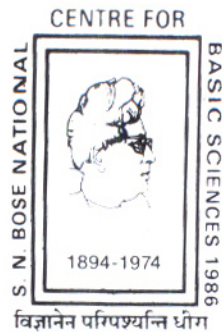


ANNUAL REPORT 1990-91



**SATYENDRA NATH BOSE NATIONAL CENTRE
FOR BASIC SCIENCES**

(Estd. 1986)

DB17 : SECTOR 1, SALT LAKE CALCUTTA- 700 064

**SATYENDRA NATH BOSE NATIONAL CENTRE
FOR BASIC SCIENCES**

Calcutta

ANNUAL REPORT

April 1, 1990 to March 31, 1991

Objectives

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

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

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

To provide a forum of 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.

Governing Body

The present Governing Body of the Centre consists of the following members :

- | | | |
|---|----------------------------------|---|
| 1 | Dr V Gowariker
Chairman | Secretary
Department of Science & Techonlogy
Government of India, New Delhi |
| 2 | Professor C N R Rao
Member | Director
Indian Institute of Science
Bangalore |
| 3 | Professor C S Seshadri
Member | Dean
School of Mathematics
SPIC Science Foundation, Madras |

(2)

- | | | |
|---|---|---|
| 4 | Professor J V Narlikar
Member | Director
Inter-University Centre
for Astronomy & Astrophysics
Pune |
| 5 | Shri B K Chaturvedi
Member | Joint Secretary & Financial Adviser
Department of Science & Technology
Government of India, New Delhi |
| 6 | Shri T C Dutt
Member
(Retired on 28.2.1991) | Chief Secretary
Government of West Bengal
Calcutta |
| | Shri N Krishnamurthi
Member
(Joined office on 1. 3. 1991) | Chief Secretary
Government of West Bengal
Calcutta |
| 7 | Professor C K Majumdar
Member | Director
S N Bose National Centre for Basic Sciences
Calcutta |
| 8 | Dr J Pal Chaudhuri
Non-member-Secretary | Administrative Officer
S N Bose National Centre for Basic Sciences
Calcutta |

At the moment the Centre operates from a rented house located at DB 17, Sector I, Salt Lake City, Calcutta-700 064. It has also rented additional space at CD 85, Sector I, Salt Lake City, Calcutta-700 064 to accommodate a part of the Centre's Library and the offices of the academic members of staff. The Centre's own buildings are under construction in Block JD, Sector III, Salt Lake City, Calcutta.

Academic Programmes

The Academic Programme Advisory Committee considers the yearly academic activities of the Centre. Scientists who are currently members of this committee are :

- 1 Professor V Singh : Tata Institute of Fundamental Research,
: Bombay
- 2 Professor S N Biswas : University of Delhi, Delhi.
- 3 Professor K L Chopra : Indian Institute of Technology, Kharagpur
- 4 Professor S S Jha : Tata Institute of Fundamental Research,
Bombay
- 5 Professor S K Joshi : National Physical Laboratory,
New Delhi
- 6 Professor A K Raychaudhuri : Calcutta
- 7 Professor K P Sinha : Indian Institute of Science, Bangalore
- 8 Professor G Rajasekaran : Institute of Mathematical Sciences, Madras
- 9 Professor M Chowdhury : Indian Association for the Cultivation of
Science, Calcutta
- 10 Professor O Siddiqui : Tata Institute of Fundamental Research,
Bombay
- 11 Professor A K Sharma : Calcutta University, Calcutta
- *12 Professor K B Sinha : Indian Statistical Institute,
New Delhi
- 13 Professor R P Bambah : Punjab University, Chandigarh
- 14 Professor M Datta : Calcutta Mathematical Society,
Calcutta
- 15 Professor A S Gupta : Indian Institute of Technology,
Kharagpur

* In the Annual Report 1989-90, the name of Professor K B Sinha was inadvertently omitted. The mistake is regretted. —Director

- 16 Professor N Mukunda : Indian Institute of Science,
Bangalore
- 17 Professor M S Narasimhan : Tata Institute of Fundamental Research,
Bombay
- 18 Professor P C Vaidya : Ahmedabad
- 19 Professor E C G Sudarshan : University of Texas, Austin, USA
- 20 Professor C K Majumdar : S N Bose National Centre for Basic Sciences

Conferences/Workshops/Symposia

Two-day Seminar following the Annual Meeting : Theoretical Physics Seminar Circuit (TPSC)

Since August 1989 the Centre has been coordinating the Theoretical Physics Seminar Circuit scheme funded by DST. There are nine centres which take part : Physical Research Laboratory, Ahmedabad ; Institute of Mathematical Sciences, Madras ; School of Physics, University of Hyderabad, Hyderabad ; Institute of Physics, Bhubaneswar ; Indian Institute of Technology, Kanpur ; University of Roorkee, Roorkee ; University of Delhi, Delhi ; Tata Institute of Fundamental Research, Bombay, and this Centre. During April 19-21 1990 Conveners of the different centres attended the Annual Meeting at this Centre, followed by a two-day Seminar where the Conveners spoke on their respective fields of research. These and the other talks held under the programme are listed later.

School on Electronic Structure of Random Alloys

During November 20—December 5, the Centre organized a School on Electronic Structure of Random Alloys. Professor A. Mookerjee was the Convener. About 34 scientists from Indian Universities/Research Institutes and the University of Dhaka, Bangladesh, participated in the School. Of them about 10 were speakers. The workshop concentrated on three distinct and powerful methodologies for first-principles study of electronic structure and total energy calculations in metals and alloys : the KKR, the LMTO and the Recursion Method. Initial lectures concentrated on detailed and pedagogical exposition of these methods, while in the final week there was discussion on how to combine these methods with other techniques like the CPA and the Augmented Space methods which deal specifically with random alloys and compounds.



List of participants :

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|----|---|----|---|
| 1 | Muktish Acharya
SINP, Calcutta | 2 | Rajeev Ahuja
Univ. of Roorkee, Roorkee |
| 3 | Md. Shawkat Akbar
Univ. of Dhaka, Bangladesh | 4 | R. Asokamani
Anna Univ., Madras |
| 5 | Chaitali Basu
SNBNCBS, Calcutta | 6 | Nagendra Beladakere
NPL, New Delhi |
| 7 | Ranjan Chaudhury
SNBNCBS, Calcutta | 8 | G. P. Das
BARC, Bombay |
| 9 | Abhijit Datta
SNBNCBS, Calcutta | 10 | Sharmistha Gangopadhyay
SINP, Calcutta |
| 11 | B. K. Ghosh
Univ. of Allahabad, Allahabad | 12 | Md. Kamrul Hassan
Univ. of Dhaka, Bangladesh |
| 13 | R. Jagadish
Anna Univ., Madras | 14 | D. G. Kanhere
Univ. of Poona, Pune |
| 15 | Abhijit Kar Gupta
SINP, Calcutta | 16 | C. K. Majumdar
SNBNCBS, Calcutta |
| 17 | S. K. Manna
SNBNCBS, Calcutta | 18 | Arun K. Mishra
L. N. Mithila Univ.
Darbhanga, Bihar |
| 19 | Sujata Modak
SINP, Calcutta | 20 | A. Mookerjee
SNBNCBS, Calcutta |
| 21 | Tanbir Najrana
Univ. of Dhaka, Bangladesh | 22 | B. Palanivel
Anna Univ., Madras |
| 23 | P. V. Panat
Univ. of Poona, Pune | 24 | S. S. A. Razee
IIT, Kanpur |
| 25 | R. S. Rao
NPL, New Delhi | 26 | P. Ravindran
Anna Univ., Madras |
| 27 | H. G. Salunke
BARC, Bombay | 28 | Debiprasad Sarkar
Jhargram Raj College
Midnapore, West Bengal |
| 29 | A. Sattar
Univ. of Dhaka, Bangladesh | 30 | Asok K. Sen
SINP, Calcutta |
| 31 | Ruma Sengupta
St. Paul's College, Calcutta | 32 | Sreekantha Sil
SINP, Calcutta |
| 33 | R. M. Singru
IIT, Kanpur | 34 | P. K. Thakur
SINP, Calcutta |

Mini-workshop in Collider Physics

As a prelude to the International Workshop in High Energy Physics Phenomenology II (January 1991) the Centre held a 'Mini-workshop in Collider Physics' between November 28 and December 2 in the Variable Energy Cyclotron Centre at Salt Lake City. The total number of participants was 10.

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| 1 Debajyoti Choudhury
PRL, Ahmedabad | 2 Amitava Datta
Jadavpur Univ., Calcutta |
| 3 Tapas Kumar Ghosh
Jadavpur Univ., Calcutta | 4 Rohini Godbole
Univ. of Bombay, Bombay |
| 5 Manoranjan Guchait
Jadavpur Univ., Calcutta | 6 Amitava Raychaudhuri
Calcutta Univ., Calcutta |
| 7 Sreerup Raychaudhuri
Calcutta Univ., Calcutta | 8 D. P. Roy
TIFR, Bombay |
| 9 Utpal Sarkar
PRL, Ahmedabad | 10 S. Umasankar
TIFR, Bombay |

Workshop in High Energy Physics Phenomenology II

The Second International Workshop in High Energy Physics Phenomenology (WHEPP II) was organized during January 2-15, 1991. It was inaugurated by Professor Shankar Sen, Vice-Chancellor, Jadavpur University. Mr. T. C. Dutt, Chief Secretary, Government of West Bengal and Member, Governing Body of the S. N. Bose National Centre, presided over the function which was graced by Swami Lokeswarananda, Secretary, Ramakrishna Mission Institute of Culture, Professor U. R. Ghatak, Director, Indian Association for the Cultivation of Science and other dignitaries.

The Workshop was sponsored by the Department of Science & Technology, Government of India, the National Science Foundation (USA), and the International Centre for Theoretical Physics (Trieste) and was organized in collaboration with the Jadavpur University, the Indian Association for the Cultivation of Science and the Ramakrishna Mission Institute of Culture. Altogether 55 physicists from Calcutta and other parts of India and 23 scientists from other countries (Bangladesh, Germany, Malaysia, Poland, Spain, USA, USSR) participated.

The principal objective of the workshop was to have intensive discussions and work sessions covering phenomenological issues of elementary particle interactions which lie at the interface of the Standard Model and possible new physics-issues which are likely to come into limelight in the 1990s with the commissioning of a new generation of colliders.



The main topics of discussion were :

1. QCD and Related Issues (structure functions at low x with emphasis on HERA measurements, polarized structure functions and higher order QCD contributions for jets, W, Z and heavy flavour production)

2 Low Energy Weak Interactions (hadronic matrix elements, B-Physics)

3 Search for New Particles

4 Radiative Corrections to Electroweak Processes (precision study of W & Z parameters, 2W physics)

Some of the leading experts in the field gave plenary talks and mini-reviews which were followed by intensive group discussions on problem areas. A number of important problems were identified and small groups were able to make considerable progress towards their solution.

The proceedings of the Workshop will be published by the World Scientific Publishing Co., Singapore.

List of participants :

- | | |
|--|---|
| 1 Praveer Asthana
DST, Government of India
New Delhi | 2 Howard A Baer
Florida State Univ.
Tallahasee, USA |
| 3 Krishnanath Bandyopadhyay
Visva-Bharati, Santiniketan | 4 Haridas Banerjee
SINP, Calcutta |
| 5 Sunanda Banerjee
TIFR, Bombay | 6 Gautam Bhattacharya
SINP, Calcutta |
| 7 Gautam Bhattacharya
Calcutta Univ., Calcutta | 8 Debasis Bhowmick
Visva-Bharati, Santiniketan |
| 9 Surajit Chakraborty
Raja Manindra Chandra College
Calcutta | 10 Ashok Chatterjee
SINP, Calcutta |
| 11 Debashis Chatterjee
SINP, Calcutta | 12 S. P. Chia
Univ. of Malaya, Malaysia |
| 13 D. K. Choudhury
Gauhati Univ., Guwahati | 14 Debajyoti Choudhury
PRL, Ahmedabad |
| 15 Amitava Datta
Jadavpur Univ., Calcutta | 16 Triptesh De
SINP, Calcutta |
| 17 Jishnu Dey
Hooghly Mohsin College
West Bengal | 18 Mira Dey
Maulana Azad College
Calcutta |

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|---|---|
| 19 M. Drees
DESY, Hamburg, Germany | 20 P. Frampton
Univ. of North Carolina
Chapel Hill, USA |
| 21 J. Freeman
Fermi Lab, Batavia, USA | 22 S. N. Ganguli
TIFR, Bombay |
| 23 V. P. Gautam
IACS, Calcutta | 24 R. V. Gvai
TIFR, Bombay |
| 25 Partha Ghose
SNBNCBS, Calcutta | 26 Subir Ghosh
SINP, Calcutta |
| 27 Rohini Godbole
Univ. of Bombay, Bombay | 28 B. Grzadkowski
Univ. of Warsaw, Warsaw, Poland |
| 29 J. F. Gunion
Univ. of California, Davis, USA | 30 V. Gupta
TIFR, Bombay |
| 31 D. Indumathi
Matscience, Madras | 32 Anjan Joshipura
PRL, Ahmedabad |
| 33 P. K. Kabir
Univ. of Virginia
Charlottesville, USA | 34 G. Karl
Univ. of Guelph, Guelph, Canada |
| 35 E. Ma
Univ. of California
Riverside, USA | 36 B. P. Mahapatra
Sambalpur Univ.
Burla, Orissa |
| 37 Kajari Majumdar
TIFR, Bombay | 38 Partha Majumdar
SINP, Calcutta |
| 39 Samir Mallik
SINP, Calcutta | 40 H. S. Mani
IIT, Kanpur |
| 41 Prakash Mathews
IIT, Kanpur | 42 A. Mendez
Univ. Autonoma De Barcelona
Bellatera, Spain |
| 43 S. P. Misra
IOP, Bhubaneswar | 44 Partha Mitra
SINP, Calcutta |
| 45 Naba Kumar Mondal
TIFR, Bombay | 46 S. Nandi
Oklahoma State Univ.
Stillwater, USA |
| 47 Patrick J. O'Donnel
Univ. of Toronto, Canada | 48 Palash B. Pal
Univ. of Oregon, Eugene, USA |



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|----|---|----|--|
| 49 | Probir Pal
Uluberia College
Howrah, West Bengal | 50 | P. N. Pandita
North Eastern Hill Univ.
Shillong, Meghalaya |
| 51 | M. K. Parida
North Eastern Hill Univ.
Shillong, Meghalaya | 52 | J. Pasupathy
IISc., Bangalore |
| 53 | Apoorva D. Patel
IISc., Bangalore | 54 | Olga Piskounova
P. N. Lebedev Physical Inst.
Moscow, USSR |
| 55 | Azizur Rahman
Univ. of Dhaka, Bangladesh | 56 | G. Rajasekaran
Matscience, Madras |
| 57 | R. Ramachandran
Matscience, Madras | 58 | V. Ravindran
Matscience, Madras |
| 59 | V. Ravishankar
IIT, Kanpur | 60 | A. K. Ray
Visva-Bharati, Santiniketan |
| 61 | Amitava Raychaudhuri
Calcutta Univ., Calcutta | 62 | Sreerup Raychaudhuri
Calcutta Univ., Calcutta |
| 63 | E. Reya
Univ. Inst. of Physics
Dortmund, Germany | 64 | S. Rindani
PRL, Ahmedabad |
| 65 | D. P. Roy
TIFR, Bombay | 66 | Probir Roy
TIFR, Bombay |
| 67 | U. Sarkar
PRL, Ahmedabad | 68 | K. V. L. Sarma
TIFR, Bombay |
| 69 | A. Shafee
Univ. of Dhaka, Bangladesh | 70 | Ranjan Shrivastava
IIT, Kanpur |
| 71 | L. P. Singh
Utkal Univ., Bhubaneswar | 72 | Amarjit Singh Soni
Brookhaven National Lab.
Upton, USA |
| 73 | Vikram Soni
NPL, New Delhi | 74 | Uday P. Sukhatme
Univ. of Illinois, Chicago, USA |
| 75 | X. R. Tata
Univ. of Hawaii at Manoa
Honolulu, USA | 76 | S. Umasankar
TIFR, Bombay |
| 77 | P. E. Volkovitsky
ITEP, Moscow, USSR | 78 | T. J. Weiler
Vanderbilt Univ.
Nashville, USA |

The Centre organized the following meetings in collaboration with other organizations :

1 National Seminar on Parallel Computer Systems and Applications, with Indian Physical Society at Variable Energy Cyclotron Centre, Salt Lake City, Calcutta (October 1990)

2 Modern methods in Spectroscopy, Dynamics and Electronic Structure, with Indian Association for the Cultivation of Science at the Centre (December 1990)

The Centre provided partial financial support to the following programmes :

1 National Seminar in Mathematics in memory of Asutosh Mookerjee, Calcutta University (June 1990)

2 First International Conference on Vibration Problems of Mathematical Elasticity and Physics, Jalpaiguri A. C. College, North Bengal (October 1990)

3 Models of Climatic Change, Calcutta University (November 1990)

4 National Seminar on Plasma Science, Jadavpur University (December 1990)

5 XII National Seminar in Crystallography, Indian Association for the Cultivation of Science (December 1990)

6 Symposium on Environment and Genome, Saha Institute of Nuclear Physics (January 1991)

7 Workshop on Polymer Physics, Institute of Physics, Bhubaneswar (January 1991)

8 XI National Symposium on Cryogenics at IIT, Kharagpur, Indian Cryogenic Centre (January 1991)

9 Physical Techniques in Earth Sciences, Indian Physical Society (February 1991)

10 Seventeenth One-day Seminar on Recent Trends in Physics Research, Indian Physics Association (March 1991)

11 Symposium on Emerging Areas in Mathematical Sciences, Calcutta University (March 1991)

S N Bose Memorial Lecture

The second S N Bose Memorial Lecture was delivered by Professor B. M. Udgaonkar of Tata Institute of Fundamental Research, Bombay, on December 7, 1990, in the lecture theatre of the Saha Institute of Nuclear Physics, 92 Acharya Prafulla Chandra Road, Calcutta. The title of the lecture was 'Nurturing Excellence'.

Seminars Organized at the Centre

1 Dr. Subrata Ray, Computer Centre, University of Burdwan, West Bengal, lectured On 'Unix and C' (June / July 1990).

2 Dr. J. Maharana, Institute of Physics, Bhubaneswar, 'Wormholes' (June 1990).

3 Dr. Ms. Madhusree Mukherjee, W. K. Kellogg Radiation Laboratory, California Institute of Technology, Pasadena, USA, 'Understanding the Interacting Boson Model through BCS ideas' (July 1990).

4 Dr. Sumit Ranjan Das, Tata Institute of Fundamental Research, Bombay, 'Random surfaces and two dimensional gravity' (July 1990).

5 Dr Siddhartha Bhowmick, Taki Government College, West Bengal, 'Convergence accelerating transforms : some applications to physical problems' (August 1990)

6 Professor Probir Roy, Tata Institute of Fundamental Research, Bombay, 'Lepton nonconservation at supercollider energies' (September 1990)

7 Professor V. L. Eletsky, Institute for Theoretical and Experimental Physics, Moscow, 'Problems of a hot gauge field theory' (November 1990)

8 Professor V. M. Belyaev, Institute for Theoretical and Experimental Physics, Moscow, 'Order parameter and effective potential' (December 1990)

9 Professor L. M. Brown, North Western University, Evanston, Illinois, USA, 'Spontaneous symmetry breakdown and its application in superconductivity' (February 1991)

10 Dr R Banerjee, S N Bose National Centre for Basic Sciences, 'On the violation of the Jacobi identity in the algebra of fermionic currents', and 'BJL definition of double commutators and the Jacobi identity' (February/March 1991)

11 Dr. Dhananjay Pandey, School of Materials Science & Technology, Banaras Hindu University, Varanasi, 'Crystals without unit cell' (March 1991)

12 Dr. Ms. Sharmistha Bhattacharya (ne'e'Ghoshal), S.N. Bose National Centre for Basic Sciences, 'Double-resonance lineshape theory for a Doppler-broadened signal in the presence of an infrared pump' (March 1991)

Short Term Visitors/Visiting Fellows at the Centre

1 Professor S. K. Bose, Regional Engineering College, Durgapur (April-June 1990)

2 Sri G. Sengupta, Institute of Physics, Bhubaneswar (June 1990)

3 Dr. Ms. Madhusree Mukerjee, W. K. Kellogg Radiation Laboratory, 106-38, California Institute of Technology, Pasadena, USA (June-July 1990)

4 Dr. Subodh K. Sharma, University of Cardiff, Wales, England (July 1990-January 1991)

5 Professor Siddhartha Sen, School of Mathematics, University of Dublin, Ireland (August 1990)

6 Dr. B. K. Ghosh, Department of Physics, Allahabad University (August-September 1990)

7 Dr. Narender K. Sehgal, Director, National Council for Science and Technology Communication, Department of Science & Technology, New Delhi (August 1990)

8 Professor V. L. Eletsy, Institute for Theoretical and Experimental Physics, Moscow (November 1990)

9 Professor V. M. Belyaev, Institute for Theoretical and Experimental Physics, Moscow (November 1990)

10 Dr. A.K. Bhattacharya, Department of Chemistry, Lady Keane College, Shillong, Meghalaya (December 1990-February 1991)

11 Sri K. L. Patra, Department of Mathematics, Behala College, Calcutta (December 1990)

12 Professor S. Datta Gupta, School of Physical Sciences, Jawaharlal Nehru University, New Delhi (January 1991)

13 Professor M. G. K. Menon, FNA, FRS, Member, Planning Commission (January 1991)

14 Professor S. Ghosh, University of Washington, Seattle, USA (February 1991)

15 Professor L. M. Brown, North Western University, Evanston, Illinois, USA (February 1991)

16 Dr. Dhananjay Pandey, School of Materials Science & Technology, Banaras Hindu University, Varanasi (March 1991)

17 Professor S. K. Dey, Department of Mathematics, Eastern Illinois University, Charleston, USA (May/June 1990)

Theoretical Physics Seminar Circuit

The Centre continued to function as the Coordinating Centre of the Theoretical Physics Seminar Circuit (TPSC). The following scientists visited Calcutta under the programme and delivered lectures :

1 Rahul Pandit, Indian Institute of Science, Bangalore, 'Hysteresis in model spin systems' and 'The statistical mechanics of micelles and microemulsions' (April 1990).

2 Avinash Dhar, Tata Institute of Fundamental Research, Bombay, '2-Dimensional quantum gravity and string theory' (April 1990).

3 Radha Balakrishnan, Institute of Mathematical Sciences, Madras, 'Non-linear dynamics in superfluid ^4He ' and 'Solitons in condensed matter physics' (April 1990).

4 Ashoke Sen, Tata Institute of Fundamental Research, Bombay, 'Recent developments in string theory' and 'Background independence of string field theory' (April 1990).

5 N. D. Hari Dass, Institute of Mathematical Sciences, Madras, 'Chern-Simons field theory, knot invariants' (April 1990 in TPSC Annual Meeting and Two-day Seminar).

6 S. M. Bhattacharjee, Institute of Physics, Bhubaneswar, 'A polymer chain in annealed media' (April 1990 in TPSC Annual Meeting and Two-day Seminar).

7 A. P. Pathak, University of Hyderabad, Hyderabad, 'Charge particle probes to solid state physics - recent developments' (April 1990 in TPSC Annual Meeting and Two-day Seminar).

8 S. M. Roy, Tata Institute of Fundamental, Research, Bombay, 'Quantum violation of Einstein-Bell locality for three and four particle systems' (April 1990 in TPSC Annual Meeting and Two-day Seminar).

9 V. B. Sheorey, Physical Research Laboratory, Ahmedabad, 'Chaotic quantum systems' (April 1990 in TPSC Annual Meeting and Two-day Seminar).

10 Subir K. Sarkar, School of Physical Sciences, Jawaharlal Nehru University, New Delhi, 'A mean field theory of scaling in immiscible radial viscous fingering' (June 1990).

11 J. Parikh, Physical Research Laboratory, Ahmedabad, 'Classical quark matter—non-perturbative aspects' (January 1991).

12 Vipin Srivastava, School of Physics, University of Hyderabad, 'Confluence of localized and extended states in disordered systems' and 'Surprises in the Hall effect' (January 1991).

13 Rupamanjari Ghosh, School of Physical Sciences, Jawaharlal Nehru University, New Delhi, 'Non-classical effects in optical interference', 'From ordinary lasers to a novel "squeezed" laser' and 'Wigner function description of quantum non-locality in non-linear optical processes' (February 1991).

Research Activities at the Centre

Physics

The research activities in physics are in the areas of particle physics, foundation of quantum mechanics, condensed matter physics and mathematical physics.

Dr. P. Ghose, Dr. D. Home and Dr. G. S. Agarwal have proposed a new experiment to throw more light on the wave-particle duality of 'single photon states' [Phys. Lett. A 153, 403 (1990)]; the corresponding experimental work has begun at the Central Research Laboratory of Hamamatsu Photonics K. K., Japan, by Y. Mizobuchi and his group. Another experiment to test the postulate of the collapse of the wave-function through single neutron interference was presented at the International Conference on Neutron Scattering at BARC in January 1991. A manifestly covariant formulation of the Einstein-Podolsky-Rosen (EPR) paradox in quantum field theory has been developed using the Tomonaga-Schwinger formalism, showing that the key issue involved in the EPR problem is locality (i. e. Einstein's 'separability condition') and not Lorentz invariance or compatibility with special relativity. Work is in progress to study the nature of quantum non-locality through interference experiments.

The particle physics work has concentrated on fermionic currents, Chern-Simons (CS) currents, cosmology and quark gluon plasma. The problem of the violation of the Jacobi identity in the algebra of fermionic currents has been shown to be connected to point-splitting regularization and the Bjorken-Johnson-Low (BJL) formalism. A modification in the definition of a double commutator is suggested by R. Banerjee and H. J. Rothe ; this manifestly respects the Jacobi identity and is also compatible with reasonable consistency conditions. CS currents in odd dimensions and their relation with anomalies in even dimensions have been studied within the perturbation framework. The possibility of quantization of pure CS theory with a modified sixth order Higgs potential is being investigated. Bose-Fermi equivalence in 2+1 dimensions in the presence of the CS term has been studied. It has been shown via path integral methods that a theory of non-self interacting charged scalars coupled to abelian CS gauge fields is equivalent to a free fermion theory while a self interacting scalar field theory is equivalent to a self interacting fermion theory. The above results do not depend on Polyakov's long wave length approximation. Background equation and space-time dimensionality are derived for Neveu-Schwarz-Ramond (NSR) superstring in curved background via Krichever-Novikov formalism on higher genus Riemann surfaces. The space-time turns out to be Ricci flat and of dimensionality ten. The same formalism is being tried to formulate constrained algebra for heterotic strings in the presence of gravitons, gauge fields and antisymmetric tensor fields.

In the bag model, the phase transition to quark-gluon plasma with colour-singlet hadron formation has been explored.

The workshop on Electronic Structure of Random Alloys held at the Centre in November-December 1991 has started several collaborative projects. Dr. A. Mookerjee has started collaborative work with Dr. G. P. Das and Mr. H. Salunke of BARC, Bombay, on Linearized Muffin Tin Orbitals (LMTO)-based Augmented Space-Recursion applied to binary alloys CuPd, NiCr and AuFe. A. Datta has tested out the Augmented Space Recursion on a model cubic alloy. The Tight Binding Linearized Muffin Tin Orbitals (TB-LMTO) parameters for a series of metals Cu, Ni, Pd and Cr have been obtained. Dr. A. Mookerjee's collaborative work with Drs. R. Prasad, R. M. Singru and Vijay Singh of IIT, Kanpur, has progressed satisfactorily with the formulation of the Augmented Space Formulation-Korringa-Kohn-Rosboker (ASF-KKR) based cluster calculations. This technique is being employed on Vanadium-based refractory alloys. Dr. Mookerjee of the Centre and Dr. M. Ahmed of the University of Dhaka, Bangladesh, have developed the Embedding Approach to small clusters. This work on the total energy calculations on clusters is a part of the Exchange Programme the Centre has established with the University of Warwick.

Moessbauer spectroscopic studies of iron-bearing minerals in Singhbhum were completed ; all the shales found in the iron ore region—black, green, brown and purple — and the banded iron formation (BIF) were examined. The iron minerals were identified and their relative concentrations measured. The technique yields the ferrous to ferric ratio most easily. Further work on magnetites and hematites of Ari-Dongri, Bastar, and chlorites and chromites of Sukinda was also completed. The work forms the basis of the Ph.D. thesis of D. Das submitted to the Jadavpur University. Analysis of radiation damage of stainless steel under low energy proton bombardment by conversion electron Moessbauer spectroscopy has been completed. A new result showing extra lines has been found in this analysis.

A theoretical study of laser operation and laser transitions has been initiated. Optical Bloch equations for a three level system with three allowed transitions in the presence of an infrared pump were solved to study Doppler free radiofrequency lineshape.

Based on the above work, the following papers have been completed and already accepted for publication :

1. Ghose P. and Home D.—A manifestly Lorentz covariant formulation of the Einstein-Podolsky-Rosen problem using the Tomonaga-Schwinger formalism (Physical Review A.)

2. Ghose P., Ansari A , Dey J., Dey Mira and Matin M.A.-Colour singlet hadron formation and phase transition to quark-gluon plasma in the bag model (Hadronic Journal).

3. Ghose P. and Home D.—Testing wave function collapse and the complementarity principle using neutron self-interference and tunnelling (Physica B).

4. Ghose P. and Home D.— Simultaneously sharp wave and particle-like property of single photon states in a two prism experiment (in the Proceedings of International Conference on Quantum Optics (Jan 5-10, 1991), School of Physics, University of Hyderabad, Hyderabad).

5. Banerjee R. Chern Simons terms and anomalies in gauge theories (Mod. Phys Lett. A).

6. Banerjee R. and Rothe H.J.— A novel approach to double commutators in chiral gauge theories consistent with Jacobi identity (Int. J. of Mod. Phys. A).

7. Banerjee H., Chatterjee D., and Banerjee R.—Electric dipole moment of the neutron in the standard model from dynamical breaking of chiral symmetry (*Mod. Phys. Lett. A*).

8. Maharana J., Paul S. K. and Sengupta G.—Krichever-Novikov Global operator Formalism : NSR Superstring in curved background (*Commun. Math. Phys.*).

9. Ghoshal S. and Datta A.—Doppler-free RF lineshape theory for a three level system with three allowed transitions in the presence of an IR pump (*J. Chem. Phys.*)

10. Raazee S.S.A., Mookerjee A., and Prasad R.—Analyticity of the KKR-Augmented Space-Cluster CPA (*J. Phys. Condensed Matter*)

11. Raazee S.S.A., Rajput S.S., Mookerjee A, and Prasad R.—KKR-Augmented space-CCPA : an application to a random one dimensional Kronig-Penny model (*Phys. Rev. B*).

Research Projects

1. Quantum Transmittance through Random Media

This research project with Professor A. Mookerjee is sponsored by the Department of Science and Technology, New Delhi, and is progressing satisfactorily. Two research scholars Indra Dasgupta and Tanusri Saha have joined. A Quantum 386/387 machine has been installed. The vector recursion programme and the package for obtaining the S-matrix have been set up. Use of efficient techniques cuts down the running time by an order of magnitude, so that very large systems are now amenable to computation. Transmittance in incommensurate systems like the generalized Aubry models and Azbel resonance in random chains have been studied. The computer programmes have been successfully run on two dimensional random lattices. Large random lattices, as large as any studied anywhere else till date, have been looked at. To study Quantum Percolation, real space renormalization of resistance is carried out. This work by A. Mookerjee, C. Basu, I. Dasgupta and T. Saha at the Centre is in collaboration with Drs. B. K. Chakravorti, A. C. Sen and P. K. Thakur of the Saha Institute of Nuclear Physics, Calcutta. An alternative approach by differential equations is being explored by S. K. Manna to study transmittance through continuous disordered media.

Based on this work, the following papers have been accepted for publication :

1. Basu C., Mookerjee A., Sen A. K. and Thakur P. K.— Metal Insulator transition in certain one-dimensional incommensurate systems in *J. Phys. (Condensed Matter)*.

2. Basu C., Mookerjee A., Sen A. K. and Thakur P. K.—Azbel Resonances in *J. Phys. (Condensed Matter)*.

2. High Tc Superconductivity

This project is sponsored by National Superconductivity Programme (NSP) (earlier by Programme Management Board (PMB) on Superconductivity) and is carried out in collaboration with the Variable Energy Cyclotron Centre, Calcutta. Dr. R. Chaudhury was research scientist in this project and resigned on Feb 22, 1991 (the vacancy has been advertised and a new person has to be appointed).

The infrared conductivity data in the high temperature (normal) phase of the oxide superconductors exhibits a finite-frequency peak and also a Drude-like behaviour for very low frequency. On this basis R. Chaudhury has explored the role of fluctuation in the microscopic mechanism for superconductivity. R. Chaudhury, with J. Chakrabarti of the Indian Association for the Cultivation of Science, has investigated 'coherent bond states' (CBS) relevant to tight-binding like models appropriate to high Tc systems and found gapless and massive models of excitation ; they have noted that charge fluctuation in the form of global Fermion number fluctuation leads to the stabilization of long range phase coherent bond state. The work is included in these papers accepted for publication :

(i) Chaudhury R., Chakrabarti J. and Sen S.—'The Algebra of the Coherent Bond States' (in *Mod. Phys. Lett. B*).

(ii) Chaudhury R. and Chakrabarti J.—'Coherent Bond States' (in *International J. Mod. Phys. B*).

A (2212) pellet of Bi-Sr-Ca-Cu-O of superconducting transition temperature 64K when exposed to 20 Mev alpha particles for a dosage 10^{16} alpha/cm² showed a rise in Tc by about 4K. This rise was unexpected and could be due to precipitation of metastable phases of higher Tc. The experiment was repeated with other samples : the rise is there but seems to disappear with thermal cycling. Also, at even higher doses, Tc is expected to decrease. Further experiments suggested by these observations are in progress. Preliminary reports have been presented in.

(i) Studies of Bi-Sr-Ca-Cu-O Superconductor under Alpha particle irradiation : preliminary report by P. Barat, S. K. Bandyopadhyay, A. Poddar, P. Mandal and C. K. Majumdar (Reported at 'Discussion Meeting on High Tc Superconductors' at J. Nehru Centre for Advanced Scientific Research, Ind. Inst. of Science, Bangalore, August 8-10, 1990) ;

(ii) Study of Bi-Sr-Ca-Cu-O Superconductors by Positron Annihilation and Alpha Particle Irradiation by S. K. Bandyopadhyay, P. Barat, P. Mandal, A. Poddar, P. M. G. Nambissan, P. Sen, P. Choudhury, B. Ghosh and C. K. Majumdar (XIth National Symposium in Cryogenics (ENSC-90), IIT, Kharagpur (2-4 January 1991).

Mathematics, Mathematical Modelling

S. K. Bose completed his investigation on ultra-high frequency longitudinal shear waves in a unidirectional fibre reinforced composite.

Particles in the atmosphere are of interest in ecological problems. S. K. Sharma has been studying optical scattering from such particles. The angular intensity functions for concentric spheres comprising a quartz core and a biological coating were examined for various coating thicknesses in the context of hydrological particles. Results indicated that it was possible to distinguish between homogeneous and coated spheres from their light scattering patterns if coating thickness was $\geq 0.75\mu\text{m}$. The derivation of the anomalous diffraction approximation from the Mie formulae was reexamined. The usual requirement $|m-1| \ll l$, m being the relative refractive index of the scatterer, was found to be over-restrictive. Relationship of the anomalous diffraction approximation with the eikonal approximation was also investigated. Work on examining the validity of various backscattering formulae for light scattering from spheres is progressing.

Dr. S. Banerjee has been working on designing parallel algorithms for some problems related to physics. In this connection she attended the advanced computing workshop in CDAC, Pune.

Collaborative Research with Warwick University, U.K./LINK Programme

Professor A. Mookerjee visited Warwick University during June 16-30, 1990, to acquaint himself with the problems of common interest and to formulate related theoretical problems that could be pursued at Calcutta. The collaborative work with the Catalysis laboratory of Dr. A. K. Bhattacharya which was identified with the catalytic effects of small transition and rare metal and bimetallic particles. In particular these include small metallic and bimetallic particles of Ag, Cu, Pd and Ru and how they bind to groups like $-\text{NH}_3$, $-\text{CO}$ and $-\text{O}$ to form particles

of varying size and geometry. Subsequently at the S. N. Bose Centre, computer packages for total energy calculation on finite clusters are being developed.

Unfortunately, the crisis in the Kuwait—Iraq region started in August 1990, culminating in a war in January 1991. All foreign visits were banned. We have, however, kept Dr. Bhattacharya informed of our progress and are planning some future work.

Publications

A. Scientific Journals

1. Banerjee R. and Chatterjee D. : Chern-Simons term in curved space time—*Mod. Phys. Lett. A5(11)* 815-21 (1990).
2. Banerjee R, Rothe H J and Rothe K D : On the violation of the Jacobi identity in the algebra of fermionic currents—*Mod. Phys. Lett. A5* (1990) 1103.
3. Banerjee R : Covariant anomalies and Schwinger terms in anomalous gauge theories—*Mod. Phys. Lett. A5* (1990) 2741-2746.
4. Banerjee R, Rothe H J and Rothe K D : B JL definition of double commutators and the Jacobi identity—*Mod. Phys. Lett. A5* (1990) 2147.
5. Chatterjee Ashok : Multidimensional bound optical polaron revisited—*Annals of Physics, 202* (2) 320-350 (1990).
6. Ghose Partha, Home D, Agarwal G S : An experiment to throw more light on light—*Phys. Lett. A 153*, No. 8, 9, 403-406. (1991).
7. Majumder C K : Resonating valence bond states in antiferromagnetism (Satyendra Nath Bose Medal Lecture-1989)—*Proc. Indian Natn. Sci. Acad., 56*, A, No. 4, 1990, 301-314.
8. Mookerjee A : Conductivity in dirty systems : effect of dynamic electron-phonon coupling—*J. Phys Condensed matter* 2 9399 (1990).
9. Mookerjee A. and Jayannavar A : Wave function envelope decay in one-dimensional random potentials—*Pramana* 34 441 (1990).
10. Mookerjee A and Mishra A K : The augmented space CCPA for magnetic alloys : application to NiFe systems—*Int J Mod Phys B* 4 605 (1990).

11. Mookerjee A, Rajput S S, Razee S S A, and Prasad R : Application of the KKR CCPA to an S phase shift semi-circular model — *J. Phys. Condens. Matter* 2 (1990), 2653.
12. Paul S. K, Shankar R, and Sivakumar M : Fermionization of self interacting charged scalar fields coupled to Abelian Chern-Simons gauge fields in 2+1 dimensions—*Mod. Phys. Lett. A* 6 553-8 (1991).
13. Sil S, and Chatterjee Ashok : Multidimensional Frohlich bipolaron and dimensional scaling. *Int. J. Mod. Phys. A* 4 1879 (1990).
14. Sivakumar M, and Rindani S D : Kaluza-Klein reduction and consistency of the massive spin-3/2 theory with external interaction—*Z. Phys. C—Particles and Fields* (1990).
15. Sivakumar M, Shaji N, and Shankar R : On Bose-Fermi equivalence in a U(1) gauge theory with Chern-Simons actions—*Mod. Phys. Lett. A*, 5, (8) 593-603 (1990).

B. Proceedings of Conferences and Symposia

1. Banerjee Srilekha : An M-code interpreter for X-puter system—*Proc. National Seminar on Parallel Computer Systems and their Applications* (October 1990) organized by Indian Physical Society.
2. Das D, and Majumdar C K : Study of Iron minerals in eastern India by Moessbauer Spectroscopy—*National Seminar on Physics in Earth Sciences*, organized by Indian Physical Society at the Indian Museum Complex (February 1991).
3. Dey Suhrit and Dey R. : A differential equation solver for numerical models—*Proc. Multiconference on Computer Simulation*, Los Angeles (January 1991).
4. Mookerjee A. : Electronic properties of disordered alloys—*Proceedings of Recent Advances in Physics*, Dhaka, published by Bangladesh Physical Society (February 1991).
5. Mookerjee A. : Azbel resonance in disordered chains—*ICTP preprint 553*, July 1990, Trieste (TC/90/198).
6. Mookerjee A, Basu C, Sen A. K. and Thakur P. K. : Quantum mechanical transmittance in disordered systems—*Proc. IV Asia Pacific Phys. Conf.*, World Scientific, Singapore (September 1990) Volume 1. p. 519 (1990).

7. Roychowdhury P. : Relaxor ceramics for multilayer capacitor application—Proc. VI National Seminar on Ferroelectrics and Dielectrics, 17-19 December, 1990 at Kakatiya University, Warrangal.

C. Miscellaneous

1. Basu C., Mookerjee A., Sen A.K. and Thakur P.K. : Transmittance in the generalized Aubry model—ICTP preprint 552/July 1990 Trieste (TC/90/197).

2. Bose S. K., Ultra-high frequency longitudinal shear waves in a unidirectional fibre reinforced composite (Research report pp. 1-16. SNBNCBS).

3. Ghose Partha : Syadvada—History of Science & Technology in Ancient India (II. Formation of Theoretical Fundamentals of Natural Science) edited by Prof. Debiprasad Chattopadhyay and published by Firma KLM Pvt. Ltd., Calcutta.

4. Ghose Partha : Scientific Studies in Calcutta : The Colonial Period (Vol. 1) and Scientific Research in Twentieth Century Calcutta (Vol. II), Calcutta the Living City (ed. Sukanta Chaudhuri), Oxford University Press, 1990.

5. Ghose Partha : Padartha Vijnaner Chokhe Srsti, Jnan O Vijnan, August-September issue 1990 (in Bengali).

6. Ghose Partha and Home D. : Quantum pot watching, Current Science (as research news), 59, 19, Oct. 1990, pp. 897-898.

7. Majumdar C. K. : Ramanujan's work and statistical mechanics, Physics News 20 (No. 2 & 3) June-September 1989, pp. 93—97.

8. Majumdar C. K. : Science & Technology in the Indian Epics, Transactions of the Bose Research Institute, Vol. 53, No. 1, 1990, pp. 1-11.

9. Majumdar C. K. : Book Review—Mehra, Jagdish, and Rechenberg, Helmut, *The Historical Development of Quantum Theory* : Vol. 5 Part I : Erwin Schroedinger and the Rise of Wave Mechanics : Part 2 : The Creation of Wave Mechanics : Early response and applications 1925-26 (Springer Verlag, New York, Berlin and Heidelberg, 1987) in Indian Journal of History of Science, pp. 341-344 (1991).

Conferences attended and seminars/talks by the Centre's staff

Dr. R. Banerjee : Talked on 'BJL definition of double commutators consistent with the Jacobi identity' at the Schladming Winter School, Schladming, Austria (March 1990).

— : Talked on 'Anomalies and index theorems in the path integral approach' at the Inst. f. Theor. Physik, Univ. Heidelberg, Germany (April 1990).

— : Talked in a seminar on 'A novel approach to double commutators in chiral gauge theories compatible with the Jacobi identity' at Heidelberg University (November, 1990).

Dr. Srilekha Banerjee : Attended 'Workshop on High performance computing' organized by C-DAC, Poona University Campus (August 1990).

Dr. A. K. Bhattacharjee : Attended the International Congress on Ultra Low Doses held in Bordeaux, France (September 1990), presented a paper entitled 'A quantum chemical study of some model anti-inflammatory compounds : the preferred conformations and their electrostatic similarities', and was the co-Chairman of the 'Biophysics' session.

Dr. Ranjan Chaudhury : Delivered a set of invited lectures on 'Overview and recent advances in high-temperature superconductivity' at the Indian Association for the Cultivation of Science during May 2-4, 1990.

Dr. Partha Ghose : Talked in a Colloquium on 'The quantum Zeno effect' organized at the Department of Physics, Visva-Bharati, Santiniketan.

— : A talk entitled 'Is there a fifth force?' was broadcast by the All India Radio on April 25, 1990 at 9-30 P. M.

— : Talked on 'High tech : quo vadis?' in a meeting organized by the Rotary Mid-Town, Calcutta at Oberoi Grand Hotel on April 23, 1990.

— : Talked on 'Quantum Zeno effect' at the Bose Institute on June 15, 1990.

— : Talked on 'Topology of the vacuum : the Aharonov-Bohm effect' at the National Seminar (Phase II) held in memory of Sir Asutosh Mookerjee at the Department of Pure Mathematics, University of Calcutta, June 1990.

— : Attended a UGC sponsored National Seminar on 'Man and Nature' at North Bengal University and delivered a talk on 'The Re-enchantment of Nature', and also chaired one session (September 1990).

— : Delivered 'S. K. Mitra Centenary Lecture' on 'Quantum pot watching' at Saha Institute of Nuclear Physics (August 1990).

— : Chaired one session of the Young Scientists Colloquium organized by the Indian Physical Society at Saha Inst. of Nuclear Physics (August 1990).

— : Participated in the UGC sponsored Video Festival at St. Xavier's College, Calcutta (December 1990).

— : Delivered a talk on 'Creation : A Physicist's Perspective' at the Academic Staff College, University College of Science, Calcutta (December 1990.)

— : Delivered a talk on 'Quantum non-locality' at the Indian Institute of Science, Bangalore (January 1991).

— : Attended the International Conference on 'Neutron Scattering' at the Bhabha Atomic Research Centre, Bombay, (January 21-25), chaired a session and presented a poster session based on a joint paper (with D. Home) entitled 'Testing wave function collapse and the complementarity principle using neutron self-interference and tunnelling'.

— : Attended an International Workshop on 'Calcutta Retrospect and Prospect' organized by the University of Calcutta and the Netaji Institute of Asian Studies, Calcutta (February 1991). Also, gave a talk on 'Calcutta and the development of Science in India'.

— : Attended a Seminar on 'Calcutta and the development of Science in India' organized by the Calcutta Tercentenary Celebrations Committee of the University of Calcutta (March, 1991) and gave a talk on Science in Calcutta : the Colonial Period.

Dr. C. K. Majumdar : Attended the get-together of Bhatnagar laureates in New Delhi (April 3 & 4, 1990).

— : Attended Workshop on Research and Development organized by Inter University Consortium, Calcutta Centre, at VECC, Salt Lake and talked on 'Materials Science Studies with Medium Energy Accelerators : Current Possibilities and Future Prospects' (July 1990),

— : Attended the Young Scientists' Colloquium—1990 held at the auditorium of Saha Institute of Nuclear Physics (August 1990).

— : Talked at Jadavpur University on 'Corrosion Studies through Moessbauer Spectroscopy' (August 1990).

— : Attended the Discussion Meeting of High Tc Superconductors : Critical Analysis of Experimental Facts at Jawaharlal Nehru Centre for Advanced Scientific Research at Bangalore (August 1990).

— : Attended a seminar on 'Vibration problems of mathematical elasticity and physics' organized by A. C. College, Jalpaiguri, West Bengal.

— : Attended 'CSI-90 Calcutta,—an exhibition of state-of-the-art Computer Systems organized by the Computer Society of India (October/November 1990).

— : Attended a seminar on 'Models of Climatic Change' organized by the Centre for Atmospheric Sciences at University College of Science, Calcutta (November 1990).

— : Attended the National Seminar on 'The Sun and our environment' at the Birla Planetorium arranged by the Indian Astronomical Society (February 1991).

— : Lectured on Electromagnetic Properties of BCS superconductors in the 5th SERC School in Condensed Matter Physics "Superconductivity" (December 1990).

— : Attended and spoke at the valediction function of Eastern India Science Fair and Camp at Birla Industrial and Science Museum, Calcutta (February 1991).

— : Attended the Seminar on Ceramics and Glasses for electronic applications at Central Glass and Ceramic Research Institute (CGCRI), Calcutta (Material Research Society, Calcutta Chapter) (March 1991).

— : Attended the Symposium of CASAMCU and a seminar given by Dr. P. K. Das on 'Will the Indian Monsoon be affected by the burning oil wells of Kuwait?' (March 1991).

Dr. A. Mookerjee : Attended the Fourth Asia Pacific Physics Conference organized by Korean Physical Society. The Conference was held at the Yonsei University, Seoul (August 1990).

— : Gave a colloquium on 'Transmittance in Random Systems' at Indian Institute of Technology, Kanpur (September 1990).

— : Visited University of Dhaka, Bangladesh, in connection with a collaborative programme and talked on 'Embedding Method and Alloys' (October 1990).

— : Participated in the International Conference on 'Disordered Materials (Structure & Properties)' organized by the International Disordered-Systems Associates Society (INDIAS) at the Devi Ahilya University, Indore ; delivered an invitation talk entitled 'Transmittance through disordered media' ; and also chaired a session (February 1991).

Dr. Samir K Paul : Attended Summer School in High Energy Physics and Cosmology at ICGP, Trieste, Italy (June-July, 1990),

— : Visited Institute of Physics, Bhubaneswer and gave a seminar on 'Factorization of Zero Curvature representations' organized by the Particle Physics Group (March 1991).

Honour received by the Centre's Staff

Dr. C. K. Majumdar was elected a Fellow of the National Academy of Sciences, India, at Allahabad.

Library

In the year 1990-91, the S. N. Bose National Centre Library added to its collection 122 new books including a set of New Encyclopaedia Britannica (32 vols, 15th ed. 1990).

Two foreign journals : (i) Nature and (ii) Journal of Physics A : Mathematical and General ; and one Indian journal, Indian Journal of Pure and Applied Physics were added to 1991—subscription. So the list of journals subscribed is as follows :

A. Foreign Journals

1. Computer Journal
2. Computers in Physics
3. Journal of Physics A : Mathematical and General
4. Nature
5. Physical Review Letters
6. Physics Letters (Section A)
7. Physics Letters (Section B)
8. Physics Reports

B. Indian Journals

1. Bulletin of Material Sciences
2. Current Sciences
3. Indian Journal of Pure & Applied Physics
4. Journal of Astrophysics and Astronomy
- * 5. Journal of Biosciences
6. Journal of Genetics
7. Pramana
- * 8. Proceedings (Animal Sciences)
9. Proceedings (Chemical Sciences)
10. Proceedings (Earth and Planetary Sciences)
11. Proceedings (Engineering Sciences)—Sadhana
12. Proceedings (Mathematical Sciences)
- * 13. Proceedings (Plant Sciences)

The library renewed its subscription to SLAC reprints in *Particles and Fields* for 1990-91. Over 25 research institutes and universities, most of which located in foreign countries, offered their reprint/preprint service to our library.

In 1990, a preprint library with a small reading room was set up at CD 85, Salt Lake, the new location rented recently for the Centre. Regular transport service and other necessary facilities for using any one of the libraries are being provided to the academic members of the Centre.

Last year we received 99 books as gift from the American Center, Calcutta. Included in that collection was a complete set of McGraw-Hill Encyclopedia of Science and Technology (20 vols 6th edition, 1987) along with its four year books beginning from 1987 to 1990.

The library offered xerox facilities to its users during seminars, symposia and other academic activities. More than eight thousand xerox copies of different materials were distributed last year. We must also acknowledge free xerox service provided by Kilburn Reprographics, Calcutta, to participants who attended in 1991 the second International *Workshop on High Energy Physics Phenomenology (WHEPP II)*, organized by the Centre.

* Proceedings (Animal Sciences) and Proceedings (Plant Sciences) merged with Journal of Bioscience from 1991.

COMPUTER CENTRE

The HP 9000 System, which was made operational in September 1989, has performed very satisfactorily during the period April '90 to March '91 and proved to be the mainstay of operation of the Centre. The System comprises a 19" B & W console, a hard disc, one cartridge drive, a dot matrix printer and a 8-pen graphics plotter. At present we are using one Quantum Work Station and a VT-100 compatible terminal as terminals of the HP 9000. This system is extensively used by scientist of this Centre and also some Scientists and Visitors from outside the Centre.

The number of users for the HP 9000 computer has recently increased considerably. As the storage capacity of the computer has become nearly full, we are planning to procure another Winchester Disk in near future. To provide short-term relief, files that are not frequently needed are transferred to a Cartridge Tape by the System Administrator.

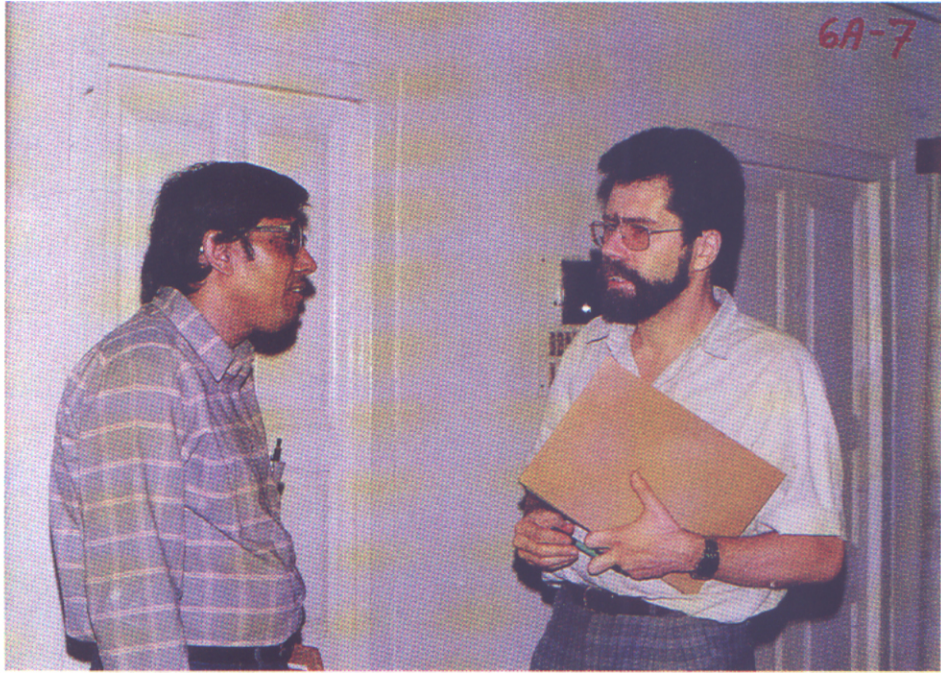
A Quantum PC with 80386 CPU running at 33 MHz, 80387 Co-Processor, 64 KB Cache Memory, 4 MB RAM has recently been installed as a part of a research project with Professor A. Mookerjee sponsored by the Department of Science & Technology. It is used for developing software packages. In addition a Quantum W. S. with Double Drive facility is used extensively for Teacher's Training Program.

The Centre is looked after by a Computer Engineer cum System Administrator who also provides day to day S/W consultancy.

From January '91 we have made operational a regular e-mail facility to World-wide network through NCST Bombay. The System Administrator acts as the 'POSTMASTER' of the e-mail in our Centre. The Centre has co-sponsored a National Seminar on Parellel Computer System and their Applications jointly with Variable Energy Cyclotron Centre, Indian Physical Society and Jadavpur University. Some courses on Structured language on PASCAL and OCCAM will be offered in the near future. We have already purchased *CODE* from CDAC for running OCCAM programs on PC.

This year the Teachers Training Course was started in December 1990. Twelve College Teachers have been attending the Centre. The course material remains the same as before : MSDOS, GWBASIC, and elements of WORDSTAR and FORTRAN 77. Each teacher has two hours hands-on experience on a machine per week. There is a growing demand for training in PASCAL and other utility software programmes. This can be considered later.

The Centre also plans to purchase Desk Top Publishing S/W and Laser Printer.



CONSTRUCTION OF THE NEW CAMPUS

Based on the decision of the Governing Body at its meeting held on December 14, 1989, the Centre is working towards implementation of the Master Plan designed by the Consultant Architects, Ghosh, Bose and Associates. As a first step towards it the work of piling and foundation had been started. Gannon Dunkerley & Company, one of the six firms which were shortlisted, submitted the lowest quotation and was recommended by the Consultant Architects for pile foundation work. The recommendation was unanimously accepted by the Construction Committee. On November 14, 1990 the work order was handed over to the Company. The first pile was struck on December 24, 1990. As on March 31, 1991, 244 piles have been driven. This represents about 39% of the work. At the moment piling work is going on for the main building, guest house and one block of the essential staff quarters. The work is expected to take about six months.

Construction of some of the major buildings will start as soon as the pile foundation work is over and climatic conditions permit. A total of 19 major construction companies from all over India had expressed interest in getting involved in the work of construction of the Centre's campus. Tenders will soon be obtained from a group of selected firms on the basis of the recommendation of the Consultant Architects and approval of the Construction Committee. The Centre hopes to get a 'go-ahead' for construction of the buildings from the Salt Lake Notified Area Authorities soon.

With the help of Globe Nursery, a well-known horticultural firm, the work of landscaping of the campus is continuing.

MEETING OF THE VARIOUS COMMITTEES OF THE CENTRE

The Construction Committee of the Centre had its meetings on May 19 & November 9, 1990 at the office of the Director. The present members of the Committee are :

1. The Director, S. N. Bose National Centre (Chairman)
2. Professor G. S. Sanyal, Director, STEP, IIT, Kharagpur (Member)
3. Professor T. K. Chattopadhyay, Department of Architecture, Jadavpur University (Member)
4. Mr A. Chattopadhyay, SSW(EZ), C.P.W.D. (Upto 5.7.1990) (Member)
Mr P. S. Chadha, SSW(EZ), C.P.W.D. (after 5.7.1990) (Member)
5. The Administrative officer, S. N. Bose National Centre (Member-Secretary)

At its meeting held on May 19, 1990, the Committee approved of the short list prepared by the Consultant Architects of firms for piling and foundation work with some alterations which, later on, were adhered to. On November 9, 1990, the Committee, inter alia, approved the appointment of the Project Engineer and endorsed the recommendation made by the Consultant Architects about the award of piling and foundation work to Gannon Dunkerley & Co. Ltd.

The Finance Committee of the Centre met on November 16, 1990, Members of the Committee are :

1. The Director, S. N. Bose National Centre (Chairman)
2. Joint Secretary & Financial Adviser,
Department of Science & Technology
Government of India (Member)
3. Secretary, Finance Department
Government of West Bengal (Member)
4. Professor A. Raychaudhuri, FNA, FASc,
INSA Senior Scientist, Calcutta (Member)
5. Director, Indian Association for the
Cultivation of Science, Calcutta (Member)
6. The Administrative officer,
S. N. Bose National Centre (Member-Secretary)

At its meeting, the Committee, among other things, approved of the Statement of Accounts for 1989/90 prepared by Roy & Bagchi, Chartered Accountants and presented by the Director.

Despite several attempts, the Governing Body and the General Body of the Centre could not meet during the period under review owing to non-availability of a date suitable to most members.

Finance

Roy & Bagchi, a firm of Chartered Accountants based at Calcutta, who were approved by the Governing Body, audited the accounts of the Centre for the period between April 1, 1989 and March 31, 1990. The report was submitted on June 25, 1990. The office of the Director of Audit, C. W. & M, Calcutta Branch, audited the accounts of the Centre for the period from April 1, 1989 to March 31, 1990 and submitted its report on January 8, 1991. Copies of the Budget Estimates for 1991-92 and Statement of Expenditure for 1990-91 are given in the annexures to the Centre's report. Copies of the report on audit of accounts for 1989-90 by Roy & Bagchi and the report of the account of the Centre for the same period submitted by the office of the Director of Audit, Government of India, are available for inspection.

Centre's Staff as on March 31, 1991

Academic

- 1) Dr Chanchal Kumar Majumdar Director
- 2) Dr Partha Ghose Academic Programme Coordinator
- 3) Dr Abhijit Mookerjee Professor
- 4) Dr Subodh Kumar Sharma Reader
- 5) Dr Ashok Chatterjee Post Doctoral Fellow (Left in June 1990)
- 6) Dr M Sivakumar Post Doctoral Fellow (Left in June 1990)
- 7) Dr Rabin Banerjee Post Doctoral Fellow
- 8) Dr Samir Kumar Paul Post Doctoral Fellow
- 9) Dr Ranjan Chaudhury Post Doctoral Fellow
- 10) Mrs Rina Das Scientific Officer

Administrative, Technical and Auxiliary

- 1) Dr Jyotirmoy Pal Chaudhuri Administrative Officer
- 2) Dr Santi Gopal Basu Librarian
- 3) Mr Apurba Kanti Sarkar Administrative Assistant (Accounts)
- 4) Mr Bhaskar Das Gupta Office Superintendent
- 5) Mr Sunish Kumar Deb Stenographer
- 6) Mr Tapan Kumar Sen Junior Assistant
- 7) Mr Sukanta Mukherjee Junior Assistant
- 8) Mr Jaydeep Kar Junior Assistant
- 9) Mr Prasenjit Talukdar Junior Assistant
- 10) Mr Pradip Kumar Bose Helper
- 11) Mr Partha Chakraborty Helper

Personnel on Campus Construction

- 1) Mr Nirmal Bhattacharya Project Engineer
- 2) Mr Samar Sur Sub-Assistant Engineer
- 3) Mr Kuntal Sarkar Sub-Assistant Engineer

Scientists on Projects

- 1) Dr Sharmistha Bhattacharya (Ne'e Ghoshal) Research Associate, CSIR
- 2) Ms Chaitali Basu Junior Research Fellow, CSIR
- 3) Mr Susil K. Manna Teacher Fellow, UGC
- 4) Mr Abhijit Datta Research Scholar, UGC
- 5) Mr Indra Dasgupta Junior Research Fellow, DST
- 6) Ms Tanusree Saha Junior Research Fellow, DST
- 7) Dr P. Roychoudhury Part Time Researcher

NOTE

According to a communication sent by the Department of Science & Technology, Government of India No. G. 20011 (2)/91-B & A/150 dated May 1, 1991 the amount proposed for the financial year 1991-92 and the amount passed by the Parliament as "Vote On Account" for the period from April to July, 1991, in respect of the S. N. Bose National Centre for Basic Sciences are as under :

AMOUNT IN LAKHS OF RUPEES

Amount proposed for 1991-1992			Amount Passed "Vote On Account"		
Plan	Non-Plan	Total	Plan	Non-Plan	Total
175	20	195	53.33	6.67	60

ANNEXURE
REVISED ESTIMATES 1990-91

Sl. No.	Item	Actuals			B.E. 1990-91	Actual upto 8/90
		1987-88	1988-89	1989-90		
1	2	3	4	5	6	7
1.	Typewriters	0.37	0.25	0.07	0.35	0.003
2.	Small Equipment	0.24	0.10	0.22	0.30	0.007
3.	Boundary Wall	0.10	10.30	—	—	—
4.	Construction of Building	—	0.27	10.97	300.00	0.10
5.	Computer Installation & Accessories	9.45	0.76	3.47	0.10	0.15
6.	Furniture, Fans & Lights, ACs & Installation of Telephones	1.21	0.81	1.03	0.50	0.53
7.	Library Books & Journals	0.55	1.38	1.73	2.30	0.10
8.	Library Almirah	—	0.14	0.17	0.20	—
9.	UPS	—	—	0.71	—	—
10.	Campus Beautification	—	—	0.40	0.50	0.16
11.	Xerox Machine	0.97	—	—	—	—
12.	Campus Land	—	0.61	—	—	—
13.	Campus Plan	0.28	—	—	—	—
14.	Purchase of Staff Car	—	1.05	—	—	—
15.	Overhead Reservoir & Water Supply	—	—	—	5.00	—
16.	Furnishing Accommodation For Visiting Scientists	—	0.73	0.03	0.10	0.007
TOTAL =		13.17	16.40	18.80	309.35	1.057

—|
AND BUDGET ESTIMATES 1991-92

(PLAN CAPITAL)

(FIGS. IN LAKHS)

Requirement for 9/90 to 3/91	R.E. 1990-91	Variation between B.E. & R.E. 1990-91	B.E. 1991-92	Variation between R.E. 1990-91 & B.E. 1991-92	Reasons for varia- tion between R.E. 90-91 & B.E. 91-92
8	9	10	11	12	13
0.147	0.15	(-) 0.20	0.45	(+) 0.30	
0.093	0.10	(-) 0.20	1.00	(+) 0.90	
—	—	—	—	—	
64.90	65.00	(-) 235.00	250.00	(+) 185.00	
0.15	0.30	(+) 0.20	5.30	(+) 5.00	
0.17	0.70	(+) 0.20	0.50	(-) 0.20	
2.40	2.50	(+) 0.20	3.00	(+) 0.50	
0.20	0.20	—	0.20	—	
—	—	—	0.70	(+) 0.70	
0.34	0.50	—	0.50	—	
—	—	—	—	—	
—	—	—	—	—	
—	—	—	—	—	
—	—	—	—	—	
0.30	0.30	(-) 4.70	5.00	(+) 4.70	
0.043	0.05	(-) 0.05	0.90	(+) 0.85	
68.743	69.80		267.55		

ANNEXURE

Sl. No.	Head of Account Major Head/Minor Head Detailed Head/Sub-Head	Actual			B.E. 1990-91	Actual upto 8/90
		1987-88	1988-89	1989-90		
1	2	3	4	5	6	7
1. Salaries						
Plan		166,031	340,416	—	426,860	—
Non-Plan		—	—	832,690	1,015,061	345,886
2. Office Expenses						
Plan		329,403	552,532	233,632	295,000	27,588
Non-Plan		—	—	779,137	1,140,500	341,534
Total Provision		495,431	892,948	1,845,459	2,977,421	715,008
Recoveries to be taken as reduction in expenditure		—	—	—	—	—
Net Provision		495,431	892,948	1,845,459	2,977,421	715,008

—I (Cont.)

(PLAN & NON-PLAN REVENUE)

(FIGURE IN RUPEES)

Anticipated Expenditure 9/90 to 3/91	R.E. 1990-91	Variation between B.E. & R.E. 1990-91	B.E. 1991-92	Variation between R.E. 90-91 & B.E. 91-92
8	9	10	11	12
177,656	177,656	(-) 249,204	440,204	262,548
669,175	1,008,753	(-) 6,303	1,040,738	31,985
267,412	226,000	(-) 69,000	876,000	650,000
798,966	1,027,200	(-) 113,300	1,102,500	75,300
1,913,209	2,439,609	(-) 437,812	3,459,442	1,019,833
—	—	—	—	—
1,913,209	2,439,609	(-) 437,812	3,459,442	1,019,833

ANNEXURE
Statement of
with effect from
NON-PLAN

Receipts	Amount	
	Rs.	P.
The Grant Received :		
SP/SN/003/90 dt. 23.04.90	4,00,000.00	
SP/SN/003/90 dt. 15.06.90	4,75,000.00	
Grant/2335 dt. 05.04.91	5,00,000.00	
Interest on Short Term Deposits		13,25,007.83
		<hr/> <u>27,00,007.83</u>

—II

Expenditure**01.04.1990 to 31.03.1991****RECURRING**

Payments	Amount	
	Rs.	P.
By Salary & Allowances	8,48,888.73	
„ Contribution to P.F.	45,297.00	
„ Medical Claim	27,842.63	
„ Provision for Gratuity	26,629.00	
„ Bonus	9,623.00	
„ Wages (Casual)	33,464.95	
„ Telephone & Trunkcalls	42,806.30	
„ Postage & Telegram	11,101.35	
„ Electricity charges	11,987.08	
„ Printing & Stationery	43,657.77	
„ Hire of Office Premises	2,23,200.00	
„ Hire of Transport	59,158.25	
„ TA/DA to Academic Staff (Abroad)	31,769.00	
„ TA/DA to Academic Staff (India)	22,132.00	
„ TA/DA to Non-Academic Staff	982.05	
„ Meeting Expenses	31,948.80	
„ Miscellaneous Expenses	19,921.92	
„ Visiting Scientists Fellows	97,641.34	
„ Publication of Seminar Proceedings	25,243.00	
„ Director's Research Expenses	60,997.32	
„ Academic staff Research expenses	15,594.38	
„ Library General Expenses	11,784.83	
„ Accommodation for Visiting Scientists	30,000.00	
„ Legal Expenses	2,400.00	
„ General Insurance Premium	15,067.00	
„ Computer Maintenance	1,65,000.00	
„ Car Maintenance	5,415.25	
„ P. O. L.	11,324.75	
„ TOTAL	19,30,877.70	
„ Balance	7,69,130.13	
	27,00,007.83	

S. N. BOSE NATIONAL CENTRE
Statement of
with effect from
PLAN-RECURRING

Receipts	Amount	
	Rs.	P.
To Balance C/d from Last year	...	1,20,95,742.06
„ Balance C/d from Non-Plan	...	7,69,130.13
„ Donation Received	...	—
„ Interest on Short Term Deposit	...	—
„ Grant-In-Aid Received :		
SP/SN/003/90 dt. 23.04.90	...	50,00,000.00
SP/SN/003/90 dt. 15.06.90	...	50,50,000.00

2,29,14,872.19

FOR BASIC SCIENCES
Expenditure
1.04.1990 to 31.03.1991
& NON-RECURRING

Payments	Amount	
	Rs.	P.
By A. Recurring		
„ Salary & Allowances	...	13,261.00
„ Generator Hire	...	9,790.00
„ Library Books	...	79,998.06
„ Library Journals	...	1,84,267.00
„ Seminar & Other Academic Expenses	...	1,85,690.55
		<u>4,73,006.61</u>
„ B. Non-Recurring		
„ Typewriters etc.	...	15,451.82
„ Small Equipment	...	9,953.60
„ Computer & Accessories	...	16,291.10
„ Campus Beautification	...	40,450.21
„ Construction of Building	...	33,98,922.96
„ Office Furniture	...	1,31,702.28
„ Installation of Computer	...	16,950.00
„ Library Almirah, Rack etc.	...	19,232.79
„ Furnishing Accommodation for Visiting Scientists	...	1,867.47
„ Building Maintenance	...	—
„ Office Maintenance	...	6,104.02
„ Repair to Equipment	...	312.00
		<u>36,57,238.25</u>
TOTAL (A+B)		<u>41,30,244.86</u>
„ Balance	...	<u>1,87,84,627.33</u>
		<u>2,29,14,872.19</u>

S. N. BOSE NATIONAL CENTRE FOR BASIC SCIENCES

Budget Estimate 1991-92

NON-PLAN RECURRING

A. Salary & Allowances

1. Director	...	Rs.	96,000.00
2. Academic Programme Co-ordinator	...	Rs.	62,400.00
3. Professor	...	Rs.	57,300.00
4. Administrative Officer	...	Rs.	53,025.00
5. Librarian	...	Rs.	45,250.00
6. Scientific Officer	...	Rs.	28,950.00
7. Post Doctoral Fellowship (4)	...	Rs.	1,09,200.00
8. Administrative Assistant (Accts.)	...	Rs.	25,020.00
9. Office Superintendent	...	Rs.	17,720.00
10. Stenographer	...	Rs.	17,960.00
11. Junior Assistant (4)	...	Rs.	47,760.00
12. Helper (2)	...	Rs.	18,504.00
13. D.A.	...	Rs.	1,84,980.00
14. H. R. A.	...	Rs.	1,09,200.00
15. C. C. A.	...	Rs.	17,160.00
16. Medical Expenses	...	Rs.	30,000.00
17. Festival Advance	...	Rs.	5,600.00
18. Bonus	...	Rs.	9,600.00
19. Contribution to P.F.	...	Rs.	60,109.00
20. Provision for Gratuity	...	Rs.	45,000.00
		Rs.	10,40,738.00

S. N. BOSE NATIONAL CENTRE FOR BASIC SCIENCES

Budget Estimate 1991-92

NON-PLAN RECURRING

B. Other Expenditure

1. Telephone & Trunkcalls	...	Rs.	40,000.00
2. Postage & Telegram	...	Rs.	30,000.00
3. Electricity Charges	...	Rs.	25,000.00
4. Municipal Tax	...	Rs.	500.00
5. Printing & Stationery	...	Rs.	50,000.00
6. Hire of Office Premises	...	Rs.	1,60,000.00
7. Hire of Transport	...	Rs.	50,000.00
8. T.A./D.A. for Academic Staff :			.
(a) Abroad	...	Rs.	50,000.00
(b) India	...	Rs.	30,000.00
9. T.A./D.A. for non-academic Staff	...	Rs.	3,000.00
10. Meeting Expenses	...	Rs.	60,000.00
11. Casual Labour	...	Rs.	40,000.00
12. Miscellaneous Expenses	...	Rs.	50,000.00
13. Visiting Scientists/Fellows	...	Rs.	1,00,000.00
14. Publication of Seminar Proceedings	...	Rs.	50,000.00
15. (a) Director's Research Expenses	...	Rs.	50,000.00
(b) Academic Staff Research	...	Rs.	50,000.00
16. Library General Expenses	...	Rs.	10,000.00
17. Accommodation for Visiting Scientists	...	Rs.	30,000.00
18. Legal Expenses	...	Rs.	5,000.00
19. Insurance Premium	...	Rs.	16,000.00
		Rs.	8,99,500.00

C. Maintenance

1. Computer Maintenance	...	Rs.	1,70,000.00
2. Car Maintenance	...	Rs.	8,000.00
3. P. O. L.	...	Rs.	25,000.00
		Rs.	2,03,000.00
Total Non-Plan Recurring (A+B+C)	...	Rs.	21,43,238.00

S. N. BOSE NATIONAL CENTRE FOR BASIC SCIENCES

Budget Estimate 1991-92

PLAN-RECURRING

A. Salaries & Allowances

1. Professor (2)	...	Rs.	1,18,800.00
2. Post Doctoral Fellowship (2)	...	Rs.	52,800.00
3. Stenographer (1)	...	Rs.	16,800.00
4. Driver	...	Rs.	11,400.00
5. D. A.	...	Rs.	86,454.00
6. H. R. A.	...	Rs.	40,800.00
7. C. C. A.	...	Rs.	5,880.00
8. Medical Claim	...	Rs.	20,000.00
9. Bonus	...	Rs.	3,500.00
10. Festival Advance	...	Rs.	1,600.00
11. Contribution to P. F.	...	Rs.	23,845.00
12. Provision for Gratuity	...	Rs.	8,325.00
13. L. T. C.	...	Rs.	50,000.00
		Rs.	<u>4,40,204.00</u>

B. Other Expenditure

1. Generator hire Charges	...	Rs.	40,000.00
2. Library Journals	...	Rs.	2,20,000.00
3. Library Books	...	Rs.	80,000.00
4. Seminar & Other academic expenses	...	Rs.	2,00,000.00
5. E-Mail	...	Rs.	1,00,000.00
6. T.P.S.C.	...	Rs.	5,00,000.00
		Rs.	<u>11,40,000.00</u>

C. Maintenance

1. (a) Building Maintenance	...	Rs.	15,000.00
(b) Office Maintenance	...	Rs.	20,000.00
2. Repair of Equipment	...	Rs.	1,000.00
		Rs.	<u>36,000.00</u>
Total Plan Recurring (A+B+C)	...	Rs.	<u>16,16,204.00</u>

S. N. BOSE NATIONAL CENTRE FOR BASIC SCIENCES

Budget Estimate 1991-92

PLAN NON-RECURRING

D. Equipment

1. Typewriter etc.	...	Rs.	45,000.00
2. Small Equipment	...	Rs.	1,00,000.00
3. U. P. S.	...	Rs.	70,000.00
4. Computer & accessories	...	Rs.	4,50,000.00
		Rs.	<u>6,65,000.00</u>

E. Buildings

1. Campus Beautification	...	Rs.	50,000.00
2. Construction of Building	...	Rs.	2,50,00,000.00
3. Water Supply	...	Rs.	5,00,000.00
	...	Rs.	<u>2,55,50,000.00</u>

F. Furniture & Fixture

1. Office Furniture	...	Rs.	50,000.00
2. Installation of Computer	...	Rs.	80,000.00
3. Library Almirah & rack etc.	...	Rs.	20,000.00
4. Furnishing accommodation for Visiting Scientists	...	Rs.	90,000.00
			<u>2,40,000.00</u>

Total Plan Non-Recurring (D+E+F)	...	Rs.	<u>2,64,55,000.00</u>
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Grand Total :

Non-Plan Recurring	...	Rs.	21,43,238.00
Plan-Recurring	...	Rs.	16,16,204.00
Plan Non-Recurring	...	Rs.	2,64,55,000.00
		Rs.	<u>3,02,14,442.00</u>

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