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SATYENDRA NATH BOSE NATIONAL CENTRE FOR BASIC SCIENCES

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Block JD, Sector III, Salt Lake
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CALCUTTA

ANNUAL REPORT

April 1, 1996 to March 31, 1997

TABLE OF CONTENTS

OBJECTIVES

The S. N. Bose National Centre for Basic Sciences was established in June 1986 as a registered society functioning under the umbrella of the Department of Science & Technology, Government of India. Its objectives are :

to foster, encourage and promote the growth of advanced studies in selected branches of basic sciences;

to conduct original research in theoretical and mathemetical sciences and other basic sciences in frontier areas, including challenging theoretical studies of future applications;

to provide a forum for personal contacts and intellectual interaction among scientists within the country and also between them and scientists abroad;

to train young scientists for research in basic sciences.

CONFERENCES/WORKSHOPS/SYMPOSIA

1. Workshop of Electronic Structure of Alloys and Phase Stability at SNBNCBS, Calcutta (April 23-26, 1996)

A Workshop on Electronic Structure of Alloys and Phase Stability was conducted at the Centre. There were 28 Participants of whom 2 came from Bangladesh and 8 from outside Calcutta. The main emphasis of the workshop was a meeting point between experimentalists and theoreticians. Experiments on magnetic alloys and surfaces were discussed. Theoretical topics included electronic structure of nanoclusters, complex bands in random alloys and surface magnetism. The meeting concluded with collaborative plans between theoreticians and experimentalists from IIT Kanpur, BARC Mumbai, University of Poona, SINP and SNBNCBS, Calcutta.

2. Discussion Meeting on Condensed Matter Days 1996 at Agartala, Tripura (August 29-31, 1996)

The Centre collaborated with the Tripura University to organize Condensed Matter Days 1996 at Agartala. The inauguration function was presided over by Prof. Y. D. Pande, Vice-Chancellor, Tripura University. Hon'ble Minister of Science, Technology and Environment was the Guest of Honour. There were 60 participants in the technical programme. The sessions were on Complex Systems, Different Experimental Techniques, Disordered Systems, Low Dimensional Systems, Material Studies, Correlated Systems and others like VLF Propagation and Atmospherics. The Keynote address was given by Prof. A. Mookerjee, SNBNCBS, Calcutta and the welcome address by Dr. K. Bhowmik, Tripura University.

3. Workshop on Fortran 90 and its Applications to Physics and Chemistry at SNBNCBS, Calcutta (October 28- November 9, 1996)

The workshop Fortran 90 was conducted at the Centre. There were 34 participants from Bihar and West Bengal. The participants were exposed to the Programming Language Fortran 90 and there were facilities to test their programmes with a Fortran 90 Compiler. The application part included Eigenvalue Problems, Linear Algebra, Monte-Carlo Technique, Genetic Algorithm and their applications in solving some of the interesting problems of Physics and Chemistry. The workshop was inaugurated by Professor Mohit Kumar Roy of Jadavpur University. The Valedictory address was delivered by Sri Soumendra Nath Brahamachari. The function was presided over by Professor Satindranath Chakravarti.

4. Novel Liquid Crystals with Special Reference to Transition Metal Discotics and Smectics at SNBNCBS, Calcutta (January 8-10, 1997)

The discussion group meeting at the Centre dealt with theoretical, experimental, biological and technological aspects of liquid crystals. There were 42 participants. Speakers were from RRI (Bangalore), IIT (Madras), NBU (Siliguri), College de France (Paris), Thapar Institute of Engg. & Tech. (Oatuaka), SINP, Bose Institute, IACS, CU, JU and SNBNCBS. Monisha Bose was the convener.

5. Second Meeting on Current Trends in Optics at SNBNCBS, Calcutta (January 14-17, 1997)

The discussion meeting at the Centre on Laser Physics, Optical Scattering, Quantum Optics and Non-linear optics. There were 45 participants. Speakers were S. V. Lawande (BARC, Mumbai), R. K. Thareja (IIT Kanpur), K. P. J. Reddy (IISc., Bangalore), H. S. Shah (Ahmedabad), P. C. S. Devara (Indian Institute of Meteorology, Pune), G. Bhar (Burdwan University) and T. N. Mishra (IACS, Calcutta). S. Ghosal, A.S. Majumdar and C. Das (SNBNCBS) attended the meeting. S. K. Sharma and N. Nayak, SNBNCBS were the conveners.

6. Group Monitoring Workshop for Condensed Matter Physics and Materials Science Projects at SNBNCBS, Calcutta (February 17-19, 1997)

Principal investigators in projects on Condensed Matter Physics under the Department of Science & Technology, Government of India attended this workshop to present the progress in research under the projects. There were 29 participants. The team of experts included Professor D. Chakravorty and Professor T. N. Mishra, IACS, Calcutta, Professor T. S. Radhakrishnan IGCAR, Kalpakkam, Tamil Nadu, Professor R. Ranganathan, SINP, Calcutta, Professor E. V. Sampathkumaran, TIFR, Mumbai and Professor C. K. Majumdar (Chairman), SNBNCBS, Calcutta. Dr. Praveer Asthana, DST, New Delhi coordinated the meeting.

7. Frontiers in Materials Modelling and Design at Indira Gandhi Centre for Atomic Research, Kalpakkam, Tamil Nadu (August 20-23, 1996)

The Centre also supported partially the Conference on Frontiers in Materials Modelling and Design. Prof. A. Mookerjee of the centre gave a talk in the Conference.

8. Workshop on Upgrading the PG Physics Laboratory at Inter University Consortium for DAE Facilities Calcutta Centre (September 22 - October 5, 1996)

The Centre supported the two week workshop on upgrading the PG Physics Laboratory conducted by Prof. B. Saraf at the IUC for DAE Facilities, Calcutta Centre, organized by the Indian Association for Physics Teachers, Regional Council -10 (West Bengal, Orissa, Sikkim and Andaman & Nicobar Islands)

Professor S F Edwards, Cambridge, on the occasion of the eighth S N Bose Memorial Lecture

Professor Dr G Frhr. zu Putlitz, Heidelberg, delivering the first Bose-Einstein Lecture at the Meghnad Saha Auditorium.

The participants (about 10) actually conducted laboratory experiments on the Nuclear Physics equipment manufactured by Prof. Saraf's team under a UGC Programme. It is hoped that some of the equipment will be built in Regional Council 10 and used in the PG Laboratories.

9. Fourth National Seminar on Physics and Technology of Particle Accelerator and their Applications (PATPAA-96) at Science City Campus, Calcutta (November 26-29, 1996)

The Centre collaborated with Inter University Consortium for DAE facilities, Calcutta Centre in running the above seminar.

10. Eastern Centre for Research in Astrophysics (ECRA) Winter School at Calcutta University (January 13-18 , 1997)

The Centre collaborated with Eastern Centre for Research in Astrophysics, Calcutta, in running the above School on Basic Astrophysics at the Institute of Radiophysics & Electronics, Calcutta University. There were 36 scholars from IIA (Bangalore), Delhi University, Tripura University, Cotton College (Guwahati), Sky Watchers Association, CU, SINP, Calcutta and Kalyani University. Speakers were M. R. Kundu (Maryland, USA), A. K. Sen (CU) and S. K. Chakrabarti (SNBNCBS)

11. International Symposium on Novel materials (March 3-7, 1997) at Puri

This symposium organised under Indo-US Science and Technology Collaboration Programme was hosted by IOP, Bhubaneshwar. SNBNCBS was an important co-sponsor. It had 87 participants — 37 from USA, Germany, Sweden, Japan, France, Brazil, Finland, Switzerland and Australia and 50 from all over India. The topics covered were clusters and cluster reactions, surface and multilayers, magnetism, electronic structure and transport, nanostructure and devices and simulations. A. Mookerjee, R. P. Dutta, G. Pari, P. P. Biswas, N. Das, S. Ghosh, B. Sanyal & C. Basu Choudhury from the Centre participated in the meeting.

S. N . BOSE MEMORIAL LECTURE

The eighth S. N. Bose memorial Lecture was delivered by Professor Sir S. F. Edwards, former Cavendish Professor, Cambridge University, England on September 6, 1996 in the auditorium of the Centre's new campus. The title was : "Soft Materials : A New Physics".

The ninth S. N. Bose Memorial Lecture was delivered by Professor Kazuo Fujikawa, University of Tokyo, Japan on December 3, 1996, in the auditorium of the Centre. The title was "Phase Operator for the Photon and Quantum Anomaly".

SEMINARS ORGANISED AT THE CENTRE

1. Das, M. P., Australian National University, Canberra : Bose-Einstein condensation (January, 1996)
2. Ray, S., SINP, Calcutta : A Bethe Ansatz study of Fateev Zamolodchikov model (Z_N Spin Model) (June 24, 1996)
3. Dey, S. K., Eastern Illinois University, Charleston, USA : (i) Invention of zero (July 2, 1996); (ii) Solution of nonlinear partial differential equations by perturbed functional iteration (July 25, 1996)
4. Gangopadhay, G., SNBNCBS, Calcutta : Quantum theory of damping for model linear and nonlinear quantum optical systems (July 9, 1996)
5. Ghosh, P. N., University of Calcutta : Diode laser spectroscopic studies of the lineshape (July 16, 1996)
6. Guha, P., Max Planck Institute, Germany : Complex cobordism, Ashtekar's equations and holomorphic poisson geometry (July 30 1996).
7. Banerjee, H., SNBNCBS, Calcutta : Resolution of Strong CP and U(1) problems (August 13 & 20, 1996)
8. Bajaj, K., University of California, Santa Barbara : Pattern formation in nonequilibrium systems (August 26, 1996)
9. Bandyopadhyay, A., Indian Institute of technology, Kanpur : Coherent and squeezed angular momentum states : Applications in quantum optics (September 10, 1996)
10. Rai Choudhuri, A., Department of Physics, IISc., Bangalore : The origin of sunspots (September 30, 1996)
11. Dasgupta, P., Department of Physics, University of Delhi : Can one gauge electro-magnetic duality symmetry ? (October 14, 1996)
12. Fujikawa, K., University of Tokyo, Japan : (i) A Schwinger term in q-deformed SU(2) algebra (December 4, 1996); (ii) BRST invariant formulation of a theory with Gribov type copies (December 6, 1996)
13. Dattagupta, S., JNU, New Delhi : Quantum Glasses (December 6, 1996)
14. Bandyopadhay, P., ISI, Calcutta : Geometrical & topological aspects of quantization [Professor Abdus Salam Memorial Lecture] (December 23, 1996)
15. Chakrabarti, S. K., SNBNCBS, Calcutta : An intensive course on Black Hole Astrophysics (a series of lectures) (January 18-24, 1997)
16. Malik, R. P., Bogoliubov Laboratory of Theoretical Physics, JINR, Dubna,

Moscow, Russia : Nonlinear realization method and integrability (February 25, 1997)

VISITORS AT THE CENTRE

1. Dr. M. P. Das, Australian National University, Canberra : visited the Centre (January 1996)
2. Professor S. K. Dey, Eastern Illinois University, Charleston, USA : visited the Centre (July, 1996)
3. Dr. P. Guha, Max Planck Institute, Germany : visited the Centre (July 30, 1996)
4. Dr. K. Bajaj, University of California, Santa Barbara, USA : visited the Centre (August 26, 1996)
5. Professor Sir S. F. Edwards, formerly Cavendish Professor, Cambridge University, UK : visited the Centre (September 4-7, 1996)
6. Dr. A. Bandyopahyay, IIT Kanpur : visited the Centre (September 10, 1996)
7. Dr. A. Rai Choudhuri, IISc., Bangalore : visited the Centre (September 30, 1996)
8. Dr. P. Dasgupta, Department of Physics, Delhi University : visited the Centre (October 14, 1996)
9. Dr. Stephan F. von Welck, Science Councellor, German Embassy, New Delhi : visited the Centre (November 29, 1996)
10. Professor K. Fujikawa, University of Tokyo, Japan : visited the Centre (December 4-6, 1996)
11. Professsor S. Dattagupta, School of Physical Sciences, JNU, New Delhi : visited the Centre (December 6, 1996)
12. Professor D. J. Saikia, NCRA, Pune : visited the Centre (Janauary 16-18, 1997)
13. Professsor Dr. G. Frhr. zu Putlitz, Director, Insitute of Physics, University of Heidelberg and Scientific Member, Max-Planck Institute for Nuclear Physics, Heidelberg, Germany : visited the Centre (February 14, 1997)
14. Dr. R. P. Malik, Bogoliubov Laboratory of Theoretical Physics, JINR, Dubna, Moscow, Russia : visited the Centre (February 25, 1997)
15. Professor M. H. Loretto, Director, Interdisciplinary Research Centre in Advanced Materials, University of Birmingham, UK : visited the Centre (March 21, 1997)

RESEARCH ACTIVITIES AT THE CENTRE

The Centre has active groups in Physics, Mathematics, Applied Mathematics and Theoretical Chemistry.

A. Physics

Together with E. C. Marino (UFRJ), R. Banerjee did an explicit bosonisation of the massive Thirring model in 3 + 1 dims for small coupling constant but arbitrary mass. The bosonised action is obtained both in terms of a Ka lb - Ramond tensor field as well as in terms of a dual vector field. An exact bosonisation formula for the current is derived. The exact bosonisation of the free fermion with arbitrary mass is obtained.

Exploiting the bosonisation formulae derived by R. Banerjee, in earlier work for QED in 2 + 1 dims, the quark-antiquark potential in this theory has been computed (with E. Abdalja, Sao Pauolo). Contrary to classical expectations, the potential vanishes asymptopically thereby signalling the phenomenon of screening. Interestingly, the classical potential is reproduced for small separation between the quarks.

The equivalence between the Maxwell-Chern-Simons (MCS) and Self-dual (SD) model was recognised by R. Banerjee with H. J. Rothe and K. D. Rothe (Heidelberg) within a more general Hamiltonian framework. It was shown how a specific combination of fields in this framework for diffferent gauge fixings, characterises either the potential in the MCS theory or the basic field in the SD model.

A gauge invariant formulation of the massive Yang-Mills theory has been analysed by R. Banerjee (with J. Barcelos -Neto, UFRJ) by providing an algorithm for extending the phase space within the Batalin-Fradkin-Tyutin formalism. It was shown that the extra fields introduced were identifiable with the scalars used in the generalised Stuckelberg approach of converting a second class system into its first class form. A method, based on phase space extension, has been discussed whereby reducible constraints can properly handled without the necessity, as in the Dirac method of isolating the independent subset of constraints or, as in the BRST method, of introducing a tower of ghosts-for-ghosts.

A gauge independent Lagrangian method of reducing the degrees of freedom in constrained systems has been developed without any explicit gauge fixing. The viability of a gauge fixed reduction is then determined through canonical transformations connecting it with the gaugeless reduction. This method was used to analyse a recent soluable quantum mechanical model, proposed by T. D. Lee and collaborators, which exhibits a Gribov-like ambiguity. The Gribov phenomenon is manifested by a nonuniqueness in the aforementioned cannonical transformations. It was also found that all Gribov

Professor B B Biswas, one of the Founding Members, giving a talk during the celebration of the first decade of the Centre (13. 6. 1997)

Attendees to the Group Meeting on 'Liquid Crystals'

copies must be treated equivalently. This agrees with the results derived by the above authors thereby leading to proposal, different to the original one by Gribov, on the handling of the gauge-equivalent copies.

Althogh many aspects of the standard model of electroweak interactions have been experimentally verified, the symmetry-breaking sector is still mostly unexplored. So far experiments have not turned up an elementary scalar in any system of ineracting particles, neither is there any positive evidence of a Higgs particle, either elementary or composite, at currently available energies. We should consider alternative descriptions of the symmetry-breaking sector of the electroweak theory and prepare for the situation that no Higgs particle is ever found. A. Lahiri showed sometime ago that the non-abelian dynamical two form (antisymmetrical tensor gauge field) can be used to generate vector boson masses if the two-form is coupled to the gauge field via a topological coupling term. In general, Higgs free theories of massive vector bosons suffers from problems of non-unitarity. However, Lahiri has proven that BRST invariance of the quantum effective lagrangian of this theory, thus proving the unitarity of the model and the feasability of replacing the Higgs sector of the electroweak theory by this model.

The abelian version of this theory is known to be dual to the Goldstone model. There are several no-go theorems which claim that the non-abelian two-form cannot be dual to non-linear sigma model. However, Lahiri has shown that by using two gauge fields it is possible to circumvent the no-go theorems. He has given an explicit construction of the duality relation between the dynamical non-alebian two-form and the non-abelian sigma model.

Hierarchies of nonlinear models S^3 and CP^1 associated to the line elements on SU(2) group and its coset CP^1 S^2 were considered by B. Chakraborty. Hamiltonian analysis of these models reveals that the symplectic structure of the CP^1 model is inherited from the global SU(2) invariant S^3 model, except the appearance of an additional first class constraint generating the U(1) gauge transformation. Subsequently the Hopf term was added to find that even in this case the symplectic structure does not undergo any change. However, the model does not reveal any fractional spin at the classical level. Quanization and its implication are currently under investigatiion by B. Chakraborty with A. S. Majumdar.

Nonrelativistic non linear sigma model coupled to the Hopf term was analysed in the Hamiltonian framework by B. Chakraborty and T. R. Govindrajan. The Hopf term was found to alter dramatically the Hamiltonian analysis, so much so that even the spin algebra is modified giving a new structure and interpretation to the system.

It is shown by S. Ghosh that under certain restrictions, a point charge interacting with a Nielsen-Olesen vortex of abelian Higgs model in 2 + 1

dimensions can have stable classical orbits. Quantum mechanical metastable states are allowed. Self adjoint extensions in some cases can give rise to negative energy bound states.

D. Gangopadhyay and P. Dey (CSIR, SRF) have developed a scheme whereby the analogue of the Isgur-Wise function for two heavy quarks can be written in terms of the Isgur-Wise functions corresponding to the single quarks. The method allows order by order corrections to be determined. Further calculations are in progress.

D. Gangopadhyay and R. Bhattacharya (UGC, JRF) have begun a study of monopole solutions. There exist solutions of Yang-Mills theory which describe objects that are not exactly point like. They may be extended in space and carry magnetic charge (monopoles) or they may be extended in time (i.e. exist only for some finite temporal interval viz. instantons). Existence of such solutions provides a rich structure to quantum field theories and also helps in understanding many topological features of manifolds. In recent years interesting multi-monopole solutions (4 monopole, 5 monopole, 7 monopole etc.) have been obtained. Moreover it now appears that the existence of monopoles is intimately related to the phenomenon of duality which is gradually emerging as some sort of fundamental physical priciple. The aim is to investigate whether multi-monopole solutions are interrelated in any way and construct effective field theories of monopoles exhibiting duality.

Lineshape theory for a multi-level system has been developed by S. Ghoshal Bhattacharya. Analysis of a four-level system has revealed new effects of multiple coupling on the absorptive and dispersive lineshapes.

R. Chaudhury in collaboration with B. K. Chakraverty (LEPES, CNRS, Grenoble, France) has derived an equation for T*, the real space local pairing instability temperature, analytically starting from negative-U Hubbard Model in 2-dimension. Further numerical investigation shows that T* ($U = U_{minimum}$) exists only for $m^* > m^*_{thres}$, m^* being the effective mass of a single fermion and $U_{minimum}$ being the minimum value of U to form a local pair. Morover for $m^* > m^*_{Thres}$, T* ($U = U_{minimum}$) decreases as m^* increases. These theoretical results are consistent with the experimentally observed pseudogap in Angle Resolved Photoemission Spectroscopy (ARPES) and other experiments performed on underdoped composition of the high-T copper oxides, seen below a certain temperature.

R. Chaudhury and D. Gangopadhyay have further analysed the possible application of Van-der-Waerden's Colouring Theorem to a termary alloy. Their new result is that in 1-dimension, the mapping to a mono-colour configuration is possible only for lattice spacings 'a' satisfying the equation $a^2 = 3 + 2 / n$ where n is any integer.

R. Chaudhary and D. Gangopadhyay have also started the investigation

of Quantum Hall Effect. As a preliminary calculation they have established the equivalence between the path integral version of the Replica Trick (as advocated by I Affleck, A. M. M. Prueisken and others) and the more conventional diagrammatic approach to disordered systems (for example B. L. Altshuler) in the absence of magnetic field. They have also derived the correct form of fermion propagator in 2D, to be used in this calculation.

S. K. Chakrabarti has been trying to solve the most general set of equations which govern viscous transonic accretion flows in the presence of a black hole geometry. He has found the complete set of topologies of the solutions and that shocks might form in a large region of parameter space. He can then find the spectra emitted from these solutions and compare them with observations.

C. Das studied vortex dynamics and turbulene. Three problems have been considered (i) dynamics of plasma containing a population of negatively charged heavy vortex elements is studied; plasma becomes birefringent to a low frquency circularly polarised wave of infinitesimally small amplitude (accepted for Phys. of Plasmas) : (ii) the evolution of a layer of electron vortices produced by the interaction of an intense laser pulse and plasma; Kelvin Helmohltz type instability sets in and a cut off is observed at high wave number; and (iii) simulation of apontaneous generation of defects in a two dimensional vorticity field in a square cavity using a multilevel vortex method; initially small local disturbances appear leading eventually to a complex state involving a variety of scales and patterns in both space and time.

Lie algebraic structure for a doubly periodic flow of 2-dimensional ideal fluid in a square domain has been studied by S. K. Paul and S. K. Venkatesan. It is shown that the area preserving diffeomorphism (Kelvin-Helmhotz Theorem) algebra can exhibit breakdown of integrability due to appearance of localized disturbances (defects) leading to 2-dimensional turbulence.

Work by N. Nayak in non linear optics can be broadly divided under the following headlines :

(i) Cavity-QED of a Raman interaction :

Consider a single Rydberg atom having two degenerate levels interacting with the radiation field in a single mode ideal cavity. The transition between the two levels is carried out by a degenerate two photon process. At the start of the interaction the atom is considered to be in a coherent state. The dynamical properties of the atom as well as the field are studied. Analysis of their entropies shows that the two systems are disentangled periodically in some cases.

(ii) Study of micromaser : (continuation of earlier work)

The micromaser action involves pumping of two level Rydberg atoms in

their upper states or in a polarised state into a very high-Q superconductivity cavity at sub-Kelvin temperatures at such a rate that almost one atom is present at any time in the cavity. In addition the flight time through the cavity is the same for every cavity. The analysis takes into account the effect of the duration when the cavity contains no atoms.

(a) Squeezing in micromaser cavity field :

When the fluctuation in one quadrature falls below that for a coherent state field at the expense of the other quadrature, the field is said to be squeezed. The product of these two fluctuations obeys the uncertainity relation. It is shown that the micromaser cavity field can be squeezed if polarized atoms are pumped into the cavity. Also, for a certain interaction time, the squeezed field in a cavity with the parameteres same as in the present experimental setup is almost in a trapped vacuum state.

(b) Simulation of micromaser dynamics :

The above analysis is based on the steady state results of a coarse-grained equation of motion. Parallelly, we have developed an exact method for the simulation of the dynamics for any statistical input of atoms either in upper or lower state. For micromaser dynamics involving atoms in upper state, the case of Poissonian pump mechanism has been completed. The case of regularly injected atoms is now studied with the DEC Alpha computer at the Centre.

An earlier Monte-Carlo simulation by J. Saha of a cholestric configuration of chiral molecules has been generalised allowing for full rotational degrees of freedom. The effect of temperature on pitch has been studied and the results are compared with the results obtained from mean field and plane rotator model studies. She has developed a site-site potential which can be used to stimulate a system consisting of cylindrically symmetric plannar disc-like liquid crystal molecules. To mimic this site-site potential a single site potential has also been developed for a spherical molecules whose potential can be used to study phases and phase transitions of disc-like molecules more reaalistically than the existing single-sit potentials in a compulationally efficient way.

Recently P. Thakur has been investigating electron localisation aspects in quasi-one-dimensional random n-mer models of coupled chains. It has been found that the different resonance regions corresponding to the single chain containing n-mer impurities will merge together when finite interchain coupling is introduced in the chains. Such quasi-one-dimensional systems will exhibit metallic behaviour for a wide energy region. T. Mitra and P. thakur have made some numerical studies on the characterisation of different resonances present in a random dimer chain. The possiblity of such resonances with non-zero measure has been explored within the multifractal scaling analysis.

A. Mehta has continued to be active in the area of granular media, but has also begun to be involved in the study of more general surfaces and interfaces. In summer 1996 she supervised the summer project of A. Majumdar from IIT Kanpur on scaling properties of deposited surfaces. A. Mehta, A. Majumdar, P. Biswas and J. K. Bhattacharjee (ICAS, Calcutta) are exploring the role of full structure factor S(k,w) in the multiple length scales in noisy nonlinear continuum equations. A. Mehta, A. Mookerjee and B. Sanyal are investigating magnetism at rough surfaces. She is working with R. Roy (ISI, New Delhi) on the nature of filamentary and pointlike voids in continuum percolation. Another project involves the exploration of a voter-like model and its application to economic systems in collaboration with K. Chatterjee (Penn State University, USA) and J. M. Luck (CEA Saclay). She is working with P. Sen and J. K. Bhattacharjee on anomalous scaling of the product correlation function in disordered systems. Her collaboration with N. Gupte (IIT MAdras) include one on the dynamical behaviour of the completely inelastic bouncing ball in the presence of random initial velocities and another on the crossover scaling in multifractal spectra in systems with multiple length scales.

Lastly she has a collaboration with G. Barker (Institute of Food Research, Nowrich) on the scaling of widths in cellular automata with complex dynamics. Her work has received citations in review articles on granular systems.

A. Mookerjee directed the workshop on "LDA and beyond" at ICTP, Trieste, Italy in June 1996.

Moessbauer studies with Fe-57 have been carried out on nanocrystalline magnetite by C. K. Majumdar in collaboration with IUC-DAEF, Calcutta.

B. Mathematics

Earlier P. Guha showed that a group much larger than SL(2,Z) (Mukai result) acts on the derived category of the sheaves on abelian variety and conjectured that this group acts projectively. At this moment S. Donaldson and P. Guha want to prove this result. Also they are interested to apply this result in mirror symmetry.

The effective action of the Seiberg-Witten theory is deeply connected to certain kind of integrable systems (Whithan system). These are the deformations of the original equations. The geometry here is very intriguing. The preliminary result shows how the function of the original equation is connected to the derivatives of prepotential with respect to "SW time" and "Whitham time".

Guha has proposed some examples of volume preserving diffeomorphic equation connected to Nambu-Poission geometry, and has given their twistor construction of tower of Nambu-Poission mechanics and its application to topological field theory.

C. Applied mathematics

S. K. Bose worked on general multidimensional nonlinear descrete systems where the nonlinearity is defined by arbitrary polynomials. It has been shown that when such a system shows chaotic oscillations, a highly oscillatory "Principal Oscillatory Part" can be extracted together with a monotonic convergent part. Under his supervision, G. C. Gorain, supported by CSIR, continued to work on the linear theory of "Vibration Control of Continuous Systems". He worked on the computational aspects of the exact controlabiltity theory developed by him for the vibrations of an elastic panel hoisted from one end and free at the other.

D. Mathematical Modelling

S. K. Sharma's studies towards examining the role of various soft particle approximation continued. He studied the near forward light scattering by an infinitely long homogeneous right circular cylinder in the anamalous diffraction approximation. The scattering function was shown to be expressible in terms of known functions by means of a series expansion. Simple formulae have been obtained for specific cases of (i) near forward scattering and (ii) a large diameter cylinder. The validity of these formulae was examined numerically. The corresponding large sphere formula was also examined to check that the analysis had indeed a general and broader coverage.

Light scattering work relating to interstellar dust paticles has been started. The accuracy of various phase functions employed in the solution of the radioactive transfer equation is being examined. A couple of phase functions have been constructed and are being validated against Mie results. Preliminary results from these phase functions are very encouraging.

During her stay at the Technical University of Denmark, S. Banerjee collaborated with V. A. Barker on "Network modelling of two phase flow in a porous medium". It stimulates the secondary oil production by waterflooding from tight chalk layers of high porosity. The main task is the evaluation of pressure in pore bodies at each time step. Cut-off conditions imposed at the interface of two fluids induces nonlinearity in the pressure equations. The system has been approached by solving either a sequence of linear systems at each time step or a single nonlinear system, adjusting conductivities according to cut-off condition at each step of a single interative process. Parallel algorithms were developed, on a transputer network with ternary tree structure, to determine eigenvalues of a tridiagonal matrix using spectrum slicing technique, and the expected speed up was noticed.

E. Theoretical Chemistry

G. Gangopadhyay have treated system-heat bath interactions to study the reduced system in various spectroscopic contexts. With S. H. Lin (Taiwan)

he has studied the effect of pure dephasing on the joint-atom-field interacting system, for example, Jaynes-Cummings Model (JCM) and in this context they have proposed some further generalization of JCM. When the reservoir is composed of finite bandwidth of vacuum modes at finite temperature, resonance fluorescence and probe absorption spectra are studied to understand the effect of finite bandwidth of the reservoir at finite temperatures. This work is done with S. Ghoshal Bhattacharya at this centre.

In an another context spectroscopic aspects of model atomic or molecular multistate system is studied when the material system is coupled to a non-equilibrium bath and then the whole system nonequilibrium bath is immersed in an equilibrium bath at finite temperature. This work is done with Dr. D. S. Ray, J. P. Ray Chaudhury and B. Deb at IACS, Calcutta.

RESEARCH PROJECTS

1. Theoretical High Energy Physics

This research project with Professor H. Banerjee is sponsored by INSA. Lattice formulation provides a framework for quantum field theory where one can in principle address questions which are non-perturbative. In practical applications, however, a serious impediment is the problem of fermion doubling. A no-go theorem states that the unwanted doublers can be evaded, but only at the price of some basic desirable properties of lattice fermion action. A variety of models in the literature get rid of doublers by abandoning one or more basic properties; the most popular among these, the Wilson model, abandons chiral symmetry and is thus unsuitable for the Standard model. Prof. Banerjee has proposed a model for lattice fermions which is (i) free from doublers, (ii) hermitian and (iii) chirally invariant. The loss of chiral symmetry in the lattice action for the Wilson fermion is traded here for the loss of hypercubic and reflection symmetries. The model is not only free from doublers, but reproduces the correct Ward identities, and most importantly the ARJ anomaly in the U(1) axial vector current. Wheras chiral symmetry is explicitly broken by the Wilson term, the irrelevant term in the proposed model is chirally invariant. This makes the latter a viable candidate for chiral gauge theories.

Publications : (i) Banerjee, H. : Resolution of the strong CP and U(1) problems - Ind. J. Phys., 1997, 71 (Spl.), 333-341; (ii) Banerjee, H. and De, A. K. : Lattice fermions and chiral symmetry - Nucl. Phys. B, 1997, (suppt.) 53, 641.

2. Nuclear Fission and Nuclear Structure Calculations

This Emeritus Scientist's project sponsored by CSIR is operated by Prof. M. K. Pal. The totally antisymmetrised theory of drip-line neutron-halo nuclei, reported earlier, has been further extended to study all its consequences and

corrections that are to be applied to the lowest-order three-body treatment. A collaboration is being developed with Prof. S. Mukherjee of BHU for completing the detailed numerical computations. Two monographs are under preparation on : (i) Selected topics in nuclear structure and (2) Nuclear reactions.

3. Collaborative Programme with Warwick University

R. P. Datta has, in quantum mechanical calculations on small metal and oxide clusters, continued to look at the geometric and electronic properties of small copper clusters using a 'hybrid' approach. The lowest energy geometries of the clusters of sizes 10-20 were determined via simulated annealing. The semi-empirical Equivalent Crystal Theory (ECT) is used to compute the total energy of the clusters in their optimum geometries using the newly developed molecular full-potential linearized muffin-tin orbital (FPLMTO) two centre fit (TCF) method of Methfessel and Van Schilgaarde. The total energies of the clusters were recomputed in the same structure using the TCF technique. The optimum structures of the clusters in the range are found to be derived from icosahedral structures. The 13-atom cluster is an icosahedron and the 19-atom one a double icosahedron. The other sizes show structures related to these. The 10 and 11 atom clusters, however, show somewhat different stuctures. The variation in the binding energies as obtained from ECT, with cluster size, is compared with those where the total energies were calculated using TCF. Variation of HOMO-LUMO gap with cluster size, and the pseudo-density of states for select cluster sizes have also been studied.

We are currently using the FPLMTO-TCF method combined with the Harris-functional technique to carry out an ab initio molecular dynamics study of copper clusters ranging in size between 2 and 9.

4. Activities at VECC and SNBNCBS on High T_c Superconductivity and Extension to Low Temperature Superconductors

The project SBR-39 was sponsored by National Superconductivity Programme (NSP), Phase I, as a collaborative project between the Centre and the Variable Energy Cyclotron Centre (VECC), and was completed in June, 1996. The project Coordinator was Dr. C. K. Majumdar. There were fifteen publications –- nine in international journals, four in Indian journals, one in a book published abroad and one in the proceedings of an international conference abroad. Out of seventeen presentations in meetings and conferences three were done abroad. The most interesting results were : increase in T_c due to alpha particle bombardment in $Bi_2Sr_2CaCu_2O_x$ (T_c = 65K) superconductor and its explanation; decrease in Tc due to alpha irradiation of single crystals of Bi 2212 (T_c = 80K) and estimate of interlayer coupling in unirradiated and irradiated crystals; study of texturing of polycrystalline samples under pressure.

5. Structure-Property Correlation in the Phase Transitions of Metallomesogens (liquid crystals)

The work in this project is done by Prof. M. Bose and Dr. C. K. Majumdar. Detailed X-ray and EPR studies of columnar C_nCu and lamellar C_nOCu, (n = 6-12), indicate that within each series, some members exhibit anomalous behaviour. Thus, in the former, even members (n = 6, 8, 10 and 12) show a single exchange-narrowed strong asymmetric g along with a weak g in pure solids, whereas odd members (n= 7 and 9) exhibit hyperfine quartets in g_{11}, indicating weak or no exchange. C_9Cu is unique with three different mesophases and is the only member C_nCu series to show a non-axial symmetry from EPR. Crystal structure indicates that C_7Cu behaves as a weak dimer in the solid, but breaks up in the mesophase (hyperfine quartet collapses to a single line). In non-axial C_nOCu, C_7OCu is similar to diameric C_8OCu viz., hyperfine structure with quartet and quadrupole forbidden transition after g_1, followed a broad g_2 and the weak g_3. Other members (n = 6, 10), possibly monomers, show the hyperfine quartet in g_1 followed by a wide g_2 and the weak g_3. Again $C_{12}OCu$ is anomalous as the quartet is after g_1, followed by g_2 and g_3, indicating that long chains may lead to a different packing mode as observed by others. The results are to appear in (i) Bose, M., Saha, J., Majumdar, C. K. and Sadashiva, B. K. : EPR spectra of alkoxy and mixed alkyl alkoxy substituted aryl diketonates of discotic copper complexes I : Computer analysis to identify the quadrupole forbidden transitions, Mol. Cryst. Liq. Crystals 1997, 37 (to be published) (ii) Bose, M., Majumdar, C. K. and Sadashiva, B. K. : EPR studies of alkyl substituted aryl diketonates of discotic copper complexes 2: Concentrated vs dilute systems, ibid.

6. Probing the Foundations of Quantum Theory

This is supported by DST, with Prof. P. Ghose, Dr. D. Home (BI) and Dr. A. Datta (JU) and Dr. A. S. Majumdar, Research Associate involved. Consequences of quantum nonlocality were examined in the context of two gedanken experiments involving quasiclassical gravity and cavity electrodynamics respectively. The CP-violation experiments in the K^0 - $\bar{K}^0$ were analyzed in depth to find that the Bohmian interpretation of quantum mechanics is necessary for the actual inference of CP-violation.

The symplectic structure of the CP^1 model was studied. No fractional spin is revealed at the classical level in the gauge independent analysis when the Hopf term is coupled. The general effects of gauging on symplectic structure were examined. It was observed that there are critical differences when the Chern-Simons term is coupled to the CP^1 model from the case involving the Hopf term.

7. Numerical Study of Transition and Noble Metal Disordered Alloys and Their Phase Diagrams

The project was sponsored by DST. Prof. A. Mookerjee was the principal investigator, Dr. G. P. Das (BARC) was the co-investigator and Biplab Sanyal was the Senior Research Fellow. Electronic structure calculations have been done in multicomponent alloys viz., binary and ternary alloys. Augmented space recursion (ASR) package has been developed for both real and bf k-space. The disordered alloy systems studied were CuPd, AuFe and CuNiZn. Stability of PdRh alloys has been studied by ASR coupled with orbital peeling method.

The following papers emerged out of these works :

(i) Sanyal, B., P., Dasgupta, I. and Mookerjee , A. : An Augmented space recursion technique for the calculation of electronic structure of random alloys— ICTP preprint

(ii) Saha-Dasgupta, T. and Mookerjee, A. : Phase stability of PdRh alloy - J. Phys. C. (accepted)

(iii) Sanyal, B. Biswas, P., Mookerjee, A., Salunke, H. G., Das, G. P. and Bhattacharya, A. K. : Investigation of the electronic structure of rough epitaxial overlayers of Fe on Ag substrates — J. Phys. C.

8. Network Program on Metals and Alloys (ICTP Project at Dhaka)

This program is funded by the ICTP, Trieste. Prof. Mesbahuddin Ahmed (Dhaka) is the pricipal investigator. Prof. A. Mookerjee, Prof. R. Prasad (IIT) and Dr. G. P. Das (BARC) are co-investigators. The methodology of k-space recursion in augmented space representation has been developed. The spectral densities, complex bands structures and fuzzi fermi surfaces have been studied for disordered AgPd and AuFe systems. The papers are :

(i) Biswas, P., Sanyal, B. Mookerjee, A. , Huda, A. , Halder, A., and Ahmed, M. : Augmented Space Recursion for spectral functions for disordered binary alloys : some comments — Int. J. Mod. Phys. B.

(ii) Biswas, P., Sanyal, B. Mookerjee, A. , Huda, A. , Chowdhury, N. Ahmed, M. and Halder, A. : A Study of spectral functions and complex band structures for the disordered binary alloys : AgPd and AuFe — Int. J. Mod. Phys., B.

Publications

A. Scientific Journals

1. Babu, D. S. S., Das, D., Sudarshan, M., Reddy, V. R., Chintalapudi, S. N. and Majumdar, C. K. : ^{57}Fe Moessbauer studies on natural ilmentes — *Ind. J. Pure & Appl. Phys.*, 1996, **34**, 474-479.
2. Bandyopadhyay, S. K., Sen, P., Barat, P., De, U., Mandal, K., Kar., S. K. and Majumdar, C. K. : Alpha irradiation of Bi-2212 Superconducter— *Physica C*, 1996, **267**, 303-307.
3. Banerjee, H. : Resolution of the strong CP and U(1) problems - *Ind. J. of Phys., 1997*, **71**, *(Spl.)*, 333-341.
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13. Bose, S. K. : Finite part representations of hyper singular integral equation of acoustic scattering and radiation by open smooth surfaces - *Proc. Ind. Acad. Sci. (Math-Sci.)*, 1996, **106**(3), 271-280.
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B. Proceedings of Conferences & Symposia

1. Banerjee, H. and De, A. : Lattice fermions and Chiral symmetry - *Nucl. Phys. B. (Proc. Suppl.)*, **53**, 1997, p. 641.
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4. Bose, M. : Role of valence fluctuation in the mixed conductors : $Li_{0.1}V_2O_5$, $YLi_xV_2O_5$, V_6O_{13} and $Li_{3.5}V_2O_5$ *Proc. 5th Asian Conf. on Solid State Ionics : New Developements*, Kandy, Sri Lanka, December 2-6, 1996, World Scientific Publishing Co., Singapore 1996, 305-310.
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14. Das, C : Theory of scattering of non-oscillating magnetic moment from Alfren waves in plasma, *Proceedings of the National Symposium on Plasma Science & Technology, Plasma 96*, October 28-31, 1996, Allied Publishers, 1997.
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21. Majumdar C. K. : Creativity in science in *Aesthetics and motivations in Arts and Science* (Ed. K. C. Gupta, published by Indira Gandhi National Centre for the Arts, New Delhi, New Age International (P) Ltd., New Delhi, 1996), Pp. 25-34.
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C. Miscellaneous

1. Majumdar, C. K. : *Iron in the soul review of Marie Curie : A Life by Susan Quinn* (Heineman) in the Statesman, Jan 5, 1996.
2. Majumdar, C. K. : *The wonder of the world* review of *Science and Wonders : Conversations about science and belief* by R. Stannard (Faher, 1996) in The Statesman, Nov. 15, 1996.
3. Majumdar, C. K. : Editorial, *Everyman's Science* - Vol. XXXI, No. 4, (October-November, 1996), p. 102.
4. Majumdar, C. K. : *From Astronomy to Aids* review of *The Cambridge Dictionary of Scientists by* David, Ian, John and Margaret Miller (Cambrige University Press 1996) in The Statesman, Jan. 3, 1997.
5. Majumdar, C. K. : Book review *Composite Materials* by J. P. Agarwal (DESIDOC, DRDO, Delhi, 1996), in *Everyman's Science* XXXI, No. 5 (December-January, 1996-97), p. 170
6. Majumdar, C. K. : *P. K. Bose of the Statistics Department* in *Science and Culture* 59, Nos. 11-12 (1993), 73-76 received only recently).
7. Mehta, A. : *A very reasonable physicist* - The Asian Age, 27 September, 1996.

D. Books, Proceedings

1. Proceedings of the National Seminar on Atmospheric and Oceanic Sciences in the University System : Perspectives and Strategies (Feb 3-4, 1996) by Dept. of Mathematics, Visva Bharati (Santiniketan).
2. Aesthetics and motivations in Arts and Science (Ed. K. C. Gupta, New Age International (P) Ltd., New Delhi 1996) (Proc. of a National Seminar in 1993 at Visva Bharati cosponsored for SNBNCBS.

E. Honours, Fellowships, Memberships

1. Dr. R. Chaudhary has been made a member of the New York Academy of Sciences.
2. Professor H. Banerjee has been elected a Fellow of National Academy of Sciences (Allahabad).
3. Professor C. K. Majumdar was awarded the S. N. Bose Birth Centenary Medal by the Indian Science Congress Association.

4. Dr. D. Gangopadhyay has been made a member of (i) The Planetary Society and (ii) National Geographic Society (USA).

F. Honorary Fellow

Professor N. Sathyamurthy, Honorary Fellow of the Centre, has published the following papers :

1. Sathyamurthy, N., Kumar, S. and Ramaswamy, R. : Overcoming the zeropoint dilemma in quasiclassical trajectories : (He, H_2^+) as a test case - *J. Chem. Phys.*, 1995, **103** (14), 6021-6028.
2. Sathyamurthy, N., Mahapatra, S. : Correlation function approach to transition state resonances in collinear : (He, H_2^+) collisions - *J. Chem. Phys.*, 1995, **102** (15), 6057-6066.
3. Sathyamurthy, N., Mahapatra, S. and Ramaswamy, R. : Quantum Chaos in collinear : (He, H_2^+) collisions - J. Chem. Phys., 1995, **104** (8), 1-19.
4. Mahapatra, S. and Sathyamurthy : Resonances in collinear H + H_2 H_2 + H reaction : energy-resolved reaction probabilities by the time-dependent wave packet approach *J. Phys. Chem. C.*

Visits by the Cenre's Staff to attend Conferences, Seminars etc.

1. Banerjee, S. attended "Some aspects of theoretical physics" at ISI, calcutta (May 14-15, 1996) : visited Tech. Univ. of Denmark, Lyngby, (Sept. 1996 - Mar. 1997) talked on "Network modelling of fluid displacement processes in a porous medium" (Mar 4, 1997).
2. Biswas, P. attended (i) workshop on LDA and beyond at ICTP, Trieste, Italy (June17-28, 1996); (ii) workshop on Electronic Structure of solids at Dhaka University , Bangladesh (November1996); (iii) Indo-US International Symposium on Novel Materials at Puri (March3-7, 1997).
3. Bose, M. : attended (i) the National Seminar on liquid Crystals at the Thapar Institute of Engineering and Technology, Patiala 147002, Punjab, (Nov. 1-3, 1996), and chaired a session ; (ii) the 5th Asian Conference on Solid State Ionics at Kandi, Sri Lanka in Dec 1996 ; (iii) "Condensed Matter Days" 1996 at Tripura University, Agartala (Aug 29-31, 1996).
4. Chakrabarti, S. K. : (i) Goddard Space Flight Centre, Maryland, USA (Dec 6 -14, 1996), (ii) Memorial lecture of S. Chandrashekhar at the University of Chicago, USA (Dec. 15-16, 1996), (iii) 18th Texas Symposium in Chicago (Dec 17-21, 1996).
5. Chaudhary, R. attended (i)the 2nd WorldCongress on Synthesis of Science and Religion at Science City, Salt Lake, Calcutta (January 9-12, 1997); (ii) the 5th International Conference on Materials and Mechanisms of

Superconductivity - High Temperature Superconductors (M^2S - HTSC-V) at Beijing, China (February 28-march 4, 1997); (iii) the discussion Group Meeting on Novel Liquid Crystals with special refrence to transition metal discotics and smectics held SNBNCBS, Calcutta (January 8-10, 1997)

6. Das, C. attended (i) workshop FORTRAN 90 and its application to Physics and Chemistry at SNBNCBS (October 28 - November 9, 1996); (ii) a seminar on INTERNET at Jadavpur University, Calcutta (December 21, 1996).
7. Das, R. : attended the National Technology Conference for the Visually Handicapped people at New Delhi (Feb 17 - 18, 1997).
8. Ghosh, S. attended (i) workshop on Electronic Structure of Solids at Dhaka University, Bangladesh (November 1996); (ii) DAE Symposium on Solid State Physics at BARC, Mumbai (December 1996); (iii) Indo-US Symposium on Novel Materials at Puri (March 1997).
9. Ghoshal, S. attended a seminar on INTERNET at Jadavpur University (December 21, 1996)
10. Guha, P. : visited (i) Research Institute for Mathematical Science, Kyoto University, Japan (Dec 1996 - Jan 1997); (ii) Hong Kong University of Science and Technology, Hong Kong (Jan 1997).
11. Majumdar, A. S. attended (i) TIFR Golden Jubilee Symposium on Foundations of Quantum Theory at TIFR, Mumbai (September 9-12, 1996); (ii) International Workshop on Seventy Years of Schrodinger's Wave Mechanics at NISTADS, New Delhi (December 28-31, 1996); (iii) 2nd Meeting on Current Trends in Optics at SNBNCBS, Calcutta (January 14-17, 1997).
12. Mookerjee, A. attended workshop on LDA and beyond at ICTP, Trieste, Italy (June 1996); (ii) Frontiers in Materials Modelling and Design at IGCAR (August 20-23, 1996); (iii) Condensed Matter Days at Agartala (August 29-31, 1996); (iv) Workshop on Novel Materials, Puri (March 1997).
13. Mukhopadhyay, P. K. : attended the workshop "Cryogenic Techniques and Instrumentation" in the Cryogenic Engineering Centre, IIT, Kharagpur (Aug 26-30, 1996).
14. Nayak, N. attended (i) a seminar on Some Aspects of Theoretical Physics in Honour of Professor P. Bandyopadyay on his 60th birthday at the ISI, Calcutta (May 14-15, 1996); (ii) 2nd Meeting on Current Trends in Optics (Co-Convenor) at SNBNCBS, Calcutta (January 14-17, 1997).
15. Saha, J. attended Nat. Sem. On Liq. Crystals at Thapar Institute of Engineering and Technology, Patiala (Nov 1-3, 1996).
16. Sanyal, B. attended (i) workshop on LDA and beyond at ICTP, Trieste, Itlay (June 17-28, 1996); (ii) workshop on Electronic Structure of Solids at Dhaka University, Bangladesh (November, 1996); (iii) Indo-U.S.

International Symposium on Novel Materials at Puri (March 3-7, 1997).

17. Sharma, S. K. attended a meeting on Some Aspects of Theoretical Physics on the occassion of 60th birthday of Professor P. Bandhopadhyay at ISI, Calcutta (May 14-15, 1996).

Seminars/Talks by the Centre's Staff

1. Banerjea A. : The Equivalent Crystal Theory and Its Applications as part of the discussions workshop Electronic Structure of Alloys and Phase Stability at SNBNCBS (April 23, 1996).
2. Banerjee, H. : (i) Fermion on Lattice and Chiral Invariance at Visva-Bharti (April 21-24, 1996); (ii) Fermion on Lattice at ISI, Calcutta (May 14-15, 1996); (iii) Resolution of Strong CP and U(1) Problems at SNBNCBS, Calcutta (August 13 & 20, 1996); (iv) Fermions on Lattice and Chiral Symmetry at CTS, IISc., Bangalore (September 20, 1996).
3. Banerjee, R. : Course on "An introduction to the theory and applications of constrained Hamiltonian dynamics" (25 lectures at UFRJ, Brazil).
4. Biswas, P. : Electronic Structure of Disordered AuFe Alloy at University of Dhaka, Bangladesh (November 14, 1996).
5. Bose, M. : Computer analysis to identify the quadrupole forbidden transition in the EPR spectra of alkoxy and alkylalkoxy substituted aryl beta diketonates of Cu(II) at the National Seminar on Liquid Crystals, Thapar Inst. Engg. Tech., Patiala in Nov, 1996.
6. Chakrabarti, S. : (i) Quasi-Periodic Oscillation and Spectral Properties of Black Hole Accretion at the Goddard Space Flight Centre (December 1996); (ii) Recent Progresses in Accretion Disk Models Around Galactic and Extragalactic Black Holes at the 18th Texas Symposium at Chicago, USA (December 1996); (iii) Invited talks on Solar Wind Astrophysical Flows Around Black Holes and Our Galactic Centre at the Winter School of Eastern Centre for Research in Astrophysics (ECRA) at Science College, Calcutta (January, 1997); (iv) Welcome address at the 1st Winter School of ECRA on Basics of Astrophysics at the Science College, Calcutta and invited address at the ECRA Training Programme on Millimeter Wave Physics (January 1997); (v) Introduction of Astrophysics in the university teaching at the Jadavpur University (February 1997); (vi) Astrophysics of Black Holes at the Symposium of West Bengal Academy of Science at the IACS, Calcutta (March, 1997).
7. Chaudhury, R. : Interacting Fermions - Coexistence of Local and Bound Fermion Pairs and Breakdown of Fermi Liquid Behaviour at 5th International Conference on Materials and Mechanisms of

Superconductivity - High Temperature Superconducters (M^2S-HTSC-V) in Beijing, China (March 3, 1997).

8. Das, C. : (i) Electromagnetic Radiation by a Tunneling Charge by M.I. Dyakonov and I. V. Gornyl (PRL 76, May 1996) at the Journal Club, SNBNCBS, Calcutta (June 28, 1996); (ii) Interaction at Physics and Applied Mathematics Unit, ISI, Calcutta (August 22, 1996).
9. Das, R. : IT-As a Carrer for Women at CSI, Calcutta (April 8, 1996).
10. Datta, R. P., Banerjea, A., Mookerjee, A. and Bhattacarya, A. K. : Study of small clusters of Cu and Ni - Presented by R. P. Datta at the conference titled Discussion Workshop on Electronic Structure and Phase Stability of Alloys - SNBNCBS, (April 23-26, 1996).
11. Dey, P. : Quantum Dynamical Tunnelling Suppression by a Laser Field at the Journal Club, SNBNCBS, Calcutta (July 4, 1996).
12. Gangopadhyay, D. : Generalising Maximal Symmetry in the Presence of Torsion at the XVII UK Institute for Theoretical High Energy Physics, University of Durham, UK (August 28, 1996).
13. Gangopadhyay, G. : Quantum Theory of Damping for Model Linear and Nonlinear Quantum Optical Systems at SNBNCBS, Calcutta (July 9, 1996).
14. Gangopadhyay, G. : The effect of finite bandwidth of the resonance fluorescence spectra at Institute for Molecular Science, Okazaki, Japan (March, 1997).
15. Ghosh, S. : A Geometrical Approach to Feenberg Multiple Scattering Series at Dhaka University, Bangladesh (November 14, 1996).
16. Majumdar, C. K. : (i) Parallel Computation and its Application to the Hooghly Estuary Problem at ISI, Calcutta (May 14-15, 1996); (ii) A Three Body Problem in Magnetism, Centenary Celebration of Prof. R. N. Sen at Pure Mathematics Department, Calcutta University (September 12, 1996).
17. Majumdar, A. S. : Towards Obtaining Empirical Signatures of Wave Function Collapse in Cosmology - invited talk at the International Workshop on Seventy Years of Schroedinger's Wave Mechanics at NISTADS, New Delhi (December 30, 1996).
18. Mehta, A. : (i) Probing Sand and Seminar on Complex Systems at CMMACS at Bangalore (June 25-30, 1996); (ii) Deposition on Surfaces : Phenomenology and Mechanisms at Dhaka University, Bangladesh (November 11-12, 1996).
19. Mookerjee, A. : (i) Electronic Structure and Phase Stabilty of Alloys at SNBNCBS, Calcutta (April 26, 1996); (ii) Magnetism on rough surfaces (Plenary talk) at ICTP, Trieste, Italy (July 4, 1996); (iii) Magnetism on Rough Surfaces at Psi-k Conference at Gmund, Germany (September 20, 1996); (iv) Growth and Electronic Structure of Thin Films at Physics

Department, Case Western Reserve University, Cleveland, USA (September 23, 1996); (v) Tunable Photovoltaic Devices at Centre for Catalytic Systems, University of Warwick, UK (September 27, 1996); (vi) Magnetism on Rough Surfaces at Dhaka University, Bangladesh (November 11-12, 1996).

20. Mookerjee, A., Datta, R. P. and Bhattacharya, A. K. : Theoretical studies on copper clusters - presented by Prof. A. Mookerjee at the International Conference on Novel Materials held at Puri, March 3-6, 1997.
21. Mitra, T. : (i) Environment Induced Decoherence Approach in Quantum Measurement Problem at the Journal Club, SNBNCBS, Calcutta (July 18, 1996); (ii) Environment Induced Super Selection Rules at the Journal Club, SNBNCBS, Calcutta (August 1, 1996); (iii) Decoherence Approach in Quantum Measurement through some Realistic Models at the Journal Club, SNBNCBS, Calcutta (August 8, 1996).
22. Pal, M. K. : (i) From transuranics to the superheavies at IACS, Calcutta (April 1996); (ii) History of the Discovery of Nuclear Fission at Visva-Bharti University (April 1996).
23. Saha, J. : (i) Modification of the Overlap Potential for Disc-Like Crystal Molecules at the National Seminar on Liquid Crystals, Patiala (November 2, 1996); (ii) Computer simulation of Thermotropic Liquid Crystals at the Discussion Group Meeting on Novel Liquid Crystals with special refrence to transition metal discotics and smectics at SNBNCBS, Calcutta University (January 10, 1997).
24. Sanyal, B. : Magnetism on Rough Surfaces and Interfaces at University of Dhaka, Bangladesh (Novembver 1996).

Theoretical Physics Seminar Circuit

The following scientists under TPSC Programme gave seminars in Calcutta :

1. Dr. Tapobrata Som, IIT Kanpur : Behaviour of Hydrogen in Materials Using Elatsic Recoil Detection Analysis at SNBNCBS, Calcutta (August 9, 1996).
2. Dr. Naba K. Mondal, High Energy & Cosmic Ray Group, TIFR, Mumbai : Search for Supersymmetry at Tevatron at SNBNCBS (September 24, 1996).
3. Dr. Arnab Rai Choudhuri, Department of Physics, IISc., Bangalore : The Origin of Sunspots at SNBNCBS (September 30, 1996).
4. Dr. N. Rathnasree, formerly Raman Research Institute, Bangalore : Lorentz Factor of Emitting Particles in Pulsar Magnetospheres at SNBNCBS (October 11, 1996).
5. Dr. Sumit Ranjan Das, TIFR, Mumbai : Microscopic Derivation of Black Holes Thermodynamics at SNBNCBS (October 16, 1996).

6. Professor Ramkrishna Ramaswamy, School of Physical Sciences, JNU, New Delhi : Driven Diffusive Lattice Gases : Traffic Models Coarseing and Pairwise Balance at SNBNCBS (December 5, 1996).
7. Dr. Neelima Gupta, IIT, Madras : Coherence and Chaotic Flows and Maps at SNBNCBS (December 27, 1996).
8. Professor S. R. Shenoy, ICTP, Trieste, Italy : Towards a Ginzburg Landau Descreption of Martensitic Textures (And Shade Memory) at SNBNCBS (January 9, 1997).
9. Professor R. Rajaram, School of Physical Sciences, JNU, New Delhi : Field Theory of Single and Double Layer Quantum Hall Sysytems at SNBNCBS (February 17, 1997).
10. Dr. S. Misra, Allahabad University : Various Techniques of Magnetic Resonance at SNBNCBS, Calcutta (March 19, 1997).

Dr A. Mehta of SNBNCBS was selected a TPSC Speaker. She gave lectures :

1. Roughness at Interfaces at Pune University (March 27, 1997);
2. The Completely Inelastic Ball at IIT Madras (March 28, 1997); and
3. Hidden Length Scales in Interface Problems at IMS Madras (March 31, 1997).

At present we have 9 full and 9 associate TPSC Centres.

The Centres are :

Full Centres :

1. SNBNCBS, Calcutta 2. TIFR, Mumbai; 3. IISc., Bangalore; 4. University of Hyderabad; 5. IMSc., Chennai; 6. PRL, Ahmedabad; 7. IOP, Bhubaneshwar; 8. IIT, Kanpur; 9. University of Delhi.

Associate Centres

1. MRI, Allahabad; 2. University of Poona, Pune; 3. Bharathidasan University, Tiruchirapalli; 4. University of Roorkee, Roorkee; 5. University of Punjab, Chandigarh; 6. North-Eastern States Consortium; 7. Visva-Bharati, Santiniketan; 8. University of Cochin; 9. BHU, Varanasi.

Educational Activities : HRD Programmes

Dr. C. K. Majumdar taught part of the Solid State Physics (special paper) in the combined M. Sc. classes of Calcutta University and Presidency College, Calcutta, during November 1996 to April 1997. Other human resource developement (HRD) programmes include the workshop on FORTRAN 90 and on upgrading the PG Physics Laboratory.

LIBRARY

The Library now subscribes to the following journals :

A. **Foreign Journals**

1. Computer Journal
2. Computers in Physics (AIP)
3. Economic Theory
4. Journal of Modern Optics
5. International Journal of Modern Physics A
6. Journal of Physics A : Mathematics and General
7. Modern Physics Letters A
8. Modern Physics Letters B
9. Monthly Notices of Royal Society of Astronomy
10. Nature
11. Physical Review A
12. Physical Review B
13. Physical Review C
14. Physical Review D
15. Physical Review E
16. Physical Review Letters
17. Physics Letters A
18. Physics Letters B
19. Physics Reports
20. Reviews of Modern Physics
21. Fractals
22. The Astrophysical Journal

The Library gets APS News, CERN Courier and Bulletin of American Physical Society.

B. **Indian Journals**

1. Bulletin of Material Science
2. Current Science
3. Indian Journal of Pure & Applied Physics
4. Journal of Astrophysics and Astronomy
5. Journal of Bioscience
6. Journal of Genetics
7. Pramana

8. Proc. Ind. Acad. of Sc. (Chemical Sciences)
9. Proc. Ind. Acad. of Sc. (Earth & Planetary Sciences)
10. Proc. Ind. Acad. of Sc. (Engineering Sciences)— Sadhana
11. Proc. Ind. Acad. of Sc. (Mathematical Sciences).
12. Resonance

The Library is expanding slowly. Its 286-MINICOMP PC and EPSON FX-1000 printer are used for the monthly and annual reports. the software dBAse III and Word Perfect 5.1 are being used for technical processing. The new HP 715 Computer will be linked up with the internal LAN and will be linked up with CALIBNET facilities in future.

The Library added 259 new books in 1996-97. The Centre continues to get electronic mail information bulletin such as C-Alert, HiTcupdate, Atom-Ph, Quan-Ph, Hep-Th, Hep-Ph, Alg-Geom etc. The users can access various publications through the internet. The library has its xerox machine Modi xerox model 1038; it xeroxed about 76800 pages in the year. It also has the older machine model 1025, used mostly for office work. It continues its connection with The Indian National Scientific Documentation Centre (INSDOC) for getting xerox copies of papers from different foreign periodicals.

The library gratefully acknowledges the gift of many issues of Astrophysical Journal from ICTP, Trieste, Italy.

COMPUTER CENTRE

The old computer HP 9000 with its accessories (one dumb terminal, dot matrix printer (DMP) and plotter) is now mostly used for electronic mail, but its starbase graphics is still available. The Centre has furbished its computing facilities thoroughly. It has now a DEC 250 4/266 machine with 8 VT 510 (Ordinary Visual) terminals and two 21" screen VXT 2000 terminals. This is connected to a laserjet 5MP printer and a line printer EPSON-LQ 1170 (ESC P2). A digital 486 machine Venturis 466 connected to a scanner is also connected to the above printer. A Silicon Graphics Indigo 2 machine is used for graphic and some project work involving long computation. For computation we have (i) PCL 386 and a colour printer TVSE; (ii) three PCL 386 with a FX 105 Sprinter and Laser jet 4ML; (iii) one LPL 486; (iv) one PCL 486 and a TVS Printer. Five Packard Bell 486 machines were bought for internet and distributed over three floors. For mathematical work, the Centre has WIPRO 486 (2 terminals), Laserjet 5MP and Panasonic 24 Pin DMP. Parallel computation is done on a PCL 486 (fitted with transputer T800 and node add on board) and a DMP MSP 155; this needs upgrading. For astrophysics work, the Centre procured Origin 200 with fronted 02 (Silicon Graphics), a Pentium and a colour deskjet printer HP 870 CXI. The condensed matter laboratory has PCL 486 computer with a Calligra 24 pin printer.

The Computers are getting linked in a local area network (LAN) through high speed catalyst switch.

The Centre has now complete internet facilities. It has taken 64 kbps dedicated lease line connected with VSNL via PSI link. (It is being heavily used to access technical literature and scientific journals present in the internet.) Originally the connection was given through the address snbose@giascl01.vsnl.net.in. After the networking in the computer room, the present access is through root@boson.bose.res.in.

Individuals are given separate accounts. The e-mail has been looked after by S. Banerjee , N. Nayak, A. Lahiri and S. K. Chakrabarti.

The Workshop on FORTRAN 90 was run with hired machines without disturbing the computer room. The teachers' training programme was not run. The interest of teachers is changing and appropriate programme will have to be thought out.

Mrs. R. Das has been busy with Brailescript project of the Computer Science & EMC Department, Jadavpur University. The project is reported to be sucessful.

THE NEW CAMPUS

The new Campus has a part of the Main Building (library and computer building), a 48-room Guest House and one block of Essential Staff Quarters.

The following parties were involved in the construction in the first phase :

1. Nabin Designers & Constructors ; 2. Pradhan & Associates; 3. Blue Star Limited; 4. CMC Limited; 5. Asco Strumech (P) Ltd.; 6. OTIS Elevator; 7. TIL Limited; 8. Larica India Limited.

The gardening and tree plantation on a small scale has been entrusted to Globe Nursery.

Security arrangements are looked after by Security Investigation Bureau on contract.

Maintenance work is entrusted to the following parties :

1. Pradhan Associates (Electrical Installations);
2. Blue Star Limited (Air-conditioning Centre & Computer);
3. Project Electrical (DG Set);
4. Larica India (P) Ltd. & Dew Drops (India) (Deironing Plant);
5. OTIS (Lifts - 6 Passenger & 8 passenger);
6. Mercantile Agency (Water Coolers, Window Type Air-conditioners);
7. Eureka Forbes Limited (Aquaguard);
8. DB Power Electronics (P) Ltd. (UPS System/Computer Room).

The Guest House is becoming popular. In this year we had about 600 guests. It was utilised for conferences run by Calcutta University, Bose Institute & Saha Institute of Nuclear Physics. The All-India Vice Chancellors Conference, organised by Rabindra Bharati University, had 58 Vice Chancellors' and UGC officials staying here. Further improvements are planned.

MEETING OF THE GOVERNING BODY AND VARIOUS COMMITTEES (1996-1997)

Governing Body

The Governing Body of the Centre held its twelfth and thirteenth meeting on 8 August, 1996 and 4 October, 1996 respectively during the period under report, at the Office of the Secretary, Department of Science & Technology, New Delhi.

Academic Programme Advisory Committee

The Academic Programme Advisory Committee meeting of the Centre was held on 28 February, 1997.

Finance Committee

During the above period, the constitution of the Finance Committee was as hereunder :

(i)	Professor C. K. Majumdar	Chairman
(ii)	Shri S. B. Krishnan/R. Sarin	Member (FA, DST)
(iii)	Professor Mihir Chowdhury	Member (IACS)
(iv)	Professor V. Krishnan	Member (IISc, Bangalore)
(v)	Shri Abhijit Gupta	Member-Secretary

The meeting of the Finance Committee was held in the office of the Department of Science & Technology, New Delhi on 4 April, 1996.

Building Committee

During the above period, the constitution of the Building Committee was as hereunder :

(i) Professor C. K. Majumdar ..... Chairman

(ii) Professor T. K. Chattopadhyay ..... Dept. of Architecture
Jadavpur University.
Member

(iii) Shri S. C. Padhi ..... SSW (EZ), CPWD Member

(iv) A nominee of DST ..... (yet to be nominated) Government of India

(v) Shri Abhijit Gupta ..... Member-Secretary

There was no meeting held during the said period as the composition of the committee was not complete for want of the nominee of the DST.

Administrative Matters

The Centre is following the provisions of the Official Language Policy to the extent possible. All letters received in Hindi are replied to in Hindi.

The reservation policy of the Government is being followed by the Centre.

Consequent to DST letter No. AI/MISC./015/96 dt. 16. 5. 1996, it was intimated by the Director in his letter No. SNB/FA 2 002/DO-38, dt. 3. 7. 1996 that no Review Committee was set up till that time.

GOVERNING BODY

During the period under report the composition of the Governing Body was as hereunder :

1. Professor V. S. Ramamurthy Chairman	Secretary Department of Science & Technology, Government of India, New Delhi
2. Professor G. S. Agarwal Member	Director Physical Research Laboratory Ahmedabad
3. Professor S. N. Behera Member	Director Institute of Physics Bhubaneshwar
4. Professor Probir Roy Member	Tata Institute of Fundamental Research, Mumbai
5. Shri S. B. Krishnan	Joint Secretary

	Member	Financial Adviser DST, New Delhi
	Shri R. Sarin	-do- (from Oct 1996)
6.	Shri A. K. Majumdar Member	Chief Secretary Government of West Bengal Calcutta
7.	Professor C. K. Majumdar Member	Director S. N. Bose National Centre for Basic Sciences, Calcutta
8.	Shri Abhijit Gupta Non-member Secretary	Administrative Officer S. N. Bose National Centre for Basic Sciences, Calcutta

The tenure of Prof. G. S. Agarwal, Prof. S. N. Behera and Prof. Probir Roy is for a period of five years with effect from 19 July, 1996 as per clause 21 of the Rules of the Centre. Others are ex-officio members.

ACADEMIC PROGRAMME ADVISORY COMMITTEE

During the year, the Academic Programme Advisory Committee of the Centre consisted of the following members :

1.	Professor N. Mukunda, JNCASR, Bangalore	(Chairman)
2.	Professor M. Chowdhury, IACS, Calcutta	(Member)
3.	Professor N. Sathyamurthy, IIT Kanpur	(Member)
4.	Professor P. K. Maitra, Agharkar Research Inst. Pune	(Member)
5.	Professor R. Sinha, NCRA, Pune	(Member)
6.	Professor C. K. Majumdar, Director, SNBNCBS, Calcutta	(Member)
7.	Professor S. K. Bose, SNBNCBS	(Member)
8.	Professor A. Mookerjee, SNBNCBS	(Member)
9.	Dr. S. K. Sharma, SNBNCBS	(Member)
10.	Dr. N. Nayak, SNBNCBS	(Member)

The committee was appointed on Dec. 12, 1994 for a three year term.

STAFF OF THE CENTRE AS ON 31 MARCH, 1997

Academic

Dr. Chanchal Kumar Majumdar	Director
Dr. Sujit Kumar Bose	Professor
Dr. Partha Ghose	Academic Programme Coordinator
Dr. Abhijit Mookerjee	Professor
Dr. Sandip Chakrabarti	Associate Professor (Joined on 26.11.96)
Dr. Subodh Kumar Sharma	Reader
Dr. Nilkantha Nayak	Reader
Dr. Rabin Banerjee	Reader
Dr. Anita Mehta	Reader
Dr. Debashis Gangopadhyay	Fellow
Dr. Manu Mathur	Fellow
Dr. Srilekha Banerjee	Fellow
Dr. Samir Kumar Paul	Fellow
Dr. Kumar Sankar Gupta	Fellow (resigned on 30.4.96)
Dr. Amitava Banerjea	Lecturer (resigned on 01.01.97)
Dr. Pratip Kumar Mukhopadhyay	Lecturer
Dr. Ranjan Chaudhury	Lecturer
Dr. Gautam Gangopadhyay	Lecturer (on leave for 2 years)
Mrs. Rina Das	Scientific Officer (Computer)
Dr. Biswajit Chakraborty	Post Doctoral Fellow
Mr. Subhradip Ghosh	Junior Research Fellow

Scientists on Projects

Professor Manoj Kumar Pal	Emeritus Scientist, CSIR
Professor Monisha Bose	Co-Principal Investigator in a DST Project
Professor Haridas Banerjee	INSA Senior Scientist
Dr. Sudhish Ch. Banerjee	Principal Investigator in a DST Project (joined on 01.3.97)
Dr. Radhika Prasad Datta	Research Associate, Univ. of Warwick Project

Dr. Archan S. Majumdar	Research Associate, DST
Dr. Govindarajan Pari	Research Associate (joined on 26.11.96)
Dr. (Ms.) Chandra Das	Research Associate, CSIR
Dr. (Ms.) Jayashree Saha	Research Associate, CSIR
Mr. Biplab Sanyal	SRF (from 19.7.96), DST
Ms. Chhanda Basu Chauduri	JRF (from 01.02.95), CSIR
Mr. Partha Pratim Biswas	SRF (from 01.01.96), CSIR
Mr. Tapas Mitra	SRF, CSIR
Mr. Prantick Dey	SRF (From 01.8.96), CSIR
Mr. Ganesh Chandra Gorain	SRF (From 26.8.96), CSIR
Mr. Nityananda Das	JRF
Dr. Prabhat Kumar Thakur	Visiting Scientist
Dr. Sarmistha Ghoshal	do
Dr. Shilbhadra Chattopadhyay	do (resigned on 19.8.96)
Dr. Narayan Bandopadhyay	do (resigned on 19.7.96)
Dr. V. V. Sreedhar	do (resigned on 22.8.96)
Dr. S. K. Venkatesan	do (resigned on 04.7.96)
Dr. Partha Guha	do (joined on 23.7.96)
Dr. Amitabha Lahiri	do (joined on 11.11.96)

Administrative Technical and Auxilliary

Mr. Abhijit Gupta	Administrative Officer
Dr. Santi Gopal Basu	Librarian (retd. on 30.4.96)
Mr. Apurba Kanti Sarkar	Administrative Assistant (Accounts)
Mr. D. P. Banerjee	Office Superintendent
Mr. Sunish Kumar Deb	Stenographer
Mr. Sukanta Mukherjee	Assistant (General)
Mr. Tapan Kumar Sen	UDC
Mr. Jaydeep Kar	Junior Assistant

Mr. Prosenjit Talukdar	Junior Assistant
Mr. Sanad Kumar Shukla	do
Mr. Santosh Kumar Singh	do
Mr. Gopal Chandra Ghosh	Driver
Mr. Pradip Kumar Bose	Helper
Mr. Partha Chakraborty	do

Personnel on Campus Construction

Mr. Samar Sur	Sub-Assistant Engineer
Mr. Aditya Pal Choudhury	Project Assistant

Abbreviations

BARC	=	Bhabha Atomic Research Centre, Mumbai
BHU	=	Benaras Hindu University, Varanasi
CERN	=	European Organisation for Nuclear Research
CSIR	=	Council of Scientific & Industrial Research, New Delhi
CU	=	Calcutta University
DAE	=	Department of Atomic Energy, New Delhi
DST	=	Department of Science & Technology, New Delhi
ECRA	=	Eastern Centre for Research in Asrtophysics, Calcutta
IACS	=	Indian Association for the Cultivation of Science, Calcutta
ICTP	=	International Centre for Theoretical Physics, Trieste, Italy
IGCAR	=	Indira Gandhi Centre for Atomic Research, Kalapakkam
IISc.	=	Indian Institute of Science, Bangalore
IIT	=	Indian Institute of Technology
IMAS	=	Institute of Mathematical Science, Chennai
INSA	=	Indian National Science Academy, New Delhi

IOP	=	Institute of Physics, Bhubaneshwar
ISI	=	Indian Statistical Institute, Calcutta
IUCAA	=	Inter-University Centre in Astronomy & Astrophysics, Pune
IUC-DAEF	=	Inter-University Centre for Department of Atomic Energy Facilities, Indore & Calcutta
JINR	=	Joint Institute of Nuclear Research, Dubna, Russia
JNU	=	Jawahar Lal Nehru University, New Delhi
JU	=	Jadavpur University, Calcutta
LEPES	=	Laboratories d'Etudes des Propriete's Electroniques des Solids, France
MRI	=	Mehta Research Institute, Allahabad
NBU	=	North Bengal University
NCRA	=	National Centre for Radioastronomy, Pune
NISTADS	=	National Institute of Science, Technology & Development Studies, New Delhi
PRL	=	Physical Research Laboratory, Ahmedabad
SINP	=	Saha Institute of Nuclear Physics, Calcutta
SNBNCBS	=	S. N. Bose National Centre for Basic Sciences, Calcutta
TIFR	=	Tata Institute of Fundamental Research, Mumbai
UFRJ	=	Universiadade Federal do Rio de Janeiro Brazil
UGC	=	University Grants Commission, New Delhi
VB	=	Visva-Bharati, Santiniketan
VECC	=	Variable Energy Cyclotron Centre, Calcutta

BUDGET SUMMARY

(1996-97)

The funds come from the Department of Science and Technology, New Delhi. The following is the summary of the budget estimates for the Year 1996-97.

(Amount in Rs. in lakhs)

	Actuals	Budget estimate	Revised estimate
	1995-96	1996-97	1996-97
Non-Plan	49.45	38.60	32.00*
Plan	107.76	210.11	230.00*
Total	157.21	248.71	262.00

* sanctioned by DST

Non Plan

1. Grant No. 171(21.5.96)	sanction	AI/SNB/003/96 (7.5.96)	Rs. 10 lakh
2. Grant No. 1140(26.9.96)	"	AI/SNB/003/96 (9.9.96)	Rs. 6 "
3. Grant No. 2114(7.1.97)	"	AI/SNB/003/96 (7.1.97)	Rs. 8 "
4. Grant No. 2834(8.3.97)	"	AI/SNB/003/96 (17.2.97)	Rs. 8 "
			Rs. 32 lakh

Plan

1. Grant No. 3248(18.3.97)	"	AI/SNB/003/96 (11.3.97)	Rs. 230 "
		Total	Rs. 262 lakh