.

IV. Prof. P.P. Chattarji Memorial Lecture

Prof. Prafulla Prasun Chattarji was an eminent Mathematician, Scholar and Teacher. He was President of the Calcutta Mathematical Society and Head of the Department of Applied Mathematics, Calcutta University. He also acted as **Secretary** of Institute of Theoretical Physics (now it is renamed Calcutta Institute of Theoretical Physics) till his death (2010). His subject of specialization was Continuum Mechanics. He taught many topics in M. Sc. courses viz., Mechanics, Electricity and Magnetism, Astronomy, Elasticity and Plasticity. He was co-author of few text books on Astronomy and Technical Mathematics.

Memorial lectures delivered by some distinguished Scientists are presented below:

Prof. Manoj Kumar Pal, theoretical nuclear physicist and director, SINP, Kolkata delivered K C Kar memorial lecture on ‘Calculations on nuclear fissions’ in 1992.

Prof. C. K. Majumdar, renowned condensed matter physicist and founder director of S.N. Bose National Centre for Basic Sciences, Saltlake, Kolkata presented K C Kar memorial lecture on “Phase Transitions” in 1993.

Prof. N C Sil, remarkable theoretical physicist and Head of the Dept. of Theoretical Physics, IACS, Kolkata delivered K C Kar memorial lecture on “Electron Capture Phenomena” in 1994.

Prof. A N Daw, Dept. of Radio Physics, CU delivered K C Kar memorial lecture on “Some recent trends in Information Technology” in 1995.

Prof. Bidyut Kumar Dutta, Dept. of Mathematics, Tripura University, ICSC World and Laboratory, 32 Cheminde Mornex, CH-1005, Lausanne Switzerland delivered P P Chattarji memorial lecture on “Einstein’s struggle for covariant formalism and the role of Levi-Civita” in 1996.

Prof. Amitava Raychaudhuri, theoretical particle physicist, Dept. of Physics, CU, deliverd K C Kar memorial lecture on “Trends in Particle Physics Research in the next decade” in 1997.

Birth centenary of Prof. K C Kar was celebrated at Presidency College Physics Lecture Theatre on 20th November, 1998 where two eminent scientists were invited to deliver talks.

Prof. A K Raychaudhuri, Senior Professor of Physics, Presidency College, Kolkata presented K C Kar memorial lecture on “From big bang to Black holes: the beginning and the end of the time”.

Prof. Ashoke Sen, theoretical physicist, Dept. of Physics, Harish-Chandra Research Institute, Allahabad delivred Prof. K C Kar Centenary lecture on “Search for a unified Theory”.

Prof. Bikas K Chakrabarti, Senior Professor of Theoretical Condensed Matter Physics, known as econo physicist, SINP delivered K C Kar memorial lecture on “Statistical Physics of the Travelling salesman Problem” in 1999.

Prof. Deb Shankar Ray, Senior Professor of Physical Chemistry, IACS, Kolkata delivered K C Kar memorial lecture on “Weak quantum noise limit of Stochastic processes” in 2000.

Prof. Kankan Bhattacharya, Director of IACS, Kolkata delivered K C Kar memorial lecture on “Recent Advances in Space and Time Resolved Spectroscopy” in 2010.

Prof. Siddhartha Sen, School of Mathematics, Trinity College, Dublin, Ireland delivered K C Kar memorial lecture on “Reflections on the Bohr Model of the Atom” organized in collaboration with Mathematics department of Scottish Church College, Kolkata in 2013.

Prof. Soumitra Sengupta, Head of the Dept. of Theoretical Physics, IACS, Kolkata delivered K C Kar memorial lecture on “ 100 Years of General Relativity - Some Key Issues” organized in collaboration with Physics and Mathematics departments of St. Xaviers College, Kolkata in 2015.

UGC sponsored National Conference on the occasion of celebration of “Central Role of Light Science and the Importance of Optical Technologies” was organized in collaboration with Physics department of St. Paul’s C M College, Kolkata during December 15-16, 2016. The speaker-list included the following scientists.

Prof. P.N Ghosh, Former VC of JU, delivered a talk on “Marvels in the world of light”.

Prof. Ajoy Ghatak, Emeritus Professor of Physics, IIT Delhi delivered a talk on" Quantum Nature of Light and Entanglement"

Prof. Asit Kumar Datta, Department of Applied Optics and Photonics, CU presented a talk on "A Chronological history of light sources"

Prof. Tapan Ganguly, Emeritus Professor of Physics, School of Laser Sciences and Engineering, JU delivered K C Kar memorial lecture on "Mechanisms of Photo degradation of Fluorescent dye pollutant by nano ZnO semiconductor and noble nano metal gold".

Prof. Jayanta Kumar Bhattacharjee, Distinguished Emeritus Professor of Physics, IACS, Kolkata delivered K C Kar memorial lecture on " Basic Concepts of Quantum Statistics" on the occasion of Celebration of 125th Birth Anniversary of Prof. S N Bose organized in collaboration with Physics Dept. of St. Paul's C M College, Kolkata on 28th July, 2018

Prof J K Bhattacharjee also delivered K C Kar memorial lecture on "Meghnad Saha and Statistical Physics" on the occasion of Celebration of 125th Birth anniversary of Prof. M.N. Saha organized in collaboration with Physics Dept. of Lady Brabourne College, Kolkata in 2019.

A Webinar was organised on the occasion of celebrating the 69th Anniversary of CITP in collaboration with Physics department of St.

Paul's C M College, Kolkata on 25th September, 2021. The following scientists were invited to present lectures.

Prof. Shibaji Raha, Former Director of Bose Institute and Raja Ramanna Fellow delivered K C Kar memorial lecture on "Climate Change- a Physicist's Perspective".

Dr. Partha Sarathi Mukhopadhyay, Senior Associate Professor of Mathematics, R.K.Mission Residential College, Narendrapur presented S Ghosh memorial lecture on" Glimpses of Mathematics in Ancient India".

Some important memorial lectures published in IJTP (Section-proceedings of symposium) are presented below:

1. M K Pal, "Calculations on nuclear fissions", Vol-40, No. 4, P-1, 1992.
2. C K Majumdar, "Phase Transition", Vol-31, No. 4, P-25, 1993.
3. N C Sil, "Electron Capture Phenomena", Vol-42, No. 4, P-1, 1994.
4. A N Daw, "Some recent trends in Information Technology", Vol-43, No. 4, P-1, 1995.
5. B K Datta, "Einstein's struggle for covariant formalism and the role of Levi-Civita", Vol.-44, No. 2, P-54, 1996.
6. A Raychaudhuri, "Trends in Particle Physics Research in the next decade", Vol-45, No. 4, P-1, 1997.
7. A K Raychaudhuri, "From big bang to Black holes: the beginning and the end of the time", Vol-46, No. 4, P-1, 1998.

8. A Sen, “Search for a unified Theory”, Vol.-46, No. 5, P-7, 1998.

9. B K Chakrabarti, “Statistical Physics of the Travelling salesman Problem”, Vol-47, No. 4, P-1, 1999.

10. D S Ray, “Weak quantum noise limit of Stochastic processes”, Vol.-48, No. 4, P-1, 2000.

11. S Sen, “Reflections on the Bohr Model fo the Atom”, Vol.-61, No.4, P-1, 2013.

12. **Special issue** of IJTP, Vol.-63, No. 1 & 2, 2015 was published to celebrate international year of light 2015.

13. **Special issue** of IJTP, Vol.-66, No. 3 & 4, 2018 was published to celebrate 125th birth anniversary of Prof. S N Bose in 2018.

LIBRARY OF CITP

In the book section there are a good number of books (about 600 in English and German languages) on specific subjects like Symmetries in Nuclear Structure, Chaotic Behavoior in Quantum Systems, Elementary Excitons in Solids, Molecules and Atoms, Supersymmetry, Scaling Phenomena in Disordered Systems, Quantum Optics, Experimental Gravitation and Measurement Theory, Quarks, Leptons and Beyond, Unification of the fundamental particle interactions, General Relativity and Gravitation etc. collected from different reputed foreign publishers (Free copies). 460 copies of books written by Prof. K C Kar are also available.


Journal of Physics
Journal of Physics
Journal of Physics
ROMANIAN REPORTS IN PHYSICS
ROMANIAN REPORTS IN PHYSICS
ROMANIAN REPORTS IN PHYSICS
Energy Research Abstracts
CMS
The following journals are available:
1. Physical Review (selective volumes)-61 copies.
2. Mathematical Proceedings of the Cambridge Philosophical Society-21 copies.
3. Romanian Journal of Physics-49 copies.
4. Romanian Reports in Physics-38 copies.
5. Nuclear Science Abstracts-184 copies.
6. Indian Journal of Theoretical Physics (1953 – 2020)-1800 copies.
7. Indian Journal of Physics -178 copies.
8. Bulletin of Calcutta Methematical Society-50 copies.
9. Energy Research Abstract - 55 copies.
10. Annales L' INSTITUT FOURIERS-27 copies.
11. Proceddings of Indian National Science Academy-17 copies.
12. Silver Jubilee Volume (1953-1977) 200 copies.

6. Establishment of Sulata Kar Sishusahitya Sangha

Sulata Kar

Dr. Kar married Sulata Mitra in 1926. They had no children. Sulata Kar studied at Bethune College, Kolkata and passed the I. Sc. Examination with 1st division in 1926 and B.A. in 1928. She also passed M.A. (Bengali) Examination in 1941. She was a staunch nationalist, who had to suffer imprisonment under the British rule, for her political views. In her later years, she devoted herself whole-heartedly to writing charming books in Bengali for the children. শিশু সাহিত্যিক সুলতা কর-এর লেখা ছোটদের গল্পের বইয়ের তালিকা— (১) ছোটদের বিদেশী গল্প সঞ্চয়ণ, (২) এন্ডারসনের রূপকথা, (৩) অস্কার ওয়াইল্ডের গল্প, (৪) বিদেশী শিশু নাটিকা, (৫) পুঁথি পুরাণের গল্প, (৬) ছোটদের সেরা গল্প, (৭) কাঠের পুতুল ক্ষুদিরাম, (৮) ছোটদের যীশুখৃষ্টের গল্প, (৯) ছোটদের ইতিহাসের গল্প, (১০) ছোটদের বৌদ্ধ গল্প।

She predeceased her husband in 1965. Dr. Kar established Sulata Kar Sishusahitya Sangha under the name of his deceased wife and allotted the Northern room of the first floor and one room in the ground floor of his premises for functioning of the Sangha.

After the demise of his wife, Dr. Kar became an incurably lonely man and the institute became the centre of his existence. With declining eye-sight, as his life rushed towards perpetual darkness, his hope defied reason. And yet he declined the proposal for the surgical removal of cataracts from his eyes. He said," All my life I have enjoyed the external world with my eye-sight. Now I am keen to develop the inner-sight to scan the internal world".

Kulesh Chandra Kar died in April 22, 1975 at the age of seventy six, still seeking the answers to more secret of time and space. As it was said about Milton, it may well be said of Him: "He soared but never roamed, true to the kindred points of heaven and home".

At present 150 people have registered themselves as life members of the institute. Inspite of hard times, after the demise of Dr. K C Kar the learned members and well-wishers are maintaining the activities of the institute under the leadership of the following directors.

The following members were also actively involved with the institute in different capacities.

SECRETARIES


Dr. M Ghosh (1953 – 1964)


Dr. C Dutta (1965 – 1972)


Dr. A K Bhattacharyya (1973 – 1977)


Dr. S D Chatterjee (1978-1994)


Dr. P P Chattarji (1995-2010)

EDITORIAL SECRETARY


Dr. P R Ghosh (1985-2013)

REGISTRAR


Dr. C Dutta (1975-2019)

ASSISTANT SECRETARY


J Biswas (1966–2010)


Prof. M Kanoria (2011-2016)

The members of the present Governing Body (2021 – 2022)


Prof .Jayanta Kr. Bhattacharjee, Distinguished Emeritus Professor, IACS, Kolkata, **Director**


Dr. Prabhat Ranjan Ghosh, Retired Reader, Vidyasagar Evening College, Kolkata, **Vice-President**


Dr. Susil Kumar Sarkar, Retired Associate Professor, Vidyasagar College, Kolkata, **Secretary.**


Dr. Partha Sarathi Majumdar, Retired Associate Professor, A P C College,24 Pgs (North), **Asst. Secretary**

Prof. Dulal Chandra Sanyal, Retired Professor, Kalyani University, **Treasurer & Editorial Secretary**

Dr. Arup Roy , Retired Associate Professor, Scottish Church College, Kolkata **Sr. Member**

Prof. Mridula Kanoria, Retired Professor, Calcutta University **Sr. Member**

Dr. Jyotirmoy Mukhopadhyay, Retired Principal, A P C College, 24 Pgs(North), **Sr. Member**

Dr.Mrinal Kanti Chakrabarti, Retired Associate Professor and Teacher-in-charge , St.Paul's C M College, Kolkata, **Co-ordinator, Seminar Committee**

Prof. Indira Ghosh, Retired Professor, JNU, New Delhi **Asst. Editorial Secretary**

Dr. Subhendu Chandra , Assistant Professor, Victoria Institution (College), Kolkata, **Member**

Citation Profile of Professor K C Kar

1. ACOUSTICAL PHYSICS

Rank	*Ranked List of Short Titles	No. Cited	First Citation	Last Citation
1	Ind.Journ.Theo.Phys. 18 (1),p.1-11, 1970	5	1972	1979
2	Phil. Mag. Pt. III, 12 (78), p. 676 – 85, 1931	4	1934	1987
3	Physik. Zeits. 24, p. 429 -34, 1923	3	1924	1953
4	Phil. Mag. 6 (35), p. 276 – 80, 1928	3	1939	1987
5	Phil. Mag. Pt.I, 9(56), p.305 – 20, 1930	3	1934	1987
6	Ind.Jour.Phys. 25, p.423 – 32, 1951	3	1952	1973
7	Phys. Rev. 21 (6), p. 695 – 98, 1923	2	1930	1939
8	Phil. Mag. 5(29), p. 547 – 59, 1928	2	1987	1987
9	Phil. Mag. Pt.II, 9(56), p. 321-24, 1930	2	1939	1987
10	Z. Angew. Math. Mech. 11(5), p.361 – 72, 1931	2	1934	1987
11	Ind. Physico-Math.Jour. 3, p.103 -4, 1932	2	1972	1987
12	Ind. Jour.Theo. Phys. 5(2),p.31, 1957	2	1971	1973
13	Phys. Rev. 20(2),p.148 – 53, 1922	1	1932	1932
14	Zeit.Phys. 61(7 -8),p.525 -37, 1930	1	1987	1987
15	Zeit. Phys. 66(5 -6),p.414 – 24, 1930	1	1987	1987

*Ref. to Bibliography

2. WAVE STATISTICS				
Rank	Ranked List of Short Titles	No. Cited	First Citation	Last Citation
1	Phys.Rev. 21(6), p. 672 – 79, 1923	6	1925	2012
2	Z.Physik..61(5-6), p.411 – 15, 1930	3	1930	1930
3	Phil.Mag. 29, p.143 – 44, 1928	2	1929	1930
4	Z. Physik. 62(7-8),p.510 – 17, 1930	2	1930	1930
5	Phil.Mag. 16(109),p.1097 – 1109, 1933	2	1938	1971
6	Ind. Jour. Phys. 24,p.545 – 65, 1950	2	1956	1971
7	Physik.Zeits. 26, p.465 – 67 , 1925	1	1929	1929
8	Z. Physik. 61(9-10),p.675 – 80, 1930	1	1931	1931
9	Z.Physik. 64(1-2),p.76 – 80, 1930	1	1931	1931

3. QUANTUM STATISTICS				
1.	Physik.Zeits. 28,p.300 -02, 1927	2	1930	1930

4. NUCLEAR AND PARTICLE PHYSICS				
Rank	Ranked List of Short Titles	No. Cited	First Citation	Last Citation
1	Ind.Jour. Phys.18,p.223 – 42, 1944	4	1950	1953
2	Ind.Jour. Theo. Phys.12(2), p.39, 1964	4	1979	1981
3	Ind. Jour.Theo. Phys.1(2)p.87 – 120, 1953	2	1967	1971
4	Ind. Jour. Theo. Phys.8(2-3),p.47 -83, 1960	2	1968	1971
5	Z.Physik.53(3-4),p.308 -11, 1929	1	1930	1930
6	Z. Physik.59(7-8),p.570 -72, 1930	1	1930	1930
7	Z.Physik.60(3-4),p.243 -49, 1930	1	1931	1931
8	Phil. Mag.21(144),p.1067 -78, 1936	1	1938	1938
9	Phil. Mag. 29(193), p.169 – 84, 1940	1	1971	1971
10	Ind. Jour. Theo. Phys. 4(1), p.21, 1956	1	1968	1968
11	Ind. Jour. Theo. Phys. 13(1), p.1-20, 1965	1	1967	1967
12	Ind. Jour. Theo. Phys. 20(2), p.33 – 38, 1972	1	1978	1978
5. THEORY OF RELATIVITY				
1	Ind.Jour. Theo. Phys. 21(1), p.1-14,1973	2	1977	1979
2	Ind.Jour. Theo. Phys. 16(1),p.1-6,1968	1	1977	1977
3	Ind.Jour. Theo. Phys.17(1),p.1-11, 1969	1	1977	1977
4	Ind.Jour. Theo. Phys.19(1),p.1-14, 1971	1	1975	1975
5	Ind.Jour. Theo. Phys.20(1),p.1-8, 1972	1	1975	1975
6	Ind.Jour. Theo. Phys.22(1),p.35, 1974	1	1978	1978
7	Ind.Jour. Theo. Phys.23(1),p.25-31, 1975	1	1979	1979
	Total No. of Cited papers: 44	Total No. of Citations: 86		

Geographical distribution of citations received by Prof. K C Kar		
Ranks	Geographical locations of institutions where citing authors affiliated to	Citations received
1	INDIA	34
2	USA	24
3	GERMANY	7
4	UK	6
5	POLAND	5
6	CZECH REPUBLIC	2
7	RUSSIA	2
8	BELGIUM	2
9	ITALY	2
10	ROMANIA	1
11	JAMAICA	1
	TOTAL	86

Uncited scientific papers of Prof. K C Kar

1. 1923 - Uber die achwingungen eines teilchens unter periodisch wiederholten impulsen,Physikalische Zeitschrift, Vol.24,p.63
2. 1924 - Uber'Spontane Schwankungen' in der Physik II, Physikalische Zeitschrift, 25, p.397
3. 1925 – Die Kinetische theorie der kompressibilitiit der Losungen und binaren flussigkeitsgemische, Physikalische Zeitschrift, Vol.26,p.737
4. 1926 – Die Molekularzerstreuug des Lichtes biem kritischen Zustande, Physikalische Zeitschrift, Vol 27,p.380.
5. 1927 – The molecular scattering of light in a Binary liquid mixture, Philosophical Magazine, Vol.3,p. 601
6. 1927 – Die Molekular zerstreuug des Lichtes beim kritischen Zustande, Physikalische Zeitschrift, Vol.28, p.710
7. 1929 - Uber die statistische Begrundung der langmuirschen adsorptionsformal, Physikalische Zeitschrift, Vol.30,p.918
8. 1929 - Uber eine verallgemeinerte zwei dimensionale Gibbssche statistic, Zeits Fur Physik, Vol.55, 546
9. 1929 - Das stralungsgesetz nach der Schrodingerschen theorie, Zeitschrift Fur Physik, Vol.56,p.286
10. 1929 - Die theorie der intermittierenden wirkung und die serienspektren, Zeitschrift Fur Physik, Vol.57p.416

11. 1929 - Verallgemeinerte statistic und Schrodinger-mechanik, Zeitschrift Fur Physik, Vol.59,p. 10

12. 1931 – Notes on the Wave-statistics , The Indian Physico-Mathe matical Journal, Vol. 2, p.15

13. 1931 –Uber eine erweiterung der wellenstastistik, Zeitschrift Fur Physik, Vol.67,p.699

14 1932 - The wave – statistical theory of fine structure. The Indian Phyisico-Mathematical Journal, Vol.3,p.65

15. 1932 - Viscosity of the phase-space, The Indian Physico-Mathematical Journal, Vol.3,p.1

16. 1932 - Wave Statistical Theory of radio-active disintegration , The Indian Physico- Mathematical Journal, Vol.3,p.81

17. 1934 – The Wave –statistical theory of electron spin , Philosophical Magazine,Vol.17,p.993

18. 1937 - On the loss of energy by an alpha particles in Hydrogen, Philosophical magazine, Vol.23,p.230

19. 1937 - The theory of of elastic scattering of a beam of particles by atoms, Philosophical Magazine, Vol. 24, p.964

20. 1937 - On the elastic scattering by Hydrogen and Helium, Philosophical Magazine, Vol.24,p.971

21. 1939 - On the Neutron –proton scattering , Philosophical Magazine, Vol.27,p.76

22. 1940 – The Wave –statistics, Journal of the Science Book Club, Vol.1,p.7

23. 1940 – The theory of Compton effect, Ind. Jour. Phys., Vol. 14,p.117

24. 1940 – On the proton – proton scattering, Philosophical Magazine, Vol.29,p.200

25 1940 – On the in-elastic scattering of a beam of particles by Hydrogen and Helium, Philosophical Magazine, Vol.30,p.487

26. 1941 - Proton-proton scattering and Yukawa-particle, Science and culture, Vol.6,p.616

27. 1940 – On Nuclear scattering, Ind. Jour. Phys., Vol.15,p.113

28. 1942 - Proton-proton interaction and Yukawa-particle. Ind. Jour. Phys.,Vol.16,p.187

29. 1942 - On the scattering of fast Beta-particle by atomic nuclei, Science and Culture Vol.8,p.191
30. 1943 – A self-consistent method of determining the mass of mesotron, Ind. Jour. Phys., Vol.17,p.316
31. 1943 – The theory on neutron- proton scattering. Ind. Jour. Phys., Vol.17, p.321
32. 1944 – The distortion of plane , x-waves and its effect on elastic scattering in Coulomb field. Ind. Jour. Phys.,Vol.18,p.144
33. 1944 – Proton – proton scattering at low velocity. Ind. Jour. Phys.,Vol.18p.303
34. 1945 – The scattering of fast electrons by atoms, Ind. Jour. Phys., Vol.19,p.147
35. 1947 – The effect of spin-spin interaction on high velocity scattering, Ind. Jour. Phys., Vol.21, p.69
36. 1948 – On the scattering of fast particles of spin one by atom nuclei, Ind. Jour. Phys., Vol. 22,p.249
37. 1949 – The relative intensity of doublet spectra, Ind. Jour. Phys., Vol.23,p.19
38. 1950 – The relativistic theory of scattering in Coulomb field by atom. Ind. Jour. Phys., Vol. 24, p.339
39. 1953 – 54 - The classical interpretation of Dirac's theory of electron. Ind. Theo. Jour. Phys., Vol.1,p.1
40. Classical derivation of the pseudoscalar interaction potential.Ind. Theo. Jour. Phys., Vol.1,p.67
41. 1954-55 – The generalized interaction potential between nucleons. Ind. Theo. Jour. Phys., Vol.2, p-2, p.17
42. 1954-55 – Note on the minimum bowing pressure, Ind. Theo. Jour. Phys., Vol.2,p.46
43. 1954-55 –A simple derivation of Klein- Nishina formula without matrices, Ind. Theo. Jour. Phys., Vol.2,p.49
44. 1954-55 – The nature of Yukawa potential, Ind. Theo. Jour. Phys., Vol.2, p.159.
45. On the summation rule for Bp and Bn Part.I, Ind. Jour. Theo. Phys. Vol.3, p.35

46. The theory of alpha disintegration , Ind. Jour. Theo. Phy. Vol.3, p.89

47. On the summation rule for Bp and Bn , Part.II, Ind. Jour. Theo. Phys. Vol.3, p.125

48. 1957- Note on the dynamical co-efficient of friction, Ind. Jour. Theo. Phys. Vol.5, p.19

49. A new derivation of Klein-Nishina formula without matrices, Ind. Jour. Theo. Phys.Vol.5,p.51

50. A simple theory of Bremsstrahlung without Dirac matrices, Ind. Jour. Theo. Phys.Vol.5, p.81

51. On the process of Beta emission, Ind. Jour. Theo. Phys. Vol.5,p.111

52. 1958 –On the linearization of the relativistic Hamiltonian Ind. Jour. Theo. Phys. Vol.6,p.65

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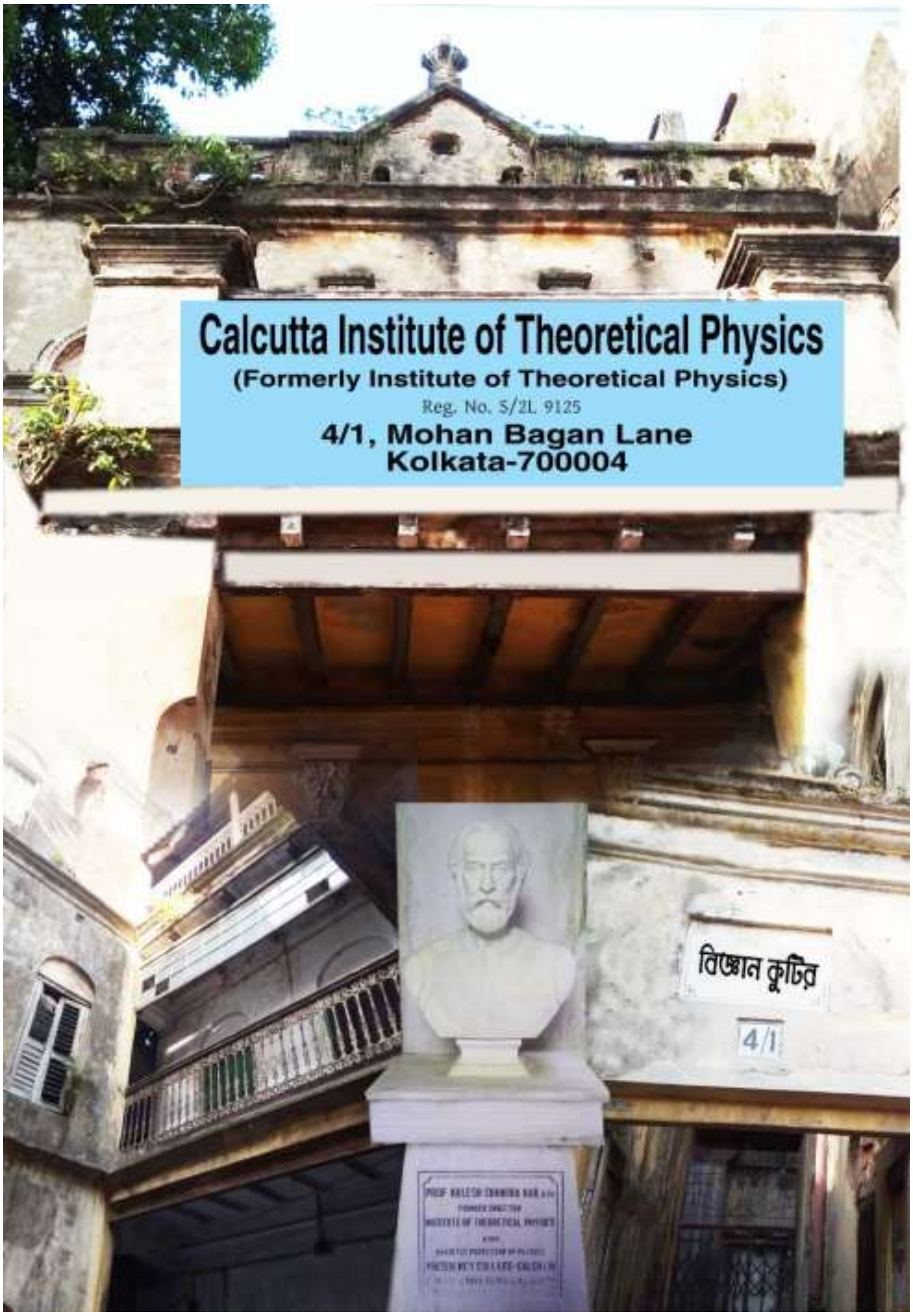

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Understanding the Strongly Correlated Systems from Theoretical Perspectives: A Brief Review

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[Abstract : This review is focused to explore the physics behind "many-body theory" that steers in understanding the strongly correlated systems. A brief overview of the Hartree, Hartree-Fock and density functional theory methods on the many-body systems has been discussed. The discussions of the strongly correlated electron systems and their recent advancement in electronic structure calculations have also been enlightened.

Keywords: Strongly correlated systems, Many-body theory, Hubbard model, Electronic structure calculations.

1. Introduction

From the eve of human civilization, human minds were engrossed to master the extractions and use of different materials, primarily for the sustenance of their livelihood. Interestingly the use of materials depicts three distinct time periods in the historical timeline that include stone, bronze and iron ages[1-3]. Stone age (4000 BCE – 2000 BCE) marked the use of different tools that had chiselled edges, sharp points or

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percussion surfaces and are now being recognized to have ended with the emergence of metals[4,5]. However, the uses of gold and copper, mostly for the purpose of ornamentation were known even at the end of stone age. Bronze age on the other hand spanned around 3300 BCE to 1200 BCE, where the extensive use of bronze in proto-writing were noted[6,7]. The remarkable use of bronze is significant from the scientific point of views as well, considering the fact that it is not a pure metal, instead an alloy containing mostly copper and around 12% tin together with other metals (ca. aluminium, manganese, nickel, zinc) and metalloids like arsenic, phosphorous or silicon. Thus the people in the pre-historic era not only had the knowledge to prepare alloys but were quite aware to use them in printing and state of art tools for household/ hunting applications. Iron age, according to recent studies, are depicted to range from 15th century BCE and lasted approximately till the 3rd century BCE, where iron workings were explicitly practiced, the most prominent example being the Nok culture of Nigeria[8-10].

Since then, with the advancement of science the world has witnessed different techniques for the extractions, characterizations and applications of fascinating materials that find wide range of applications in technology and medicine. However, understanding the electronic, optical and magnetic properties of materials were far from analytical consequences until the development of faster computations[11-21]. With the development of Quantum Mechanics along with the advancement of modern computational facilities and techniques, the “many-body theory” that can address the microscopic properties of materials in finer details has undergone a paradigm shift in the offing of Materials Sciences and Condensed Matter Physics.

In this context advanced computational methods like Hartree, Hartree-Fock (restricted/ unrestricted) and density functional theory (DFT) are seen to be quite successful in predicting the electronic properties of many fascinating materials (ca.NaF, NaCl, SiO_2, Al, B_2O_3, boron nitride (BN) etc.) in close agreement with the experimental evidences[22-25]. However, for possible spintronic materials like transition metal compounds (TMCs) and heavy fermion systems (HFNs) the pre-referred computational methods surprisingly fail to reproduce the experimental band gaps, ground state electronic and the magnetic properties[15,26-30]. While DFT calculations predict the metallic properties of the TMCs or HFNs, the experimental evidences on the contrary confirm them to be insulators[15,26-32]. The apparent disagreement between the DFT predicted results and the experimental observations had now been recognized to be linked with the presence of partially filled electrons in the "d" and "f" orbitals of TMCs and HFNs systems.

With these things in mind, the present review is focussed on the advancement of various theoretical approaches to address the correct physics of strongly correlated TMCs and HFNs. In this connection it may be worth to mention that such strongly correlated systems (SCSs) have drawn significant attentions to the physicists and materials scientists because of their potential applications as topological insulators[33-37], Dirac-Weyl semimetals[36,38-42], high temperature superconductors[43-45] and cathode materials[46,47]. The article has been organized in the following manner. In section 2, the fundamental many-body theory that laid the foundation stone for the electronic structure calculations of materials has been discussed. In section 2.1, the many-body theory specifically tailored for SCSs, has been shared. Recent advancements in the methods of electronic structure calculation methods specifically for SCS shave been discussed in Section 3. The overall summary of the review is highlighted in Section 4.

2. Many-body theory

Materials in quantum scale are polyatomic systems consisting of a large number of interacting atoms. The physics to understand the collective behaviour of such large number of interacting atoms are designated as "many-body theory" in Material Science. The Hamiltonian for such systems is in general expressed as:

$$\boldsymbol{H} = -\sum_{i=1}^{n} \frac{\hbar^2}{2m} \nabla_{r_i}^2 - \frac{e^2}{4\pi\varepsilon_0} \sum_{I=1}^{N} \frac{Z_I}{|r_i - R_I|} + \frac{e^2}{2} \sum_{i \neq j} \frac{1}{|r_i - r_j|} - \sum_{I=1}^{N} \frac{h^2}{2M_I} \nabla_{R_I}^2 + \frac{1}{2} \sum_{I \neq J} \frac{Z_I Z_J e^2}{|R_I - R_J|} \quad \dots (1)$$

where $\boldsymbol{r_i}$ and $\boldsymbol{R_I}$ represent the position of electron $\boldsymbol{i}$ and nucleus $\boldsymbol{I}$ with charge $-\boldsymbol{e}$ and $\boldsymbol{Z_I e}$ respectively of the system. The first term in the Hamiltonian is the kinetic energy associated with the "n" electrons of the polyatomic systems, the second term is the attractive Coulomb potential generated from the contribution of "N" nuclei and "n" electrons of the system, the third term signifies the repulsion between electron-electron interactions, the fourth and the final terms are the kinetic energy and the attractive potential of the "N" nuclei of the system respectively. As it is known that electron in an atom is ~ 1830 times lighter than its nucleus, so in practice one can consider the motion of the electrons alone in a fixed nuclear frame at a given instant of time. Here the inter nuclear distances between the atoms appear as parameter instead of variable in all the dynamical equations of motions. This approximation is known as the Born-Oppenheimer (BO) approximation where the motions of the electron is treated to be moving in fixed nuclear frame[48].In the light of non-relativistic BO approximation, the Hamiltonian of many-body systems can therefore be modified to

$$\boldsymbol{H} = -\sum_{i=1}^{n} \frac{\hbar^2}{2m} \nabla_{r_i}^2 - \frac{e^2}{4\pi\varepsilon_0} \sum_{I=1}^{N} \frac{Z_I}{|r_i - R_I|} + \frac{e^2}{2} \sum_{i \neq j} \frac{1}{|r_i - r_j|} \qquad \ldots (2)$$

However, the above referred Hamiltonian of the many-body system is still difficult to solve even after BO approximation because of the existence of the third term in equation (2) that involves electron-electron correlation. Single-electron approximation thus has been developed to take into account the electron-electron correlation part in the above referred Hamiltonian. In this regard, theme an-field theory[49,50],as reported by Hartree based on the self-consistent field model, had been the first prominent approach to solve the modified Hamiltonian as framed in equation (2) (*vide supra*)[51].According to the mean-field theory (MFT) each electron is subjected to move in an average or mean field created by all other electrons in an atom. The MFT takes into account the electron-electron correlation term in the Hamiltonian and the associated Schrödinger equations are then solved by means of an iterative method.

Though Hartree theory is successful in predicting the electronic properties of some molecules and solids, however it does not take into the anti symmetric nature of electronic wave functions. With the independent insights from Slater[52,53] and Fock[54], Hartree reformulated the Hartree theory as Hartree-Fock (HF) theory by incorporating the anti symmetric nature of the electronic wave functions as the electronic exchange term[55].While HF theory is moderately successful in predicting the electronic structures of molecules and solids, the major pitfall of this theory is the neglect of electron correlations for the electrons of opposite spins. Moreover, the HF theory fails to describe the magnetic properties of materials accompanying with the transition metals like Fe, Pt, Pd, Mn, Cu, Nietc. and their respective density of states[56-63].

An alternative approach to solve the many-body systems is the density functional theory(DFT)which takes into account the electron correlation explicitly. The semi classical approach of DFT was suggested by Thomas and Fermi (TF)[64,65].This theory included the oversimplified electron-electron interactions classically and thus their theoretical predictions in most cases are far from experimental results. The modification of the TF model was proposed by Hohenberg, Kohn and Sham[66,67]. This modern DFT approach uses local density approximation (LDA) and generalized gradient approximation (GGA) to address the electron correlations which satisfactorily proved to be effective in reproducing the electronic structures of most of the materials like NaF, NaCl, SiO_2, Al, B_2O_3, BN, reduced graphene oxide, aluminene, RuO_2, LiX (X = F, Cl, Br and I) etc.[22-25,68-75].

2.1. Many-body theory for strongly correlated systems

SCSs refer to a wide class of materials mainly belonging to TMCs and HFNs where the electron-electron repulsion plays a pivotal role in determining their exotic physical properties. These systems have a special place in Materials Science because of their wide range of applications in technology and medicine. However, the physics of MFT imposes severe limitations in understanding the properties of SCSs. While DFT calculations predict TMCs and HFNs as metals, but in reality, experimental observations ascribed them to be insulators. The apparent disagreement between the theory and experimental results for such SCSs may be rationalized. For TMCs and HFNs, the valance electrons of the systems partially occupy in the narrow d or f orbitals and thus their respective wave functions are more localized towards the corresponding nuclei in comparison to the wave functions associated with the electrons residing in the s or p orbitals of similar energies. The localized valance electrons within the d or f orbitals thus spend longer times on an atomic site of the crystal which in turn makes the spatial distance $|r_i - r_j|$ between two neighbouring electrons much closer within the respective orbitals. This makes the inclusion of electron correlations so important to understand the correct physics of the SCSs[15,29,31,32,76-78]. In DFT, the LDA and the GGA approximations do not explicitly consider the electron correlation effect in the SCSs and thus proved to be inaccurate to reproduce the correct electronic and magnetic properties in harmony with the experimental observations[15,29,79,80]. To describe such strongly correlated systems, the modified many-body theory has been considered. The inclusion of on-site coulomb repulsion (+U) in the many-body Hamiltonian splits the metallic LDA/GGA bands in the band structure of the partially filled d-orbital systems into two sets of bands[77]. These newly split bands named as upper and lower Hubbard bands (UHB &LHB)are seen to successfully reproduce the electronic band gap of the SCSs and justify their insulating nature in accordance with the experimental evidences. These insulators are called Mott-Hubbard or Mott insulators[81]. The inclusion of on-site coulomb repulsion term (ca.LDA+U or GGA+U) was completely absent in the earlier DFT calculations (estimated mostly from LDA or GGA approximations) and inclusion of + U correction in the model Hamiltonian gave birth to a new theory especially for the strongly correlated electron systems which has the unique power to reproduce the experimental band gaps, ground state electronic and the magnetic properties of these compounds[79,82-84]. The on-site Coulomb interaction term U is expressed as

$$U = \int dr\, dr' |\psi_L(r-R)|^2 U_s(r-r') |\psi_L(r'-R)|^2 \qquad \text{... (3)}$$

where $\psi_L(r-R)$is the Wannier-like wave function positioned at an atomic site R and U_s is the screened coulomb effect between the electrons.

The model Hamiltonian for the SCSs, after inclusion of the on-site Coulomb interaction term (+ U) between the electrons of opposite spins, is expressed as

$$H = -t \sum_{<i,j>,\sigma} (c^{\dagger}_{\boldsymbol{i},\sigma}\, c_{\boldsymbol{j},\sigma} + h.c.) + U \sum_{\boldsymbol{i}} n_{\boldsymbol{i},\uparrow}\, n_{\boldsymbol{i},\downarrow} \qquad \text{... (4)}$$

where$< i, j >$ denotes nearest-neighbour atomic sites; $c^{\dagger}_{\boldsymbol{i},\sigma}$, $c_{\boldsymbol{j},\sigma}$and $n_{\boldsymbol{i},\sigma}$ are the creation, annihilation and number operators for electrons with spin σ residing on the atomic site i or j respectively and "t" is the corresponding hopping parameter. U is the on-site Coulomb interaction which is proportional to the product of the occupation numbers of atomic states on the same atomic site. The occupation numbers are defined as the projections of occupied Kohn-Sham (KS) orbitals (ψ^{σ}_{kv}) on the states of a localized basis set (ϕ^{I}_{m}):

$$n^{I,\sigma}_{m,m'} = \sum_{k,v} f^{\sigma}_{k,v} < \psi^{\sigma}_{kv} \middle| \phi^{I}_{m'} >< \phi^{I}_{m} \middle| \psi^{\sigma}_{kv} > \qquad \text{... (5)}$$

where $f_{k,v}^{\sigma}$ are the Fermi-Dirac occupations of the respective KS states.The above Hamiltonian in equation (4) is renowned as Hubbard model[85-87].

Evidence of Mott insulator was first reported by M.R. Norman for Cobalt oxide (CoO) system[88].The conventional band theory predicted CoO as metal, however inclusion of on-site Coulomb interaction term U in the many body Hamiltonian, it was found to be insulator with band gap energy (E_g) ~ 2.33 eV[89]. This result is in complete agreement with the experimental observation by *Kurmaev et al.* who reported CoO to be an insulator with E_g ~ 2.6 eV[90].L. F. Mattheiss in his seminal work studied the electronic properties of CaO, TiO, VO, MnO, FeO, TiO compounds with the inclusion of +U in the many-body Hamiltonian and suggested them as M-H insulators[91]in concordance with the experimental observations[90]. Later *Anisimov et al.* fixed the U values for the above transition metals from the Slater's transition-rule[79].

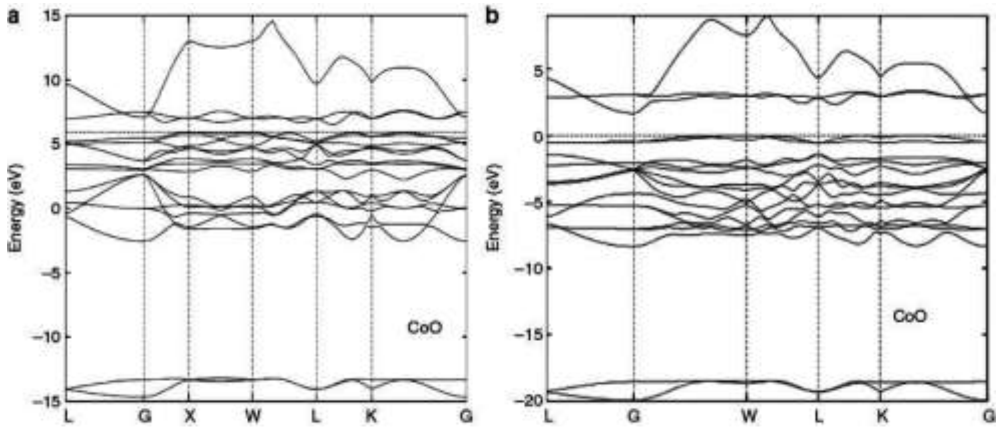

Figure 1.

Electronic band structure of CoO computed with (a) GGA and (b) GGA+U.

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Recently *Kumari et al.* studied on a series of 3d[1] perovskite ($SrVO_3$, $CaVO_3$ and $YTiO_3$) systems and showed significant alterations in band gap of these compounds by incorporating the Hubbard U parameter in the calculation[26]. Similar observations have been found by *Wong-Ng et al.* in double perovskite compounds Sr_2WCoO_6 and Ba_2WCoO_6in accordance with the experimental results[92].

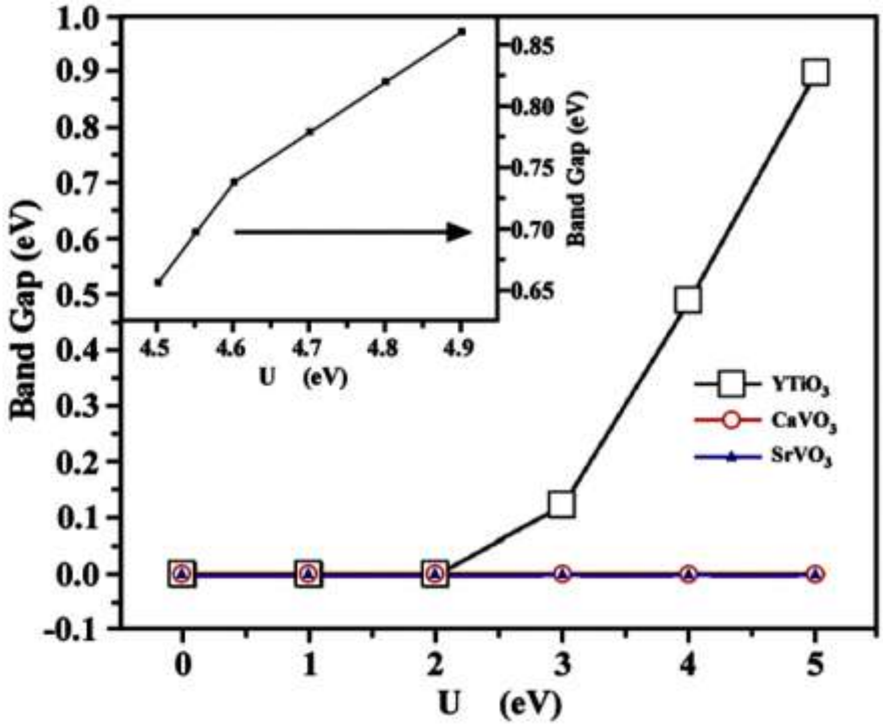

Figure 2.

Electronic band gap versus Hubbard U correlation for the 3d[1]perovskites. The inset shows the narrow region of U for $YTiO_3$. Copyright ©2018 Elsevier Ltd.[26]

Emily et al. recently showed the electronic band gap ofHFNsNdNiO$_2$where the alteration in band gap has been observed by incorporating GGA+U level of theory in the first-principle calculation in agreement with the experimental observations[93].

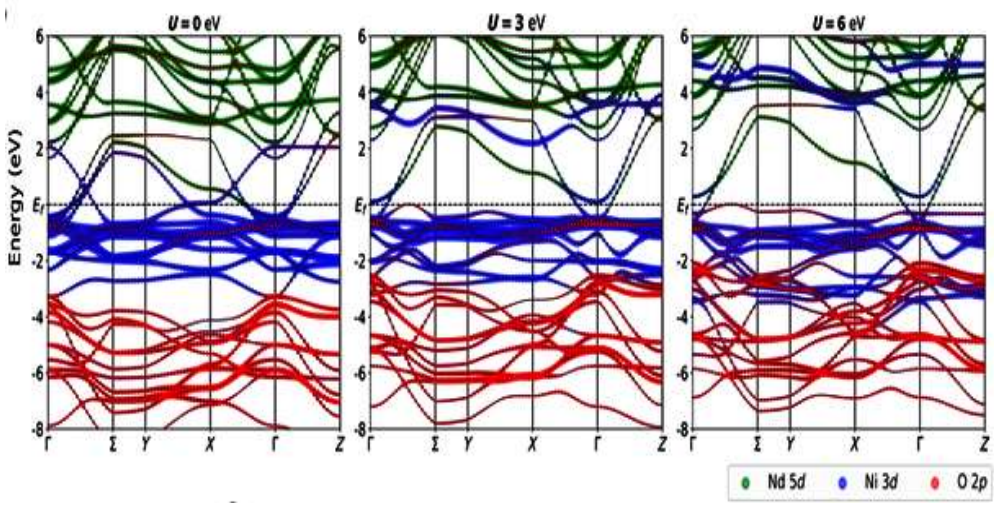

Figure 3.

Electronic band structure of $NdNiO_2$. GGA and GGA+U(U=3and 6 eV) calculations of the band structure and the corresponding atomic orbital character of $NdNiO_2$. The "lower Hubbard band" and "upper Hubbard band" splitting in GGA+U scenarios are apparent; specifically, for U = 6 eV. Copyright © 2021American Physical Society[93].

Interestingly, apart from the Mott-Hubbard insulators, there are another class of insulators known as charge transfer (CT) insulators. The electronic properties of the CT insulators involve p orbitals of the anions or ligands surrounding the transition metal atoms. Electron transfer from the p orbitals of the anion or the ligands to the respective transition metals of the compound result an energy cost Δ, known as CT energy.The basic difference between the M-H and CT insulators comes from the Zaanen–Sawatzky–Allen (ZSA) diagram[77]. The energy dispositions of the d orbitals for the transition metals and p orbitals of the surrounding ligands determine the final nature of the insulator to be of M-H or of CT type. *Kunes et al.*[94]and *Arumainayagamet al.*[89] reported NiO to be a CT insulator with band gap energy ~ 3.5 eV for U value fixed at 8 eV. *Canfield et al*. suggested the rare-earth perovskite compounds $PrNiO_3$ and $NdNiO_3$as CT insulators[95].

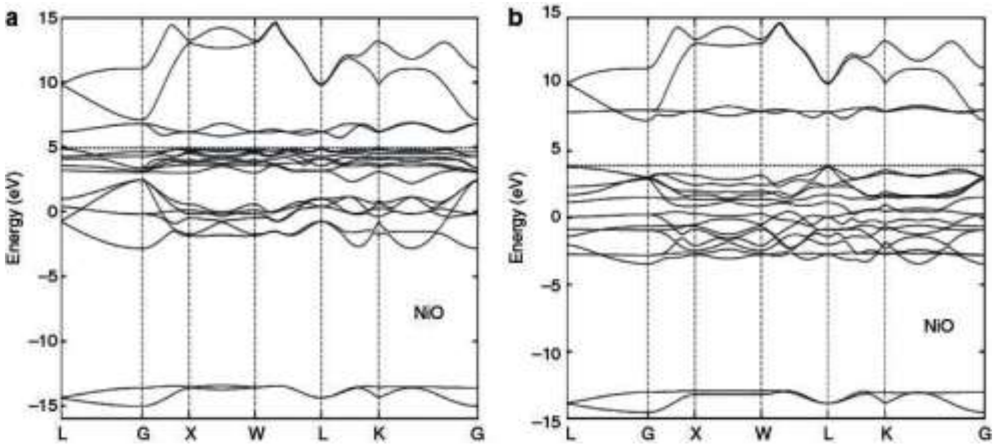

Figure 4.

Electronic band structure of NiO computed with (a) GGA and (b) GGA+U.

A recent study by our group focussing on the structural and electronic properties of Hg_2Cl_2 designates the compound as CT insulator albeit its energy dispositions in the orbital resolved density of states do not follow ZSA diagram. Our results suggest that the ZSA diagram which is so far considered to be the hallmark of CT insulators for TMCs is not necessary seen to be firmly obeyed in the case of CT insulators for post transition metals like Hg. Furthermore, as Hg atom in Hg_2Cl_2 has completely filled $5d^{10}$ orbital, this prevents the electrons to hop from any degenerate "d" orbitals to the other upon excitation, resulting in no energy cost +U (U_{dd}) associated with them ($d^n d^n \nrightarrow d^{n-1} d^{n+1}$). Therefore the on-site Coulomb interaction does not have any effect in the band structure of the compound[96].

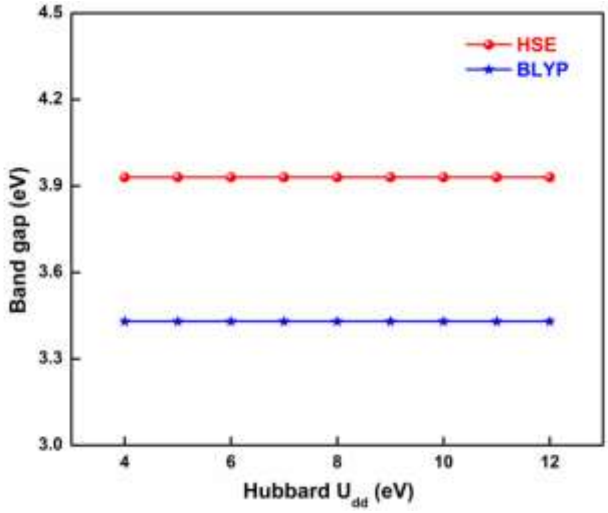

Figure 5.

Variation of band gap energy for Hg_2Cl_2 compound upon the inclusion of on-site Coulomb repulsion $+U_{dd}$. The band gap values have been estimated from the GGA - HSE (red trace) and GGA - BLYP (blue trace) calculations. Copyright © 2021, Elsevier B.V.[96].

3. Recent advancement of electronic structure calculation methods for strongly correlated systems

Only few models can accurately describe the correct physics in SCSs. Hubbard model based on the LDA+U and/ or GGA+U approximations in DFT, as discussed in detail under Section 2.1 is exceedingly successful in exploring the physical properties of SCSs for many TMCs and HFNs systems. Recently non perturbative semi-analytical two-particle-self-consistent (TPSC) approximation has proved to be successful in solving the established Hubbard model in finer details[97-99]. Of late cluster perturbation theory (CPT) as proposed by *Gros et al.*[100]and *Senechal et al.*[100], is seen to reproduce the optoelectronic and magnetic properties of correlated Fermi systems in close agreement with the experimental observations[100]. Recently, the dynamical mean-field theory (DMFT) and cluster or cellular DMF Tare also proved to be successful in understanding the strongly correlated electronic systems. Detail discussions on the DMFT approach are beyond the scope of this review and interested readers are suggested to go through the excellent reviews reported elsewhere [15,29,101-112].

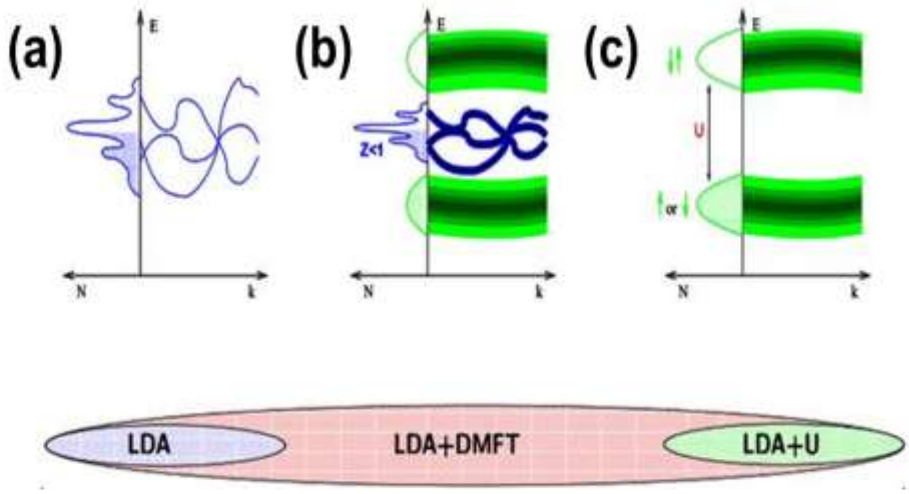

Figure 6.

Diagrammatic representations of **(a)**LDA where the on-site Coulomb interaction is weakcompared to theLDA bandwidth, **(b)**LDA+DMFT which the intermediate regime where Hubbard bands formed for the weaklycorrelated LDA metal in form of aquasiparticle peakand **(c)**LDA+U where the U becomeslarge, theLDA band splitsinto two Hubbardsubbands. Copyright © 2006, Taylor & Francis[15].

4. Conclusions

This review is primarily focused to explore the basic physics of the strongly correlated systems from theoretical perspectives. Staring from the fundamental and widely recognized mean field approximation in many-body theory, the many-body theory for the strongly correlated systems has been discussed. In this connection a brief overview of the

Hartree, Hartree-Fock and DFT methods on the many-body systems has been highlighted. Recent advancements in the electronic structure calculation methods for strongly correlated systems have also been enlightened.

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Declaration of conflicts of interest

There are no conflicts of interest to declare.

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