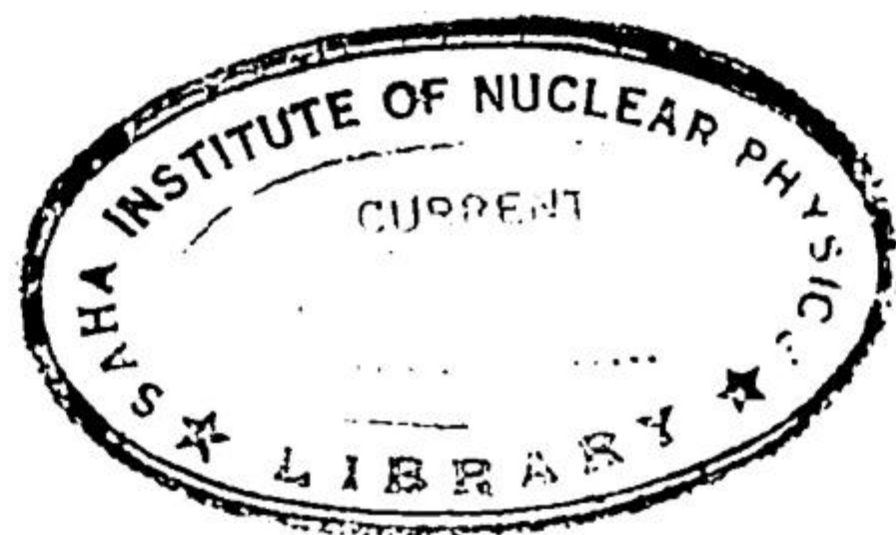


Annual Report

1982



SAHA INSTITUTE OF NUCLEAR PHYSICS
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CALCUTTA - 700 009

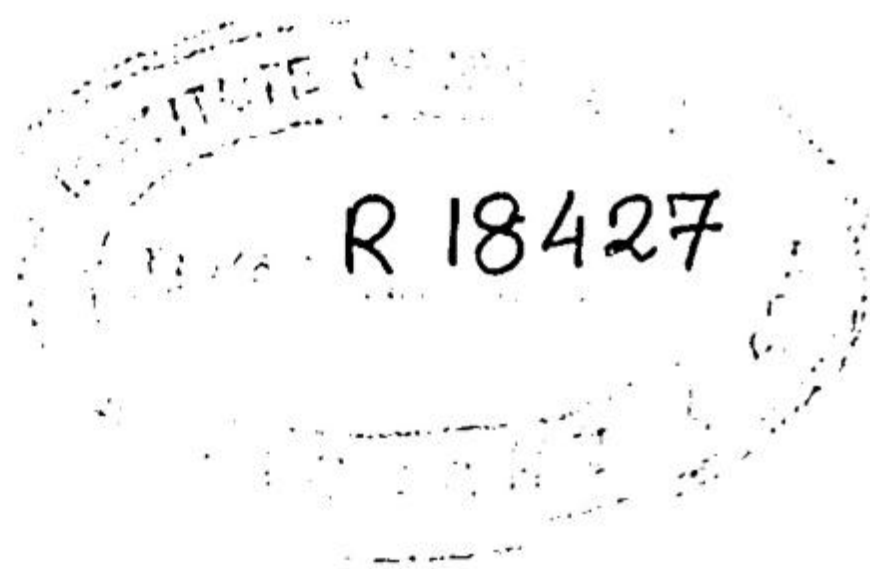
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FOREWORD

The report in the following pages contains an account of the activities of Saha Institute of Nuclear Physics, Calcutta, during the year 1982. The descriptive write-up has been edited and compiled by the two editors, Professor A. K. Raychaudhuri and Dr. M. L. Chatterjee, from texts provided by the various Divisions and Sections. I express my deep appreciation of the dedicated effort they have put in, and congratulate them on the successful completion of their task. The result is highly commendable both in its content and format.

The Annual Report is by no means a substitute for a complete presentation of an individual's or a group's research or developmental work which is best done by a communication to a journal or a professional conference. Its purpose is to disseminate to an audience, much wider than the immediate expert group, an easily comprehensible and yet concise version of the total activity of the Institute during a given year. The report presented here satisfies this criterion and will enable the readers to judge our successes and failures, our strong and weak points in pursuing the R & D and the teaching and training activities to which we are committed. I am sure the account of these activities compiled in this report will amply establish that the Institute workers, as a team, have not belied their commitment. They have been continuously delineating some new areas of exploration ; in the territory already trudged by them they are more often able to transcend the limits of routine repetitive work and move on to more refined and clearly motivated new investigations.

(M. K. Pal)
Director.

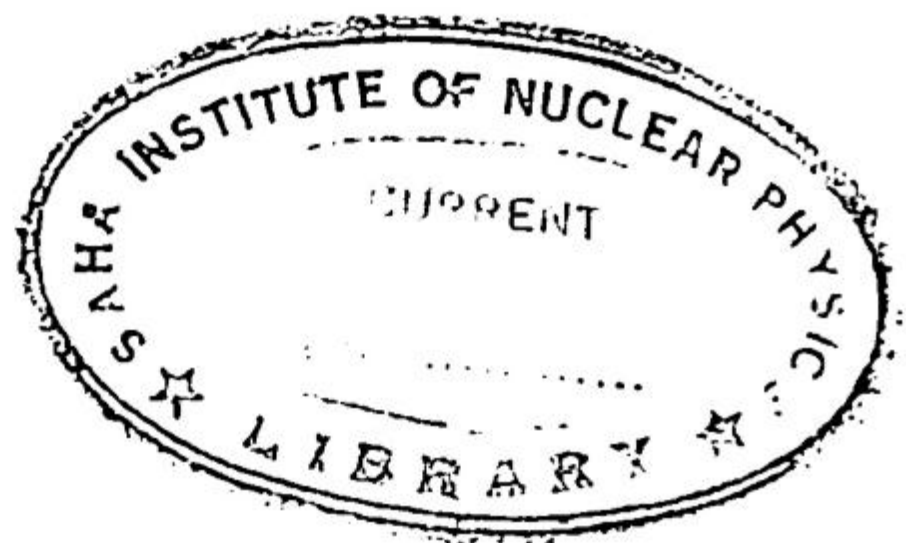


CONTENTS

FOREWORD

1	Cyclic Accelerator Division
5	Electrostatic Generator Division
9	Theoretical Nuclear Physics Division
14	Nuclear Chemistry Division
17	Solid State & Molecular Physics Division
24	Mass Spectroscopy and Isotope Separator Section
27	Crystallography and Molecular Biology Division
33	Plasma Physics Section
36	Instrumentation Division
41	Biophysics Division
49	Teaching Programme
51	Facilities and Administration
54	List of Publications
58	Papers Accepted for Publication
61	Papers Presented in Symposia and Conferences
65	Seminars held in the Institute
67	Seminar Lectures given at other institutes by members of the Institute
69	Staff List

The sign † on the name of a worker denotes an External Collaborator or a Guest Worker.



CYCLIC ACCELERATOR DIVISION

The activities of the Division were evenly distributed between research and development of new facilities. In the research side the activities were directed towards studies of metastable states using high resolution γ -spectroscopy, of nucleon structure of $N=88$ isotones and of radiation induced damages in materials using positron annihilation technique. In the developmental side the activities were around (a) Linear Induction Accelerator, (b) External Deflector System for selecting single and multiple bunch, (c) PIXE Studies and (d) Single Crystal Growing Facilities.

Several members of the Division have been actively engaged in utilising the α -beam from the VEC, Calcutta.

Cyclotron : The emphasis this year continued on developmental activities. The additional pumping system was installed in the external beam line. For operational convenience the deflector plates of the external bunch selector system which was so far horizontal have been made vertical. The heat exchanger is being fabricated. A new pair of Q-pole magnet have been designed for installation in the beam line for PIXE studies (R. Roy, B. Basu and A. P. Patro).

Decay of ^{99m}Rh (4.7 h) : The 4.7 h activity of ^{99}Rh has been produced in our laboratory by bombarding enriched ^{99}Ru with 3.8 MeV protons from cyclotron. The major interfering activity is from ^{100}Rh (20 h) decay which was earlier studied in our laboratory. Gamma-rays have been studied with 41.6 c.c. HPGE detector and 110.9 c.c. Ge(Li) detector system. Gamma-gamma coincidence experiment has been performed using a 32.2 c.c. Ge(Li) and the 41.6 c.c. HPGE detector combination. Two new levels at 1027.1 ($7/2^+$, $9/2^+$) and 1278.6 ($7/2^+$, $9/2^+$) keV have been proposed in the present work in addition to confirming the population of 89.7 ($3/2^+$), 322.3 ($5/2^+$), 340.7 ($7/2^+$), 576.0 ($5/2^+$), 617.9 ($7/2^+$), 719.0 ($9/2^+$) and 1261.4 ($7/2^+$, $9/2^+$) keV state in ^{99}Ru from the ^{99m}Rh (4.7 h) decay (S. Bhattacharya and B. Basu).

External Beam Bunching System : The 428 keV ($9/2^+$) state of ^{73}As which has a lifetime of nearly $6 \mu\text{s}$ was chosen for testing our external beam pulsing system. Natural GeO_2 was bombarded by the undeflected 3.8 MeV proton beam. Due to low abundance (7.8%) of ^{73}Ge in natural Ge, this state is weakly populated. Further studies are planned using enriched ^{73}Ge (R. Roy, A. M. Mandal and A. P. Patro).

Linear Induction Accelerator : Preliminary testing of the imported cores of larger volume has been made. Final assessment of the suitability of the cores would be made after a large number of such cores have been tested (R. Ray and A. P. Patro).

PIXE Studies : At initial stages PIXE technique will be applied to bio-medical and material research problems using HPGE X-ray detector. The machine drawing of the sophisticated PIXE chamber along with multiple target holder, electron gun and a set of collimators and filters has been completed and the chamber is under construction (P. Sen).

Radiation Damage Studies : A full fledged positron research laboratory, to investigate the annealing behaviour of the radiation induced defects in application important materials, has been commissioned using both the lifetime and the Doppler broadening systems. The prompt time resolution (FWHM) of the lifetime system at the positron window settings achieved is 260 ps. The energy resolution (FWHM) of the Doppler system at the 514 keV gamma line is ~ 1.0 keV. The isochronal annealing studies, employing a versatile home built vacuum annealing furnace with automatic temperature controller, on alpha irradiated nickel and gallium arsenide specimens have been performed via the positron annihilation technique (PTA) using both the Doppler broadening and the lifetime methods. 30 MeV alpha particles and a dose of $\sim 0.7 \times 10^{17}$ alpha/cm² from the VEC have been used in the irradiation. The variation in the annihilation lineshape parameters for the annealed and alpha irradiated specimens are observed to be complementary to the positron lifetime parameters in these specimens. The positron parameters, for the case of nickel, showed a pronounced decrease between 400 and 650 K indicating thermal dissolution of the vacancy loops. For the case of gallium arsenide, isochronal annealing studies on alpha irradiated specimens are underway (A. Sen Gupta, S. V. Naidu and P. Sen).

Furnace for Growing Single Crystals of Mercuric Iodide : A two zone horizontal furnace for growing single crystals of mercuric iodide by vapour growth technique has been constructed. The two zones with the desired temperature gradient have been obtained by slipping two glass tubes of different diameters over the main glass tubular furnace and by adjusting the separation between these two outer tubes. These two tubes act as heat shields and allow visibility of the crystal during growth process. A temperature profile of the furnace has also been studied (M. Rama Rao and J. K. D. Verma).

Radiation Damage in Single Crystals of Silicon by 30 MeV α -Particle : In order to study the nature of damage introduced by irradiating semi-conducting materials, single crystals of silicon have been bombarded with 30 MeV α -particles available from variable energy cyclotron (VEC) at Calcutta. The samples were irradiated at a beam current of 3 μ A for over a period of 1 hour. The irradiated samples were examined under a Philips PSEM 500 scanning electron microscope (M. Rama Rao and J. K. D. Verma).

Level Structure of the N=88 Isotones : The level structures of the N=88 isotones, ^{140}Pm , ^{151}Eu and ^{153}Tb are studied in the unified vibrational model incorporating both pairing effects and anharmonicity in the core vibrations. The proton quasiparticle states in the Z=50—82 shell are coupled to anharmonic vibrations of the corresponding even cores. The calculated level energies, spectroscopic factors and E2 transition strengths are compared with available experimental data and predictions of other theoretical calculations (S. Bhattacharya, S. Sen and R. K. Guchhait[†]).

Dipole-Dipole Interaction and Quasi-Rotational Bands in Odd-A In and Sb Isotopes : The level properties of the high spin positive (negative) parity bands in In (Sb)—isotopes are calculated in the core-particle coupling model with a view to studying the role played by the dipole-dipole interaction term in the Hamiltonian in producing quasirotational bands (S. Bhattacharya, S. Sen and R. K. Guchhait[†]).

Scattering Experiments with VEC Beam : Scattering studies with α -particles from VEC is continuing. Necessary modifications in the scattering chamber have been made for experimental needs. The scattering chamber installed earlier is working satisfactorily in the zero degree port of the VEC, Calcutta. The chamber had been aligned with the cyclotron exit port last year. Semi-automatized target mounting system was installed early in the year. But when experiments were performed in June it was found that accurate target rotation (on its axis) is necessary when detectors are moved in the chamber. Hence after the experiments, modified design of the target holder was constructed at the workshop and installed before the December series of experiments. New detector holders, holding both E and ΔE detectors along with their preamplifiers on the same stand were installed. Six pre-amplifiers with a more compact layout were built and installed. In trying to improve the vacuum the flange was replaced with imported IC bases as glass to metal seals and complete wiring of the chamber was done afresh. This has improved the vacuum considerably and one can reach the 10^{-5} torr range from atmosphere in 40 minutes. New vacuum measuring gauges have been also put on the Faraday cup (B. B. Baliga and R. Bhattacharya).

Scattering of alpha particles from the Variable Energy Cyclotron using ^{12}C and ^{197}Au targets was performed. Data were taken at different angles varying from 15° to 60° . The pre-amplifiers used in the experiment were designed and fabricated in the institute and the targets used were natural carbon ($150 \mu\text{g}/\text{cm}^2$) and gold ($1 \text{ mg}/\text{cm}^2$). The beam current was measured by a Faraday cup integrator system with secondary electron suppression voltage fixed at 300 volts. Taking the incident energy of the alpha beam as 28.2 MeV as measured earlier for the same settings of cyclotron parameters, the elastic and inelastic peaks of carbon at 15° were identified. The FWHM of the elastic peak after necessary corrections for finite target thickness and solid angle was found to be 135 keV. The shifts with angle of the elastically scattered peaks from gold at four different angles is commensurate with the calculated values from kinematics. Rutherford

scattering crosssections have been calculated and they are generally in good agreement at forward angles (T. K. De, B. B. Baliga and R. Bhattacharya).

It was proposed to do α -scattering experiments on ^{12}C , natural Mg, ^{24}Mg , ^{28}Si , ^{32}S , ^{130}Te and ^{197}Au targets at $E = 30\text{--}50$ MeV using VEC facility. Main interest in the α -elastic scattering experiments on Mg, Si and S targets lies in a systematic study of the back—angle anomaly in the α -elastic scattering. Alpha-elastic and inelastic scattering experiments on ^{130}Te target was also planned. Due to serious problems encountered during run time because of beam instability and trouble in the data acquisition system it was possible to take data on Au-target only from 30° to 165° in intervals of 15° . Experiment was performed using the Saha Institute Scattering Chamber. Analysis of the data is in progress (T. K. De, S. Bhattacharya, S. Sen, M. L. Chatterjee, B. B. Baliga and R. Bhattacharya).

ELECTROSTATIC GENERATOR DIVISION

Major activities of the division are given below under the headings : Neutron Generator, Charged Particle Spectroscopy, Gamma Ray Spectroscopy, and Nuclear Reactions and Structure Studies. The new neutron generator is nearing completion, while the old generator has also run satisfactorily after major overhauls. Spectroscopic studies of short lived activities are made. The charged particle group is constructing a multiwire position sensitive detector. A Compton suppressed gamma ray spectrometer has also been installed whose performance is satisfactory for the detection of very weak gamma rays. The in-beam spectroscopic work with alpha beam from VEC has progressed with a test run. Timing characteristics of Ge-detectors are investigated. Several theoretical studies are undertaken on nuclear structure, fission and reactions.

Neutron Generator

Modification of the Neutron Generator : The fabrication of the high voltage power supply was completed. Due to constraints of components work progressed only upto the voltage doubler stage instead of the tripler that was originally planned. It was tested using a 60 KV, 50 Hz transformer. Initially a maximum voltage of 130 KV was obtained. The sources of corona were located and after minimizing these losses the terminal voltage rose to 150 KV (S. K. Mukherjee, H. Majumdar, Sudip Ghosh, S. S. Brahmachari and H. K. Das).

Over-Current Fast Static D.C. Circuit Breaker : This unit is a part of 3.4 KW (approx.) capacity Inverter now under development to be used with the new neutron generator. Its function is to protect fast S.C.R.'s of the main inverter against over-current. Sensing of d.c. voltage (≈ 10 mV) proportional to over load limiting current and converting it to fixed higher value have been made for forced commutation of the series conducting S.C.R. (S. C. Mukherjee, Rita Das and J. Panja).

Fast Solid State A.C. Voltage Stabiliser : A.C. Voltage stabilizer with fast rate of correction and sinewave output with low distortion has been designed. Tracking of the mains voltage variation by linear-cum-digital processing has been used (S. C. Mukherjee and J. Panja).

High Voltage Pulser and High Voltage Regulated Supply : Design and fabrication of a h.v. pulser with 400 volts (peak), 150 ns rise time, and 1 Hz to 1 KHz repetition frequency has been completed and tested. A high voltage regulated power supply (5 KV @ 50 mA) has been developed and tested. Its load regulation is 0.08% (D. Banik).

Maintenance/Repair of Neutron Generator : The neutron generator was repaired and overhauled. Smooth and flawless operation of the machine was achieved towards the end of 1982 (B. Sethi, R. K. Chattopadhyay† and J. M. Chatterjee).

Charged Particle Spectroscopy

Multiwire Proportional Counter : The work on Multiwire system has been continued. A new design, where the counter parts can be easily hooked up to the chamber and other counters that can be used in tandem, is being tried. Developmental work on flow type gas counters is in progress (P. Basu, M. K. Sengupta and M. L. Chatterjee).

Work on Fission : Incorporation of $N=82$ shell closure has modified the charge fragmentation probability $P(Z_{II}, Z_I)$ in the double core model. Further studies are on. Investigation of charge division mechanism in terms of DCM established its close identity with ECD and Modified UCD (P. Basu and M. L. Chatterjee).

Developmental Work : Building up of a Mobile Vacuum Bench has progressed. This bench will be useful for work in the accelerator beam line with flow type counters and for testing the accessories of a vacuum system (M. L. Chatterjee and B. K. Pramanik).

Gamma Ray Spectroscopy

In-Beam Experiment at VEC : Work on the fabrication of the experimental set up for in-beam γ -ray spectroscopy experiments at VEC was completed. A test run was carried out at VEC with a 10 nA beam of 30 MeV α -particles on mylar target. Gamma-rays were detected with a shielded NaI (T1) detector, to study the feasibility of the proposed experiments at VEC. Further developmental work viz. installation of a beam viewer inside the reaction chamber, a target changing device and an improved version of trolley for mounting the reaction chamber and the associated systems is in progress (P. Banerjee, B. Sethi, J. M. Chatterjee, R. K. Chattopadhyay† and P. Bhattacharya).

Shielding for the 110 c.c. Ge(Li) Detector : The shielding comprising 120 kg lead rings, with mounting arrangement and rugged support, was designed, constructed and installed, to reduce the room background of Ge(Li) detector, for detection of weak γ -transitions in the study of radionuclides produced by fast neutron activation. The system was successfully used in the study of the decay scheme of the 72 d ^{160}Tb and the energy levels and transitions in ^{160}Dy (B. Sethi, R. K. Chattopadhyay† and J. M. Chatterjee).

Installation and Performance of a Compton-Suppressed Ge Detector : The detection of extremely weak gamma decays in the presence of strong high energy gamma rays is difficult but necessary to test the validity of different nuclear models. To overcome this problem a Compton suppressed gamma ray spectrometer has been installed. It consists of a 55 c.c. ORTEC N-type Gamma-X detector surrounded by a 256 mm dia \times 200 mm long Bicron NaI (T1) veto detector. Fast electronics (ORTEC) enables the system to handle large count rates. With ^{137}Cs the Compton suppression factor is 7.5, the corresponding peak-to Compton ratio is 350 : 1 at 661 keV. A six-hour trial run has enabled us to detect the 347 keV $4^+ \rightarrow 2^+$ transition in the ^{60}Co decay, whose intensity is 10^{-5} compared to that of 1332 keV gamma-ray (P. Mukherjee, P. Sen, I. Mukherjee and C. Samanta).

Determination of L Capture Probability : The good detection efficiency of the newly purchased 55 c.c. ORTEC Gamma-X detector for both low as well as high energy gamma rays has been utilised to measure the L-capture probability by summing method. In the decay of ^{207}Bi populating the 2340 keV state in ^{207}Pb , this L capture probability has been determined (P. Mukherjee, C. Samanta and I. Mukherjee).

Rise Time of Solid State Photon Detectors : For better time resolution with large volume semiconductor photon detectors, the study of the rise time characteristics of the detector is essential since the rise time of the output pulses from large solid state detectors is dependent on incident photon energies. The rise time of a 110 c.c. Ge(Li) and a 55 c.c. n-type HPGE detector were measured at high and low incident photon energies by sampling the rise of the output pulse at 10% and 90% of photo peak amplitude by two fast discriminators. The width (FWHM) of the rise time distribution was 150 and 64 ns, respectively, for p-type Ge(Li) and n-type HPGE detectors. The width of the rise time distributions increased with lower photon energies. The present observations showed that the time characteristics of n-type HPGE detectors are better than those of p-type Ge(Li) detector. The energy resolution of the detectors can also be improved by selection of the rise time of the detectors. The p-type Ge(Li) detector showed an improvement of 5% in energy resolution by rise time selection. (P. Bhattacharya and P. Banerjee).

Nuclear Reaction and Structure Studies

Effect of core Polarization on the Charge Distribution in ^{208}Pb : The charge distribution of ^{208}Pb has been calculated with several optical potential parameters with and without core polarization correction (P. Mukherjee, R. Bhattacharya[†] and C. Samanta).

Proton and Alpha-induced Cluster Knockout Reactions : From the analysis of the d, t, and ^3He —cluster knockout reaction data on ^{16}O , taken at the University of Maryland Variable Energy Cyclotron, a striking discrepancy has been found between the 100 MeV proton and 140 MeV alpha-induced knockout reactions (C. Samanta).

Studies in Nuclear Reaction Mechanism : The attempt to develop a complete semi-classical model to describe precompound reactions was continued. To the concept of finite nuclear temperature and nucleon momentum distribution at non-zero nuclear temperature optical effects at the nuclear surface have been added for both entrance and exit channels. The inclusion of these effects becomes necessary to account for the angular distribution of the ejectile at extreme forward angles where single step direct processes are of prime importance. In contrast to the quantum mechanical theories of Feshbach et al and Tamura et al. the calculations in this semi-classical formalism are simple and involve very little computer time (Anuradha De[†], Siddhartha Ray[†] and Sudip Ghosh).

Statistical Analysis of Prompt Neutron Kinetic Energy Distribution : A simple statistical analysis is made to estimate the kinetic energy distribution of prompt neutrons in binary fission as a function of fragment mass A_F . Le Couteur's formalism is used and modifications are introduced by including (i) nuclear structure effects and excitation dependence of the level density parameter $a(U)$. Reasonable agreement is obtained for the cases studied (H. Majumdar and A. Chatterjee⁺).

Fission Energy Tables : Fission Energy tables are being constructed to include (i) most probable fragment charges (ii) most probable energy release (iii) neutron binding energies to the fragments (iv) fusion barriers, asymmetry parameters etc. (H. Majumdar and A. Chatterjee[†]).

THEORETICAL NUCLEAR PHYSICS DIVISION

The activities of the Division are concentrated in five major areas of research : Nuclear Physics, High Energy Physics, Plasma and Statistical Physics, Physics of Macromolecules and General Physics. A short description of these activities during 1982-83 are given in what follows.

Post M.Sc. teaching of the Institute is under the charge of a Professor of the Division and our Division members undertook a fair share of the load of Post M.Sc. teaching in Physics. 4 students did review work under their guidance.

One student working (part-time) in the Division submitted the Ph.D. thesis.

One faculty member of the Division commenced his one year visit at CERN, Geneva during the present year, and another member visited the Institute for Fusion Theory, Hiroshima University, Japan for eight months. These members also participated in International Conferences held in Paris and Kyoto respectively. One Ph.D. student of the Division participated in an International Conference held in Bad Honnef, West Germany and visited on the same occasion KFA, Julich for two weeks. One faculty member and 4 research fellows participated in various symposia, conferences and workshops held in India.

8 seminars by local and guest physicists were organised by the Division during the present year. In addition informal weekly seminars have been regularly held in which reports on interesting current papers and on research work being done or planned have been presented.

Nuclear Physics

It has been shown that the second order terms resulting from an expansion of the **ATDHF** theory in powers of the adiabaticity parameter leads to a consistency condition that uniquely determines the **ATDHF** valley path out of the infinite set of solutions of the two equations of the **ATDHF** theory obtained from the zero and first order terms of the aforementioned expansion (A. Mukherjee and M. K. Pal).

The consistency condition and the two equations for the determination of the **valley path of the ATDHF theory** have been expressed in the co-ordinate space as single particle equations using the Skyrme two-body interaction. Detailed numerical computations are being attempted (A. Mukherjee and M. K. Pal).

Various meson-exchange currents have been considered in computing their contributions to the **magnetic moment of several oddmass nuclei**. Combined with the core polarisation contribution to the magnetic moment calculated earlier, fairly good agreement is obtained with experimental data (J. Nag⁺ and M. K. Pal).

Work on the effect of continuum states in stripping and uniqueness problem in **non-relativistic scattering theory** has been continued (S. Mukherjee and T. K. Roy).

A **nuclear level density formula** for two particle states in an interacting medium has been obtained for definite spin-isospin values following Claude Bloch's method. Calculation of spreading width of the $J=4^+$ isobaric analogue resonance excited in $V^{51}(p, n)Cr^{51}$ ($E_p=2.34$ MeV) reaction is in progress (D. Pal).

A programme of **analysing (p, n) reaction data** with light target nuclei over a large energy range ($E_p=7-100$ MeV) has been started with a view to understanding the role of antisymmetrization (D. Pal).

A **study of two particle transfer reactions** with odd-even collective targets in transitional region is being undertaken in super symmetric framework by describing the even-even part in the Interacting Boson Model (IBM) and introducing Super Symmetry through the boson fermion interaction between the odd fermion and the bosons of the even-even part (D. Pal).

The work on **inclusive distribution and production of hadrons in high energy nuclear collisions** is continued with special attention given to proton production. The inclusive distribution of protons at small p_T exhibits a peak at some value of x_F which is not so for other hadrons. The direct fragmentation (DF) and hard scattering (HS) models are used to explain the observed distribution and it is seen that the position of the peak may be related to the number of nucleons in the projectile and energy (J. Mahalanabis and P. Bandopadhyay[†]).

The shift of the total **cross-section in the pion-nucleus interaction** from that of the elementary pion-nucleon resonance position is studied near resonance energies. The shift is explained in terms of an effective momentum and resonating partial wave of the π -A CM-system. The appropriate choice of collision energy of the free π -N t-matrix is seen to be the most important factor (J. Mahalanabis and A. Roy[†]).

Charge exchange reactions in ${}^9\text{Be}$ induced by protons at medium energy exciting the ground state and the first excited state of ${}^9\text{Be}$ which are isobaric analogue states of ${}^9\text{Be}$ are studied. The ground state transition involves spinflip and no spin-flip contribution whereas the first excited state involves only spinflip contributions. Calculations are in progress (J. Mahalanabis).

Theoretical calculations for the scattering of K^+ and K^- by a series of nuclei are done for the energy region 0-1 GeV incident energy. The K^+N interaction is very weak whereas the K^-N interaction has a lot of resonance at even lower energies. Optical model calculations using co-ordinate space and $K^\mp N$ phase shifts are being done. The energy dependence of the total, differential and reaction cross-sections are investigated (J. Mahalanabis and M. N. Sinha Roy).

High Energy Physics

We find by directly evaluating diagrams using the Feynman gauge that at the two loop level the **Bloch-Nordsieck cross-sections for the process (a) $q \bar{q} \rightarrow \gamma^*$ and its inverse (b) $\gamma^* \rightarrow q \bar{q}$** are both infra-red divergent. The uncanceled infra-red divergent piece has a doubly logarithmic leading behaviour (H. Banerjee, A. Chatterjee and M. Sengupta).

We have found the **complete set of Green functions for the two dimensional Thirring and Rothe-Stamatetscu models** by using a technique due to Fujikawa (H. Banerjee, R. Banerjee and A. Chatterjee).

The reduction in the dynamical degrees of freedom of **lattice gauge theories** in the limit of large N and the corresponding reduced quenched models have been studied (A. Chatterjee and D. Gangopadhyaya).

Work on a **two-component quark-gluon model for particle production** in high energy pp and $\bar{p}p$ collisions is well in progress. According to our model the hadronisation of the two leading clusters produced by pomeron-proton collisions and containing the valence quarks of the projectiles, obeys scaling. The central gluonic fireball, produced by pomeron-pomeron collision, constitutes the nonscaling component. Its hadronization occurs via the intermediate state of a quark-antiquark part. Predictions for charged particle multiplicity for the π^+/π^- ratio were compared with the available data and found to agree remarkably well. Furthermore, the recent observation, in experiments with the $\bar{p}p$ Collider at CERN, of the growth of average transverse momentum per particle has also been explained in terms of our two-component model (H. Banerjee, D. Syam and T. De).

The contribution of the 'simple wave' regions which was neglected in our previous work on a **hydrodynamical model for hadron production** in e^+e^- annihilation has been reanalysed. We have studied the number of particles and the amount of energy carried away by the 'simple wave' parts of the hadronic fireball produced in e^+e^- collisions. We have found some errors in the earlier estimates. Our investigations have shown that the particle number contained in the 'simple wave' regions is approximately 15-20 percent at the PETRA energy range (A. Biswas and T. De).

Plasma and Statistical Physics

An attempt has been made to obtain an analytical as well as a numerical solution of the problem of the **evolution of k-dV solitons in inhomogeneous media** under definite initial values. A suitable numerical algorithm necessary for computation is still being explored (T. S. Nag and B. Dasgupta).

Investigations are being made on the parametric excitation of **low frequency instabilities in inhomogeneous media** in the linear and nonlinear regimes. The possibility of development of absolute and convective instabilities, suggestions regarding their stabilization, the relevance of this interaction process to the heating mechanism in plasma devices are a few of the topics that will be stressed (T. S. Nag).

The **numerical solution of the k-dV equation in an inhomogeneous medium** with definite initial profiles was attempted. The work is nearly complete (B. Dasgupta and T. Watanabe[†]). The effect of an oscillating magnetic field on **tearing mode instabilities** was investigated (B. Dasgupta and U. Basu[†]). Studies have been made of the **streaming tearing mode**, and a new mechanism for energy conversion has been discussed (B. Dasgupta, T. T. Sato[†] and M. Shigeta[†]).

Physics of Macromolecules

The effect of an electric field on the order-disorder transition in bilayer lipid membranes : Bilayer lipid membranes consist of an inner hydrocarbon tail region and the hydrophilic polar heads on either side. The order-disorder transition in the hydrocarbon tail region is characterised in terms of a Landau-deGennes description. The effect of an external electric field, through the surface charges on the bilayers or the polar groups, on the phase change from the fluid (liquid crystalline) to gel state is studied. To highlight possible biological implications of such phase transitions, a model is developed in which ion channels (taken to be composed of protein bundles) are postulated to be surrounded by lipid molecules in a fluid (liquid crystalline) phase, when the excitable membrane is in its resting state ; the surface charges and the polar heads of the lipid molecules respond to electrical stimuli, inducing a transition in the hydrocarbon tail region of the surrounding (boundary) lipid to gel (or crystalline) phase, which in turn, through a coupling with the relevant modes of the protein bundles, results in the opening of the ion channels, providing thereby a mechanism for the triggering of nerve impulses (B. Dutta-Roy, D. Bhaumik[†], T. Chaki[†] and A. Lahiri[†]).

A Model of Macromolecules with Excited Polar Modes : Macromolecules and their aggregates (such as protein bundles in bio-membranes) possess polar modes which, when excited, tend to deform the system and call into play elastic restoring forces. A model of such systems, characterised typically by electric polarisation modes stabilised on the one hand by quartic self-interactions and on

the other through coupling to the elastic deformations, admits of the possibility of localised excitations (solitary waves) propagations with subsonic velocities, possessing the features of relative stability and efficient transport characteristic (associated with the collective nature of the phenomena), and at the same time provides a mechanism of control and variability which could be of considerable interest in biology (D. Bhaumik[†], B. Dutta-Roy and A. Lahiri[†]).

General Physics

Rotating Two-dimensional Harmonic Oscillator : It is generally believed that for a harmonic oscillator there is at least $\frac{1}{2} \hbar \omega$ energy for each degree of freedom. This popular myth constitutes the content of the quantum folk theorem. Using the $1/N$ expansion technique (where N is the dimension of the configuration space) it is shown that for a rotating two dimensional oscillator described by the potential $\frac{1}{2} m \omega^2 (r-r_0)^2$ the ground state energy asymptotically approaches $\frac{1}{2} \hbar \omega$ from below for large values of the "displacement" parameter r_0 . (R. Gangopadhyaya, G. Ghosh and B. Dutta-Roy).

Viscous Forces in Quantum Systems : Solov'ev has shown that by a mapping of co-ordinate and time the time-dependent Schroedinger equation can be transformed into that for a simple harmonic oscillator. It is shown that by a similar map damping can be introduced into a quantal system which is being compared with the other methods used for the study of viscous forces in quantum mechanics (R. Gangopadhyaya, G. Ghosh and B. Dutta-Roy).

NUCLEAR CHEMISTRY DIVISION

Research activities of the division may broadly be classified under the heads of Analytical Chemistry, Separation Chemistry and Radiation and Photochemistry. Details of these studies are incorporated in the individual reports. The division launched a programme of investigation on photo-induced electron transfer process because of its obvious implication in solar energy conversion.

Analytical Chemistry

Neutron Activation Analysis of Traces of Rare Earths in Geological Materials : Attempts have been made to develop a simple method for the preconcentration of rare earths from the bulk materials present in rocks and minerals. The aim is to find out a suitable non-isotopic scavenger for carrying out rare earths for subsequent neutron activation analysis (N. R. Das and S. N. Bhattacharyya).

Separation Chemistry

Separation of Molybdenum and Tungsten using HDEHP as Extractant : Separation of molybdenum and tungsten using di (2-ethyl hexyl) phosphoric acid (HDEHP) from various acid media in aqueous feed has been studied. It was observed that of all the acids studied phosphoric acid provides the most useful parameter for their separation. Distribution ratio increases initially with increasing pH, passes through a maximum and then decreases. This behaviour is observed both in tracer and in macro-scale. The position of the maximum, however, shifts towards lower pH as the macro concentration of the metal ion is increased. This has been explained by the chemistry of formation of hydrolytic polymeric species whence hydrogen ions are consumed in the process. The efficiency of the separation was ascertained through γ -ray spectroscopy (N. R. Das, B. Nandi and S. N. Bhattacharyya).

Effect of Nitric Acid Concentration on the Extraction Mechanism of Rare Earths in Tracer Scale by Di (2-ethyl hexyl) Phosphoric Acid : A comparative study of the interfacial mass transfer kinetics for the extraction of trivalent rare earths (Nd^{3+} , Tb^{3+} and Tm^{3+}) by di (2-ethyl hexyl) phosphoric acid (HDEHP) was carried out. The metal ion distribution ratios between the organic and the aqueous phases were determined at various nitric acid concentrations of the aqueous phase. Interfacial mass transfer kinetic rate constant values both for the forward and backward reactions were evaluated. The

observations can be attributed to the effect of lanthanide contraction (S. Sarkar, K. M. Ganguly and S. N. Bhattacharyya).

Chemical Behaviour of the Recoil Sulphur Atoms : For the study on the chemical behaviour of the recoil sulphur atoms in solution formed by the nuclear reaction, $^{35}\text{Cl}(n, p) ^{35}\text{S}$ with different halides, attempts have been made to develop a simple ion-exchange procedure using a suitable eluent for quick and effective separation of the species formed just after dissolution of the irradiated samples (N. R. Das and P. Chattopadhyay).

Separation of Carrier free ^{90}Y from ^{90}Sr : Carrier free ^{90}Y activity was separated from ^{90}Sr over a column of freshly prepared ceric phosphate. The crystalline variety of ceric phosphate prepared was found to be very useful in which the ratio of cerium (ic) : phosphate was analysed to be 1 : 2. The study of β -activity of the separated ^{90}Y determined the radiochemical purity quantitatively. The process took less than 30 minutes (D. K. Bhattacharyya and A. De).

Adsorption Behaviour of Tracer Cations in Titanium Phosphate Column : A crystalline variety of titanium phosphate was prepared by mixing a proportional quantity of titanous chloride in 2N HCl with 1.25 M H_3PO_4 , and keeping the mixture for 24 hours. The ratio of titanium : phosphate was found to be 1 : 2.02, with an ion exchange capacity (IEC) of 3.5 meq/gm. Adsorptions of Na^+ , K^+ , Rb^+ , Cs^+ , Ag^+ , Ba^{2+} , Sr^{2+} , Y^{3+} , Tb^{3+} and Zr^{4+} cations in tracer scale have been studied. The K_D value in each case indicated that the stability of the exchanger increases in the presence of the monovalent ions in the order $\text{Na} < \text{Ag} < \text{K} < \text{Rb} < \text{Cs}$ similar to that of monohydrogen zirconium phosphate (α -ZrP). The IEC and K_D values indicated (a) the possibility of the use of the exchanger in certain cation separations, and (b) that different cations are fixed on the exchanger by different mechanisms (D. K. Bhattacharyya and A. De).

Radiation and Photochemistry

Gamma Radiolysis of Uracil : Aqueous solutions of uracil (U) in presence of Cu(II)-NTA were irradiated with Co-60 gamma rays under different conditions and the radiolytic products were separated by paper chromatography. Radiolytic reduction of Cu(II)-NTA to Cu(I)-NTA was followed spectrophotometrically. No apparent radiosensitization by Cu(II)-NTA was observed in deaerated and aerated solutions. But in N_2O saturated medium, the presence of Cu(II)-NTA was found to increase the base degradation yield, G(-U), from 3.1 to 4.2. It is argued that the transients, UOH, UH and U^- reduce Cu(II)-NTA to Cu(I)-NTA but no base degradation is initiated by UH and U^- . It is only the UOH which initiates base degradation leading to the formation of glycols and isobarbituric acid. However, in the higher dose range, the Cu(I)-NTA combines with UOH to form an intermediate consisting of a Cu—C bond which later hydrolyses to give hydroxydihydrouracil and uracil dimer (S. N. Bhattacharyya and P. C. Mandal).

Kinetics of Radiation Induced Grafting : Kinetics of grafting reactions of mixtures of styrene and acrylamide onto gamma irradiated cellulose acetate films have been studied by determining the extents of grafting at different times and at different temperatures. Thus various kinetic parameters viz., initial grafting rate, energy of activation, the relation between rate of propagation and rate of termination of the graft copolymerization were found out. From such study it is evident that 1 : 1 mole ratio of monomer shows the highest grafting rate and is as well characterized by lowest energy of activation. From the bromine labelling experiments the amounts of active centres in the irradiated cellulose acetate molecule were found out. From this study the growth rate, average life time, probability of deactivation of the graft radicals and the number average molecular weight of the graft copolymer were found out. With increase of reaction time the growth rate of the graft radicals decreases while the average life time increases but both decrease with the increase of acrylamide content in the binary monomer mixture. The calculated number average molecular weight of graft chains also increases with increase of reaction time but decreases with decrease of styrene content in the binary mixture (S. N. Bhattacharyya and D. Maldas).

Photo-Induced Electron Transfer Reactions : (a) **Interfacial Effects :** Photoinduced electron transfer reactions ($A + D \rightleftharpoons A^- + D^+$) are reversible in nature. In order that such electron transfer processes might be applied to solar energy utilisation, conditions should be so chosen that the back reaction is inhibited. Interfacial systems are used to obtain effective charge separation. Attempts are being made to use a suitable colloidal system which will create the required heterogeneity in the system and bring forth efficient charge separation (S. N. Bhattacharyya and Samita Basu). (b) **Use of Polymer :** Suitable electron transfer processes can be utilised in the photolysis of water leading to the formation of H_2 which constitutes one of the most important renewable sources energy. Photosensitized electron transfer processes are reversible in nature. For the inhibition of backward reaction, heterogeneous reaction medium has been proved to be very fruitful. This heterogeneity can be brought forth with the use of polymer. Attempts are being made to develop a suitable polymer system which may find useful application in effecting efficient charge separation (S. N. Bhattacharyya and V. K. Pandey).

SOLID STATE & MOLECULAR PHYSICS DIVISION

In the year 1982, work was done on different aspects of (a) Phase Transitions ; (b) Magnetic Properties of Solids ; (c) Narrow Band Solids ; (d) Solid Surfaces ; (e) Spectroscopic Studies : Raman, Infra-red, Microwave, Optical ; (f) Nuclear and Electron Paramagnetic Resonance Studies of Solids ; (g) Mossbauer Studies of Solids ; and (h) Anionic Conduction and Ultrasonic Attenuation.

Members of the group shared considerable responsibility in running the Solid State Physics stream of the Post M.Sc. Diploma course of the Institute. They also looked after the maintenance of the cryogenic facility and a minicomputer which are widely used by the other Divisions.

Four research fellows were awarded the Ph.D. degree of the Calcutta University and one research fellow submitted Ph.D. thesis during this period.

The following members contributed to International Conferences : Prof. D. K. Ghosh—9th Austin Symposium on Molecular Structure, University of Austin, U.S.A. ; Prof. (Mrs.) M. Bose—Int. Conf. on Magnetism, Kyoto, September, 1982 ; Dr. B. G. Ghosh—International Workshop on Phase Transitions, Magnetism and Superconductivity in Rare-Earth Materials, Bad Honnef, West Germany.

Members who gave talks at other Institutes in India are : Drs. B. K. Chakrabarty (I.I.T., Kharagpur, I.I.Sc., Bangalore and T.I.F.R., Bombay) and N. Chatterjee (Institute of Chemical Biology, Jadavpur, I.I.T., Kharagpur).

Phase Transition Studies

The effect of lattice compressibility (annealed impurity) on the critical behaviour of Ising systems has been studied using Monte Carlo technique. The observation of a cross-over from second order to first order transition has been analysed and compared with various renormalization group theoretical calculations (B. K. Chakraborty, N. Bhattacharya and S. K. Sinha).

Dominance of quenched fluctuation effects over the annealed fluctuation effects has been established in dilute Ising systems and impure Ising-Mattis system using Monte Carlo technique and using some exact transformation and renormalization group results respectively (B. K. Chakraborty, A. K. Roy and S. K. Roy).

The effect of lattice dilution on the critical behaviour of Self-Avoiding-Walk (SAW) statistics has been studied using the real space renormalization group technique. The phase diagram has also been obtained by a computer simulation of SAW's and compared with the renormalization group results (A. K. Roy[†], B. K. Chakrabarty, K. Bhadra[†] and S. N. Karmakar).

Specification of a direction of walk, as in the case of directed percolation, has been shown to affect the SAW critical behaviour. The new critical behaviour has been established using some analytic and computer simulation methods (B. K. Chakrabarty).

Transition temperature (T_c) of displacive systems with strong crystal defects has been calculated using the replica trick and an average t-matrix approximation. The results have been fitted to the experimental phase diagrams for Tri-Sarcosine Calcium Bromide and mixed $\text{Hg}_2(\text{Cl}_c\text{Br}_{1-c})_2$ (S. Bhattacharya, B. K. Chakrabarti and R. N. Roy).

Scaling laws for the correction to the statistics of SAW's of finite sizes (steps of walks) are being investigated using the magnetic equivalence (S. S. Manna, B. K. Chakrabarti and R. N. Roy).

A computer simulation of the transverse Ising model is being studied using some renormalisation group field theoretic equivalences (P. Roy, B. K. Chakrabarti and S. K. Sinha).

Structural Phase Transition : The third order and the fifth order couplings between the order parameter and the elastic strains in a second order structural phase transition have been considered in Landau's phenomenological free energy expansion model and it has been shown that the ratio of the contributions to the spontaneous straining due to the fifth-order coupling and the sum of the third and fifth order coupling are directly related to the ratio of the temperature derivative of the order parameter and that of the spontaneous strain (A. N. Das and B. Ghosh).

Magnetic Properties of Solids

Magnetic properties of two-dimensional ferromagnets like K_2CrCl_4 , Rb_2CrCl_4 and Cs_2CrCl_4 have been studied using the correlated effective field theory. These compounds have tetragonal crystal field which leads to anisotropy and allows long-range order to persist. Magnetisation in absence of external magnetic field has been calculated self-consistently in agreement with the experimental results (Ibha Chatterjee and Subhasis Mukhopadhyay).

Generalised Intermediate Coupling Scheme developed for the second and third series of transition metal ion octahedral complexes has been applied to a $5d^1$ system, OsCl_6 . The study has demonstrated the convenience of this scheme compared to the usual (rather laborious) strong field coupling scheme applied earlier in studying the complex. The intermediate coupling scheme has been further generalised to incorporate the effects of crystal fields of lower symmetry, tetragonal or trigonal (A. S. Chakraborty and S. Basu).

Narrow Band Solids

The effect of alloying on the formations of local moments on a magnetic site of a transition metal has been studied using the functional integral formalism. It has been found that alloying has an important effect on the critical value of the correlation strength which is also dependent on the filling up of the band and that the critical value is no longer symmetrical around the centre of the band upon alloying with a non-magnetic metal (S. N. Karmakar and R. K. Moitra).

Magnetic excitations in narrow band solids are being studied using the two-band (s- and d-) Hubbard Model in RPA. A Stoner type criterion for magnetic ordering has been derived analytically. Such a criterion clearly shows the dependence of magnetic phase on s-d hybridization. Numerical calculations of cohesive energy and magnetization are in progress (P. B. Maity and R. K. Moitra).

Solid Surfaces

The effects of cluster size on the chemisorptive properties have been studied by approximating the surface Green's function by the tight binding cluster Bethe lattice model. It has been found that this model yields result for chemisorption of a single orbital adsorbate on a simple cubium in excellent agreement with the results obtained by Einstein and Schrieffer (S. K. Saha, B. C. Khanra and R. N. Roy).

Friedel's sum rule and the concept of spin-density oscillations are being used to calculate the hyperfine interaction and Knight shift of chemisorption systems with hydrogen as the adsorbate and copper-nickel alloy as the substrate (S. Modak, B. C. Khanra and R. N. Roy).

The tight binding techniques are being used to determine the criteria of dissociations of carbon-monoxide chemisorbed on transition metal surface (S. K. Saha, B. C. Khanra and R. N. Roy).

Efforts are under way to investigate the variation of hopping interaction between an adsorbate and a metal surface with coverage of chemisorbed species. This will help to understand the order-disorder phase transition in chemisorbed overlayers (B. C. Khanra).

Spectroscopic Studies

Raman and Infrared Studies : Raman Spectra of $\text{ZnTiF}_6 \cdot 6\text{H}_2\text{O}$ and $\text{MnTiF}_6 \cdot 6\text{H}_2\text{O}$ single crystals have been observed in different modes of states of polarizations. The various mode frequencies have been identified by studying the solution and comparing the data with those existing for similar systems. Phase transition in the systems has been observed by studying the infrared spectra at different temperatures. The librational modes of water change significantly around the transition temperature (P. Choudhury, B. G. Ghosh, G. S. Raghuvansi†, O. P. Lamba† and H. D. Bist†).

Microwave Spectroscopy : Analysis of the rotational spectrum of the parent species of the Cis conformer of 3-fluorophenol in the ground vibrational state has been measured over the frequency ranges 12.5–18.0 GHz and 21.5–25.0 GHz. The measured transitions have been assigned upto the rotational state $J=28$. The rotational and centrifugal distortion constants have been derived. In order to establish the Cis conformer and to get a better understanding of the orientation of the OH group, deuterated species of the molecule have been prepared and the analysis of the rotational spectrum in the ground vibrational state is in progress (D. K. Ghosh, A. I. Jaman and N. Chatterjee).

Analysis of the low resolution microwave spectrum of 2-Fluorophenylisothiocyanate revealed existence of two stable conformers viz., Cis and Trans. In the gaseous state the characteristic Q-type R-branch bands for both the conformers have been assigned, and tentative structures have been proposed. Analysis of the high resolution rotational spectrum of the Cis conformer of 2-Fluorophenylisothiocyanate is in progress (D. K. Ghosh and A. I. Jaman).

Optical Spectroscopy : Optical absorption spectra of an iron-doped yttrium aluminium garnet was studied. The strong and sharp bands were assigned to Fe^{3+} ions in T_d and O_4 sites. Mossbauer spectrum of the sample shows the presence of Fe^{3+} but is not resolvable because of low concentration of the metal ion. The optical spectrum of Cr-doped garnet has been studied and analysis of the results is in progress (S. K. Datta).

Diffuse reflectance spectra of a number of rare-earth borides, MB_6 were studied. The spectra show in general an absorption band in the visible (with the exception of SmB_6 which shows two). A strong absorption band in LaB_6 at 600 nm indicates that the band is not ionic in nature (M. Bose, A. Basu and S. K. Dutta).

Diffuse reflectance studies of the "red membrane" isolated from halobacterium rubricutum show a strong absorption band around 500 nm. The transmission spectrum in solution shows a similar band, besides other nearly equispaced peaks on the shorter wavelength side. These bands arise from a chromophoric group which is apparently responsible for the characteristic light absorption property of the bacterium (P. Chakraborty and S. K. Datta).

NMR and EPR Studies

Experimental NMR Studies : NMR studies of superionic conductor LISICON system has been made. ^7Li NMR line narrowing occurs even at room temperature in samples $\text{Li}_{1.4}\text{Zn}(\text{GeO}_4)_4$ (sample I) and $\text{Li}_{1.2}\text{Zn}_2(\text{GeO}_4)_4$ (sample II). Activation energy calculated for sample I (0.19 eV) is slightly greater than that of the sample II (0.17 eV). Effect of moisture has been studied, and ^7Li NMR spectra reveal that, on storage, Li^+ mobility is drastically affected, as observed from the decrease in intensity of the narrow ^7Li NMR line with time and its virtual disappearance over a period of several weeks. Moreover, the presence of strong ^1H signal suggests that water molecules absorbed by the samples occupy the vacant interstitial site. Further NMR study of solid solution electrolytes of composition $\text{Li}_{3.75}\text{Ge}_{0.75}\text{V}_{0.25}\text{O}_4$, $\text{Li}_{3.67}\text{Ge}_{0.67}\text{V}_{0.35}\text{O}_4$ and $\text{Li}_{3.25}\text{Ge}_{0.25}\text{V}_{0.95}\text{O}_4$ has shown that motional narrowing starts at different temperatures for different compositions, at 300 K, 254 K and 290 K, respectively. Activation energies are determined as 0.51 eV, 0.25 eV and 0.27 eV. The results are in accord with the conductivity data (M. Bose and A. Basu).

^2D NMR study in $\text{ZnTiF}_6 \cdot 6\text{D}_2\text{O}$ and $\text{NiTiF}_6 \cdot 6\text{D}_2\text{O}$ (single crystal) in the range 100–300 K reveals structural phase transitions at around 230 K and 120 K, respectively. The results show that the transition is of the first order in the nickel compound while for the Zn compound it is of higher order. Further, the ^2D NMR result in nickel compound is unique in the $\text{ABF}_6 \cdot 6\text{H}_2\text{O}$ series. In others, the transition is manifested by the change in quadrupolar splitting frequency only but the equivalence of deuterons is not destroyed. However, in the Ni compound this equivalence is destroyed as revealed from the splitting of the individual lines below T_c indicating a different symmetry. (M. Bose, K. Roy and A. Ghoshray).

Line-Shape Problem in NMR : Calculations of (a) nuclear spin-fluctuation in presence of dipolar spin-spin interaction and nuclear spin-phonon interaction, (b) the strain field distribution due to elastic misfits and (c) realistic and theoretically possible more complicated dislocation structures in specific crystal lattices are being done with a view to calculating the inhomogeneous line-broadening and satellite structures observed in NMR, using the statistical model (S. K. Sinha and U. S. Ghosh).

Electron Spin Resonance : ESR lines were observed in paranitroacetophenon samples in presence of UV source. Identification of ESR lines is in progress (S. Sanyal and A. K. Roy).

Mossbauer Studies

^{57}Fe Mossbauer studies in $\text{Co}(\text{L})_3 \text{Fe}(\text{CN})_6$ systems (L=phenanthroline and 2-2 bipyridil) have been made at room temperature. Spectra of

these compounds can be considered as superposition of two doublets corresponding to Fe^{3+} and Fe^{4+} (both in low spin configuration) and a single line due to Fe^{2+} (low spin). The result upholds the general concept of electron transfer between Fe and Co. Electron transfer in these compounds occurs simultaneously in both the directions. Investigation at low temperatures for the system with L=ethylene diamine is in progress. ^{57}Fe Mossbauer studies of water intercalated layer compound $\text{Mg Mg}(\text{HMT})_2\text{Fe}^{\text{III}}(\text{CN})_6$ where HMT=hexamethylene tetramine, have revealed that electron transfer causes a drastic change of Fe ion properties wherein the charge state of iron is found to be Fe^{II} (low spin) (S. Das, S. Ganguly and M. Bhattacharya).

Anion Conduction and Ultrasonic Attenuation

Studies of Anion Conduction in Some Lead Compounds : Electrical conductivity studies of some lead based compounds viz. (1) $\text{PbO—M}_2\text{O}$ and (2) M_2PbF_4 have been undertaken to study the variation of the ionic conductivity with different metallic alkali ions (M) in the temperature range $30^\circ\text{C—700}^\circ\text{C}$. From the semilogarithmic plot of conductivity vs reciprocal temperature activation energies and transition temperatures were determined. Relative contributions of ionic and electronic conduction of alkali metals have been estimated. In Na_2PbF_4 , motional averaging of the ions was detected and investigated at different temperatures through ^{19}F NMR signal narrowing (N. Chatterjee, S. Ganguly and T. K. Mallick).

Elastic Constants of Binary Alloys : The ultrasonic pulse-echo pattern for single crystals β -Brass (Cu-Zn atomic ratio 50 : 50) has been observed at room temperature using 10 MHz compressional waves. The samples are cut in cylindrical form with axes along [100], [110] and [111] crystallographic directions, the opposite faces being parallel and polished optically flat. The detection system is being further improved for obtaining quantitative data (S. K. Sinha and N. Bhattacharya).

Investigations in the following areas have also been carried out :

Debye Temperature, Cohesive Properties : The relationship between microhardness H and Debye temperature θ of III—V series of semiconducting compounds has been investigated. It has been observed that H varies as $\theta^{1.8}$. Investigation for other iso-structural groups of semiconductors is in progress (Debasri Roy and J. K. D. Verma).

Studies in Nuclear Physics : A systematic study on the shell closure in the deformed nuclei has been undertaken and a computer programme is being developed to estimate gamma-ray branching of several even-even Pt-nuclei in terms of the IBM-model (Ila Mukherjee).

Diamagnetism of Molecules : The formal similarity between the gauge variation method and the variation perturbation theory used in the calculation of diamagnetism of molecules has been further investigated. It has been found that in single-electron system the variation perturbation theory in the "Multiplicative Approximation" is, indeed, formally similar to the gauge variation method, but the calculated second order energy remains arbitrary to a multiplicative constant. It was also found that in many-electron system the variation-perturbation theory in the multiplicative approximation lacked formal justification. The calculation of diamagnetism of CO₂ molecules is in progress (S. K. Sinha and R. Ghosh[†]).

MASS SPECTROSCOPY AND ISOTOPE SEPARATOR SECTION

In the year 1982, the secondary ion mass spectrometer was successfully operated with the ultra high vacuum system at $\sim 10^{-8}$ mm Hg and the secondary ions Cu^+ , Cu_2^+ , Mo^+ etc. were studied as a function of bombarding ion energies. The inhomogeneous mass spectrometer was used to study the multiple small angle scattering of ions in the presence of magnetic focussing showing invariance of the scattering parameter. The Isotope Separator was used to study the sputtering phenomena and surface morphological features in crystals under fast intense ion bombardment.

Cone Formation on Argon-bombarded Polycrystalline Cu and Ni : Cone formation on Ar^+ -bombarded Cu and Ni surface was studied at 20.5 keV energy from a Bernas-type ion source for different doses ranging from 5×10^{18} to 1.8×10^{20} ions/cm². Later, the samples were also bombarded by 30 keV $^{40}\text{Ar}^+$ ions from the electromagnetic isotope separator at the dose of 5×10^{19} ions/cm². The critical dose and the cone apex angle were determined and the results discussed in the light of the existing theories showed the importance of secondary and tertiary effects in the evolution of the structure of cones (D. Ghosh, D. Basu and S. B. Karmohapatro).

Sputtering of Germanium by 15 to 35 keV Noble Gas Ions : Sputtering yields of Ge bombarded by 15-35 keV $^{40}\text{Ar}^+$, $^{84}\text{Kr}^+$ and $^{132}\text{Xe}^+$ ions from the electromagnetic isotope separator, have been measured. The data are discussed on the basis of Sigmund's linear collision cascade theory taking into account the different reduced nuclear stopping cross-section functions as suggested by different authors. For Ar and Kr ions the theory with the stopping cross-section due to Wilson et al. agrees reasonably well with the experiment. The yields for Xe ions tend to increase from the theoretical curve. The cause of the discrepancy is discussed in the light of the energy deposition in the loaded target with projectile ions and the spike effect arising due to heavy ion irradiation, which are not included in the simple cascade theory (D. Ghosh, D. Basu and S. B. Karmohapatro).

Development of Surface Morphological Features on Argon-bombarded Silver Single Crystals : The morphological evolution of cones on 30 keV $^{40}\text{Ar}^+$ bombarded Ag (111) and (100) surfaces, as a function of consecutive doses from 1×10^{19} to 1.54×10^{20} ions/cm² has been studied. The main observations are : (a) The cone density is orientation dependent, (b) Cones are not an equilibrium structure consistent with the observations of Auciello et al., (c) Some pits on

(111) face are conical and strongly faceted with the same symmetry as that in the sputtered ejection pattern from the same face. The results are explained with reference to the current models of cone formation (D. Ghosh, D. Basu and S. B. Karmohapatro).

Studies on Single and Multicharged Ions from a Bernas-type Ion Source.: The intensities of Ar^+ , Ar^{2+} , Ar^{3+} ions from a Bernas-type ion source have been studied as a function of the source magnetic field, the arc voltage and the source pressure with a view to studying the discharge characteristics of the ion source and to find the most suitable operating conditions, since the isotope separators serve as low energy accelerators and multicharged ions play an important role in extending the upper energy range of particle accelerators. The experiments were carried out with a fixed acceleration voltage of 30 kV. It is observed that the ion source magnetic field H_s causes hysteresis on the beam currents of Ar^+ , Ar^{2+} and Ar^{3+} i.e. beam current reappears at lower value of H_s at which the discharge was quenched previously. Beam current shows a maximum with respect to variation of arc voltage and maxima shift to higher values of arc voltage with increasing charge state of the ions due to increasing ionization potentials. When the source pressure is increased keeping other parameters constant, the beam currents of Ar^+ , Ar^{2+} and Ar^{3+} gradually decrease. The declining nature of the curves arises due to the charge transfer between energetic ions and slow atoms along the path of the beam which increases with the increase of pressure in the main system, thereby reducing the number of charged particles in the beam (D. Ghosh and D. Basu).

Radiation Damage Studies on Cu by the Bombardment of 30 MeV α -Particle from Variable Energy Cyclotron : Mirror-polished Cu surface was bombarded by 30 MeV α -particle from VEC. The beam current was 2–3 μA on the target and the bombarding dose was $\sim 2 \times 10^{16}$ ions/cm². After irradiation the specimen was examined under a Philips PSEM 500 Scanning Electron Microscope. A high density of pits of diameter approximately 3 μm is seen on the bombarded surface. For determining the nature of the damage, a larger dose of ions will be required to bombard the target (D. Ghosh, D. Basu and S. B. Karmohapatro).

Study of Cluster Ion Emission from a Polycrystalline Al Surface : For the study of variation of secondary ion intensity with projectile ion energy, some ion-target combinations were used viz : $\text{Cd}^+ - \text{Zr}$ and $\text{Zr}^+ - \text{Al}$. An ultra-high vacuum chamber, was coupled to the existing high vacuum chamber. The ultra-high vacuum chamber consisted of an Ion-Pump, a suitably designed stainless steel tube coupled to the pump and a 2" \times 2" stainless steel box connected to one end of the tube. The box was provided with two small holes, one at the top and the other in one of the side faces of the box facing the Quadrupole Mass Spectrometer. These two holes were for primary beam entrance and secondary ion exit respectively. These two holes also maintained communication between the high vacuum and the ultra-high vacuum chamber. The ion pump

needed a backing pressure $\sim 10^{-5}$ torr for proper functioning. This backing pressure was provided by the high vacuum pumps. With the ion pump in operation, repeated baking of the stainless steel tube enabled us to attain a vacuum of 5×10^{-8} torr in the ultra high vacuum chamber, the pressure in the high vacuum chamber being 2×10^{-6} torr. An aluminium target was placed inside the stainless steel box. Ion beam from the ion source was incident on the target through the ion entrance hole and secondary ions were extracted from the ion-exit hole in the box. Using this experimental set up, we studied the intensity variation of Al^+ , Al^+_2 and Al^+_3 ions (clusters) with bombarding Cd^+ ion energy. In all the cases, the intensity increased almost linearly with bombarding ion energy, attained broad maxima and then decreased steadily. The curves for Al^+ , Al^+_2 and Al^+_3 were found to be similar and the maxima occurred in the same region around 5 keV. From these results we concluded that the clusters are emitted 'as such' from the target surface (P. Chakravarty and S. D. Dey).

Multiple Scattering of Neon Ions in Helium in the Presence of Magnetic Focussing : The total collision cross-sections of Neon ions in Helium gas of reduced thickness lying between 2.25×10^{-3} to 1×10^{-2} were determined in a 210° —two direction focussing mass spectrometer. The results were compared with the multiple scattering theory, modified to accommodate the magnetic focussing effect (S. Kundu, T. Chakrabarty and S. B. Karmohapatro).

Charge Exchange between Negative Ions and Atoms : The two state theory impact parameter method is used to calculate the charge exchange between negative ions and atoms of Chlorine and Hydrogen. Further calculations on Cs^- , Li^- , Na^- , K^- with the parent atoms are in progress (S. Kundu and S. B. Karmohapatro).

CRYSTALLOGRAPHY & MOLECULAR BIOLOGY DIVISION

The research work of the Crystallography & Molecular Biology Division are carried out in the following areas : Crystal and Molecular Structure Study of Biologically-Important Molecules by X-ray Crystallographic Methods, Enzymology, Physical Biochemistry, Quantum Biology & Conformation Study and Radiation Biology.

Dr. C. K. Das Gupta has joined the Ultrastructure group and has taken up a project on genetic recombination in eukaryotic cells.

In addition to the research activities, the academic staff members of the Division took active part in both theory and laboratory courses in the Post M.Sc. Bioscience Teaching programme of the Institute.

One research student of the Division has submitted thesis for the Ph.D. degree of Calcutta University this year.

Academic staff members and research fellows of the Division attended National and International Symposiums, Seminars and Summer Schools at Nagpur, Madras, Kharagpur and Trieste (Italy).

Crystal and Molecular Structure

X-ray crystallographic methods have been successfully used to solve the crystal and molecular structures of a large number of biologically important compounds.

Crystals of **synephrine and Aspartic acid (1 : 1) complex, synephrine Hydrobromide, synephrine Phosphate, Norephedrine Phosphate and a complex of sympathomimetic amine norephedrine and an amino acid glycine** were grown for X-ray study. Structure analysis of synephrine phosphate shows p-hydroxyl and aminogroups of the synephrine cations strongly bonded to oxygen atoms of the phosphate anion, indicating a putative environment of these drug molecules at their receptor and storage sites in biological systems. Structure determination of other compounds is in progress (B. P. Mukhopadhyay, S. C. Bhattacharyya, A. Poddar and J. K. Dattagupta).

Structure of **DL-Metanephrine Hydrochloride** was solved by direct methods and refined to a R-value of 0.065 ($R_w=0.040$) for 1785 diffractometric data. The ethylamine side chain is in folded form, the C(1)—C(6)—C(7)—C(8) and C(6)—C(7)—C(8)—N torsion angles being -112.2° and 53.8° respectively. The height of the N-atom from the phenyl ring is 2.56 Å. The distance of the amino N atom from the centre of the phenyl ring is 3.73 Å. The structure is stabilised by three dimensional network of hydrogen bonds of the types N—H...Cl, O—H...Cl, N—H...O and Van der Waals forces (R. Pattanayek and N. N. Saha).

The structure of **Piperlongumine N—(3, 4, 5—trimethoxycinnamoyl)—3—Piperidine—2—one** a compound isolated from the medicinal plant Piperlongum, has been solved by direct methods and refined to a R-value of 5.3%. The compound crystallizes in the space group $P2_1/n$ with $a=15.793(3)$ Å, $b=4.089(4)$ Å, $c=24.645(5)$ Å, $\beta=97.56^\circ$ and $Z=4$. The heterocyclic ring adopts a half-chair conformation. There is an intramolecular C—H...O interaction involving the ethylenic hydrogen of the side chain and the keto oxygen of the heterocyclic ring. The structure determination has resolved the ambiguity regarding the position of the double bond in the heterocyclic ring (T. Banerjee, S. Chaudhuri†, P. Thomas Muthiah and S. K. Mazumdar).

Structure of a polymorphic form (form (ii)) of **Trichloroadeninium zinc (II)** has been solved by Patterson and Heavy atom methods using diffractometric data. The compound crystallizes in the space group $P2_1/c$ with $a=8.223(1)$ Å, $b=6.755(4)$ Å, $c=18.698(3)$ Å, $\beta=96.1(2)^\circ$. The structure has been refined to a final R value of 2.8% ($R_w=3.5\%$). Zinc is coordinated to the base through N(7); three chlorines attached to zinc complete the distorted tetrahedron. Base pairing about a centre of inversion through a pair of N(9)—H...N(3) hydrogen bonds and an intramolecular hydrogen bond involving the exocyclic amino group and one of the chlorines coordinated to zinc are the striking features of the polymorph (from ii) as well as of the polymorph (from (i)) reported by Taylor. The dissymmetry of exocyclic angles at N(7), differing by more than 18° has been noted in both the structures and several other N(7) coordinated complexes. The adenine base is protonated at N(1) resulting in an increase of the internal angle by about 6° —a feature common to all N(1) protonated adenines. The folding of the pyrimidine and imidazole rings about C(4)—C(5) bond is less pronounced in form (ii) than in form (i) (P. Thomas Muthiah, S. Chaudhuri† and S. K. Mazumdar).

Structure of **N—(4,6—Dimethyl—2—Pyrimidinyl) sulphonamide** crystallizing in the monoclinic space group $P2_1/a$ having cell dimensions $a=7.427(2)$ Å, $b=18.986(11)$ Å, $c=9.323(4)$ Å and $\beta=99.09(2)^\circ$ with $Z=4$, was solved by direct method with a final R value of 0.044. The molecules in the unit cell are held together by two types of hydrogen bonds N—H...N and N—H...O and it forms dimers in molecular packing. Structure of N—(4-

isopropoxybenzoyl)-P—aminobenzene sulphanilamide crystallizing in the monoclinic space group $P2_1/c$ with $a=9.08(1) \text{ \AA}$, $b=11.263(4) \text{ \AA}$, $c=9.585(1) \text{ \AA}$, $\beta=103.08(2)^\circ$ and $Z=4$ was solved and refined to a final R-value of 0.043. Further analysis is in progress (A. K. Basak, S. Chaudhuri† and S. K. Mazumdar).

The structure of the compound **2—imino 4—6—Dimethyl pyrimidine HCl** crystallizing in the orthorhombic space group $Pna2_1$ with $a=14.35 \text{ \AA}$, $b=8.08 \text{ \AA}$, $c=6.68 \text{ \AA}$ and $Z=4$ has been solved by the heavy atom method and refined to a final R-value of 4.8% (A. Haldar, A. K. Basak, S. Chaudhuri† and S. K. Mazumdar).

The structure of **Arprinocid Hydrochloride Monohydrate** crystallizing in the space group $P1$ with $a=10.617(4) \text{ \AA}$, $b=13.913(3) \text{ \AA}$, $c=5.080(2) \text{ \AA}$, $\alpha=93.08(3)^\circ$, $\beta=101.36(3)^\circ$, $\gamma=107.30(3)^\circ$ and $Z=2$, has been solved by direct methods and refined to a R-value of 5.6%. The structural features have been compared with those of Arprinocid and its zinc complex reported earlier (A. Haldar, P. Thomas Muthiah, S. Chaudhuri† and S. K. Mazumdar).

The compound **1, 1-Bis (p—Ethoxyphenyl) Ethylene** was crystallized from a solution of the material in cyclohexane. The structure was solved by direct methods. The space group is $Pbcn$ with $a=7.71(1) \text{ \AA}$, $b=6.66(1) \text{ \AA}$, $c=29.68(1) \text{ \AA}$ and $Z=4$ and a crystallographic diad coinciding with the molecular diad. The final R-value is 0.044. The ethylenic bond distance is $1.342(3) \text{ \AA}$. The angle subtended by the two C (aromatic) atoms at the corresponding ethylenic carbon is $119.5(1)^\circ$. The ethoxy chain is fully extended, the relevant torsion angle being 173.5° . The dissymmetry of the exocyclic angles (differing by 8°) at the aromatic carbon to which the ethoxy group is attached has been noted. The structural features have been compared with related compounds. The structure of **1,1—dichloro—2,2 Bis (p-Methoxyphenyl) Ethylene** crystallizing in the space group $C2/c$ with $a=18.290(4) \text{ \AA}$, $b=7.694(1) \text{ \AA}$, $c=11.103(2) \text{ \AA}$, $\beta=115.76(2)^\circ$, $Z=4$ and the crystallographic diad coinciding with the molecular diad, was solved by the heavy atom method. The structure was refined to a final R-value of 4.2%. The ethylenic bond distance is $1.326(3) \text{ \AA}$ as compared with $1.337(2) \text{ \AA}$ in ethylene. The C—Cl distance of $1.728(2) \text{ \AA}$ is shorter than the normal C (aromatic)—Cl distance. The angular contraction of the benzene ring at the substituted atom ($117.85(14)^\circ$) has been noted. The angle subtended by the two chlorine atoms at the ethylenic carbon ($110.31(13)^\circ$) and the angle subtended by the two C (aromatic) atoms at the other ethylenic carbon ($117.56(18)^\circ$) are less than 120° . Such angular contractions, attributed to non-bonded interaction, have been observed in similar compounds. The two benzene rings make a dihedral angle of 82.8° with one another and a dihedral angle of 47.8° with a reference plane defined by an ethylenic carbon and two aromatic carbons attached to it. The twist about the ethylenic bond is 9.7° . The dissymmetry at the exocyclic angles (differing by

more than 9°) about the aromatic carbon to which methoxy group is attached has been noted (S. Chaudhuri†, T. Banerjee, P. Thomas Muthiah and S. K. Mazumdar).

The crystal structure of the potential antitumor and the antibacterial compound **Hexan-2, 5-dione bis (4-phenyl thiosemicarbazonato) Nickel (II)** has been investigated to find out the nature of the coordinations and the stereochemistry of the Ni-(II) chromophore and to have some idea of its biological activity. The complex crystallises in the monoclinic space group C2 with $a=17.414(1)\text{Å}$, $b=8.485(1)\text{Å}$, $c=15.129(3)\text{Å}$, $\beta=104.09(3)^\circ$, $Z=4$. The structure was solved by Patterson and Heavy atom methods and refined to a final R-value of 0.033 using 1743 diffractometer reflections. The Nickel (II) ion has been found to lie on the distorted square planar ligand field of the tetradentate ligand forming one dissymmetric seven-member and two five-member chelate rings. The biological activity of the complex is probably due to the axial coordination of bacterial DNA to the coordinatively unsaturated metal ion (S. Chaudhuri† and S. K. Mazumdar).

The crystal and molecular structure of **Chloro [N-ethyleneamine (methyl-2-amino-1-cyclopentenedithiocarboxylato)] Nickel (II)** a nitrogen sulphur chelating agent having antibacterial and antitumor activity, was solved using diffractometric data. The complex crystallises in the triclinic space with $a=8.770(3)\text{Å}$, $b=9.548(2)\text{Å}$, $c=8.365(4)\text{Å}$, $\alpha=105.28(2)^\circ$, $\beta=97.61(3)^\circ$, $\gamma=64.29(1)^\circ$, $Z=2$. The structure was solved by Patterson and Heavy Atom methods and refined to a final R-value of 0.042. The Ni (II) coordination plane is distorted with Ni—Cl, Ni—S, Ni—N (amino) and Ni—N (Ethyleneamine) distances of $2.216(1)\text{Å}$, $2.143(1)\text{Å}$, $1.868(2)\text{Å}$ and $1.934(2)\text{Å}$ respectively. The ligand forms one five-member and one six-member chelate rings. The bond distances in the six-member ring indicate a great deal of π delocalization (S. Chaudhuri† and S. K. Mazumdar).

Single crystals of **copper complex of N-p hydroxy phenyl glycine. Adenosine, Adenosine-5-di-phosphate** (P. K. Dutta and P. N. Roy), **N-6 benzyl adenine hydrochloride, N-6 benzyl adenine with uridine, 9 [(S)-3, 4-dihydroxybutyl] adenine, Zn^{2+} , Cu^{2+} and Ag^{2+} complexes of N-6 benzyl-adenine and Ag^+ complex of Arprinocid** (P. Thomas Muthiah and S. K. Mazumdar) have been prepared for single crystal study.

The structures of **N-(p-Aminobenzoyl)-L-Glutamic Acid hydrochloride** (Chandana Chakrabarti), **5-methyl-3-sulphanil Amidoisoxazole** (A. K. Basak, S. Chaudhuri† and S. K. Mazumdar) and **8-hydroxyquinoline-5-sulphonic acid dihydrate** (A. K. Basak, T. Banerjee, S. Chaudhuri† and S. K. Mazumdar) have been refined to a final R-value of 0.065, 0.039 and 0.030 respectively. Also, investigations on the systematics of the self-pairing in the crystal structures of **Arprinocid (9-(Chloro-6-Flourobenzyl) Adenine)** and

related compounds (P. Thomas Muthiah and S. K. Mazumdar), on a **dynamical model of DNA molecule** to show how longitudinal and torsional vibrations of DNA molecule can be generated resulting in drug intercalation, breathing or conformational transition (S. K. Mazumdar) and on growing large single crystals of the protein **abrin**, purified from *abrus precatorius* (D. Chatterjee and S. K. Mazumdar) have been undertaken.

Studies on Enzymes

Homogeneity of the purified α -amylase isolated from goat pancreas has been established by acrylamide gel electrophoresis studies. Homogeneity of the purified enzyme is also confirmed by sedimentation velocity experiments. $S_{20,w}$ value has been determined. Amino acid analysis of the purified enzyme at three periods of hydrolysis has been carried out (S. D. Bhattacharya and S. K. Bose).

Physical Biochemistry

Studies on Crystallins : The project on the isolation, purification and aggregational properties of Crystallins—the eye lens proteins, has been continued. In order to explain the anomalous binding behavior of sodium dodecyl sulfate (SDS) with the constituent polypeptide chains of some polymeric proteins i.e. alpha-crystallin, binding studies of SDS with amino acids have been done. Electrophoretic experiments were conducted with all the naturally occurring amino acids under various experimental conditions on both filter paper strips as well as on polyacrylamide gel both in presence as well as in the absence of SDS. These studies indicate that basic and hydrophobic amino acids bind the detergent at acidic pH. On the other hand, at neutral pH where proteins are known to bind an enormous amount of SDS, most of the amino acids usually show no tendency to bind much of the detergent. Binding has been observed at comparatively higher concentrations of SDS (generally above the critical micelle concentration). A staining technique, hitherto unknown, has been developed in the laboratory in order to detect the migrated amino acids in the gel column. This procedure has been found to be applicable over a wide range of pH and both in the presence as well as in the absence of SDS. These data indicate that the application of polyacrylamide gel electrophoresis technique can also be extended to amino acids. Further work is in progress (B. Roy and S. K. Ghosh).

Studies on Collagen : (i) Isolation, purification and comparative biochemical and physicochemical studies of different collagen types (Type II and Type IV) are well underway. A collagenous and a non-collagenous component from an insoluble cartilagenous tissues of elasmobranch fishes have been isolated. The final purification and detailed physicochemical studies of the collagenous components are being continued. From the non-collagenous portion, another minor component has been purified. This material contains a large amount of tyrosine of the parent material and almost no hydroxyproline. Attempts are now being made to collect a workable amount of this component before any detailed study on this is undertaken (Y. Sharma and S. K. Ghosh) ; (ii) In the ultrastructural

and aggregational studies on collagen, investigations on the influence of the purified non-collagenous component mentioned above as well as of other relevant factors on the *in vitro* fibrillogenesis of collagen are being continued. Attempts are also being made to show that obliquely striated native-type fibril which has been precipitated so far from only two different tissues using different methods, can be precipitated following a common general methodology (S. K. Ghosh and H. P. Mitra).

Conformation Studies

The study of conformational aspects and electronic structures of several GABA-inhibitors by molecular orbital methods have been completed. The study on the interactions of some GABA-inhibitors and a model GABA-receptor has been undertaken and is in progress. An ab-initio self consistent field molecular orbital calculation using minimal basis STO-3G has been undertaken recently and preliminary studies have already been performed on β -aminoisobutyric acid, a moderate GABA-inhibitor. The results obtained by ab-initio SCF-MO calculation are to be compared with those of approximate SCF-MO-CNDO/2-method (D. Majumdar and Sephali Guha).

A programme to study several molecular complexes of biological interest has been undertaken and preliminary studies by spectroscopic methods (UV and visible) have already been made. A biologically interesting compound six-hydroxy dopamine has been found to act as a false adrenergic transmitter and to degenerate adrenergic nerve terminals. The ability of this compound to form molecular or donor-acceptor complex with different acceptors will be studied. As a first step the UV absorption spectra was studied in aqueous solution and in citric acid-sodium phosphate buffer (from pH 3 to pH 7.4) at room temperature, over a period of 24 hours. The study of the conformational aspects of molecular interaction has also been undertaken, the preliminary-work is in progress (Samir K. Mazumdar and S. Guha).

Radiation Biology

Effects of Syringic Acid on Cancerous Tissues and Cells : Experiment to study the effects of syringic acid on cancerous tissues and cells is in progress. Chemical carcinogenesis is developed in different tissues and cells and the effect of syringic acid in checking its progress is now under investigation (S. R. Basu[†]).

Effects of toxic substances and the population density on unicellular organism and its biological control : Reduction in life span of different types of unicellular organism due to increase in population density has been studied. The possible reasons behind this reduction are under investigation. Experiments have also been done to find out some biological means of controlling this effect on life span of high population density with initial success (A. K. Jana and S. R. Basu[†]).

PLASMA PHYSICS SECTION

The Plasma Physics Section was organised this year out of the Director's Research Group. The members of the Section played an active role in formulating the proposal of the Hot Plasma Project of the Institute. In this context a detail review has been made on the steady state operation of tokamaks.

Studies on Vlasov-Poisson's System : In continuation of a previous work on the non-linear distribution function for the Vlasov-Poisson's system, the non-linear distribution function for the full Maxwell's equation and the Vlasov system has been derived. The coupled wave equations for the longitudinal and transverse modes have been derived and solved by using the method of multiple scales for the case of slowly varying frequency and amplitude. The coupled non-linear dispersion relation for a uniform wave-train solution has been obtained. The modulation instability for a slowly varying wave-train is being investigated. The derivation of the non-linear distribution function for the Vlasov-Poisson's system in the presence of a uniform magnetic field is being worked out (S. K. Mazumdar).

Wave Propagation in Magnetoplasma enclosed in a Conducting Cylinder :

In continuation of a previous work on the wave propagation in an axially magnetised plasma column enclosed in a conducting cylinder, the study of the dispersion characteristics of various intermediate frequency modes, as given by the dynamic method, has been carried out for analysis of the features not predicted by the usual quasi-static approximation. Detailed investigations have been made on the propagation of the I_{11}^- and I_{21}^- modes in the frequency domain $0-\omega_{ci}$ and that of the I_{01} , I_{02} , I_{12}^+ and I_{12}^- modes in the domain $\omega_{ci}-\omega_{lh}$, where ω_{ci} and ω_{lh} the the ion cyclotron frequency and lower hybrid frequency respectively (S. K. Das and J. Basu). A study of the propagation problem for an axially magnetised collisional plasma column filling a conducting cylinder has been done to derive the formulae for the attenuation and phase coefficients, using the quasi-static approximation. The coefficients for propagation in a hydrogen plasma have been plotted as a function of the operating frequency ω in the whole frequency range $0-\omega_{uh}$ (where ω_{uh} is the upper hybrid frequency) for different values of the effective collision frequency ν , assuming ω_{pe} the electron plasma frequency and ω_{ce} the electron cyclotron frequency, to have typical values. An S-band microwave bench has been set up for experimental verification of some of the derived theoretical results (S. Biswas (nee Ghorai) and J. Basu).

Ionization Wave phenomenon in a Glow Discharge : The work on ionization wave phenomenon has been continued to develop a new method of exciting moving striations in a uniform positive column by impressing some additional electrons emitted by a filament placed in the Faraday dark space. The striations have frequencies very close to the frequency of self-excited striations under the same discharge parameters (D. Sengupta and S. N. Sengupta).

Ion Beam Plasma Interactions : The ion source of the ion beam plasma interaction system has been fabricated. The plasma diffusing into the drift chamber from the plasma source at the other end has been diagonalised to have a typical density of 10^8 cm^{-3} and a temperature of 7.5 eV at a pressure of 2.5×10^{-4} torr (N_2). An active microammeter having three ranges of $1 \mu\text{A}$, $10 \mu\text{A}$ and $50 \mu\text{A}$ has been built for measuring current from the Langmuir probes (S. K. Saha and S. N. Sengupta).

Lorentz Accelerator : The performance of the Lorentz Accelerator built at the laboratory has been tested for different values of the discharge voltage, discharge current, magnet current, filament current and operating pressure. An electron temperature of 30 to 40 eV, considered a high figure for a laboratory discharge system under DC operation, has been recorded. The significant roles of the radial magnetic field and the operating pressure have been noted (N. K. Majumdar).

Correlation between the Gas Temperature and the Electron Temperature has been studied for a gaseous plasma. The study demonstrates the relevance of t_g , the gas temperature as a basic plasma parameter (N. K. Mazumdar).

Solution of Poisson's Equations in a discharge system made up of a Lorentzian gas in which electrons are the ionizing agents, shows that the quantity V_s^2/n_e is conserved along the ionizing electron stream, where V_s is the space charge potential that the ionizing electron stream produces at any point and n_e is the electron density. Implications of the conservation property have been investigated (N. K. Mazumdar).

Negative Hydrogen Beam Extraction : The Duoplasmatron ion source assembly has been used to improve the negative beam yield by optimising electrostatic lens action for maximum overlap of the extracted ion beam with the cesium exchange canal. Arrangements for obtaining ion beam below 1 keV for best yield of the negative hydrogen current is under progress. The negative hydrogen conversion efficiency has reached 5% as against 10% efficiency considered satisfactory in the literature (N. R. Roy and N. K. Majumdar).

Soliton Propagation in a Plasma : Theoretical analysis of the soliton propagation in a collisionless plasma with two different ion components of finite temperature and electrons of two different temperatures has been made (Swantana Raychaudhuri). The construction of a double plasma device for experimental

study of solitons in plasma are in progress (Swantana Rayshaudhuri and S. N. Sengupta).

Study of Low Frequency Behaviour of Space Charge Sheaths in Discharges :

An audio frequency bridge for simultaneous measurement of resistance and reactance (inductive or capacitive) has been built for use in studying space-charge sheaths formed in front of electrodes and probes in discharge plasmas (P. S. Bhattacharya, S. Biswas (nee Ghorai) and J. Basu).

Hot Plasma Project : A proposal for a Hot Plasma Project at the Institute has been formulated by the Core Group of the Project, in which all the faculty members of the Plasma Physics Section acted among others as members. The proposal has envisaged a project on magnetically confined plasma in toroidal geometry with a view to carrying out research and development in (a) atomic and molecular processes in the hot plasma (b) RF heating of plasma, (c) steady state operation by RF-driven current and (d) diagnostics of hot plasma.

INSTRUMENTATION DIVISION

In the year under review the divisional research and developmental activities were somewhat slowed down because of shifting of the laboratories. Laboratory arrangements in the new campus engaged lot of efforts and time. Microwave laboratory has been recommissioned.

The activities of the division have also been extended to developing instruments for other divisions and projects of the Institute. A complete renovation of the wiring of the 30" scattering chamber installed at VEC has been completed. The associated electronics have been redesigned and fabricated to suit the needs of the users in VEC.

Dr. B. K. Sinha has gone abroad on a Post-doctoral assignment.

A Solid State Frequency Standard

An all solid state 500 MHz frequency standard of improved design was constructed for a Microwave Spectrometer. The standard became operative in November, 1982 and has the following features : (i) Modular construction of the instrument for rack-mounting and plug-in card system of design for its various subsystems for removal of interactions among themselves, and for easy testing and service-ability, (ii) All the four multiplier stages of the system, viz., 5 to 25 MHz, 5 to 50 MHz, 25 to 125 MHz and 125 to 500 ($125 \times 2 \times 2$) MHz are each built separately on a double-copperclad-glass-epoxy printed circuit board plug-in unit. Both 250 and 500 MHz multipliers make use of tunable coaxial resonators fabricated in the Institute's Workshop, (iii) Separate power supply for each plug-in listed in (ii), (iv) Adequate tuned buffers provided in each subsystem to attenuate spurious sidebands to about 120 dB below the carrier power level, (v) Especially designed brass shields provided for each resonator (numbering 25) for achieving high unloaded Q_s , (vi) Both 50 and 500 MHz outputs can be individually tested for power level and frequency, (vii) Special network designed to provide a composite signal of 50 and 500 MHz for driving a microwave harmonic generator/mixer so that 50 and 500 MHz do not interact with each other, and (iii) 50 and 500 MHz applied as in (vii) to a K-band harmonic mixer produce marker frequencies spaced by 50 MHz in the 18 to 26 KMHz band. The standard produces 50 and 500 MHz outputs from a 5 MHz input derived from the HP Standard and delivers more than 500 milliwatts across a 50 ohm termination. A plug in unit is under development to extend basic

marker frequencies viz., 50 and 500 MHz to 50 MHz and 2 GHz so that the frequencies available at the out put of the microwave harmonic mixer in the 18 to 26 KMHz become large to facilitate frequency measurements (P. K. Gupta and K. S. Patel).

Computer Compatible Digital Phase Detector : A digital phase detector circuit has been designed and fabricated which incorporates a new concept. The design of the phase detector circuit is the outcome of a theoretical analysis worked out by us, on the sampled data system of representation of a phase locked voltage controlled L-C oscillator. The special features which underline its superiority over the currently available phase detector design are : the phase of the VCO relative to a reference quartz crystal oscillator can be set precisely by computer compatible digital command, the phase detector permits the frequency of a single lead VCO to be changed by an amount which is much smaller than what is achievable by conventional design in multiloop configuration. The VCO has almost negligible overshoot under phase lock condition. These types of phase detectors will simplify the control of individual phases of a large number of oscillators by a digital computer, as is found in linear accelerators and phase array radar systems (P. K. Gupta and S. Sen).

The Atomic Level Life-time Measuring Apparatus : The apparatus for the measurement of the life-time of the excited states of atoms and molecules has been completed. The electron gun which developed leakage early in the year has been replaced. Special components are required to raise the electron energy to 5 KV and above. However, the whole system has been assembled and a beam has been steered through all the bending and deflecting systems upto the reaction chamber. The beam can be swept across the narrow slit to produce a 2 nanosecond electron beam—burst of energy from 2.5 keV to 3.5 keV. The reaction box is equipped with the arrangement for differential pumping through a small orifice provided with a cryocooling attachment all around which condenses the gas under investigation in the reaction chamber and helps differential pumping. Inside the reaction chamber there is a vacuum isolated teflon-chamber in which the reaction gas is passed with suitable rate controls. The entrance window for 2.5 keV electrons will be provided through collodion films. It has been possible to make ultra thin film covers of thickness 500 Å which withstand a differential pressure of 10^{-5} torr on one side and 10^{-2} torr on the other. The absorption characteristics of these films for electrons are under detailed investigation. Interposition of these leak-proof films isolating the gas from the rest of the system will enable elimination of the differential pumping problems. Conventional way of focussing the beam at the inlet slit of the bending magnet failed to transmit maximum beam current at the outlet port of the magnet. The necessity of having a double-focussing type bending magnet was eliminated by focussing the input beam to a point which is nearly as far away from the inlet as the length of the arc within the magnet between the inlet slit and the outlet port. Under this condition the transmitted beam has almost as much current strength as at the inlet point. The teflonchamber has a side opening covered with a leak tight transparent win-

dow to allow photon emitted from the inside—gas to travel up to the photomultiplier via the monochromator and is also provided with an electrode to collect the beam. The current pulse of the beam produces a 0.1 volt pulse which is amplified by a pulse amplifier of 200 MHz bandwidth. This fast amplifier of gain 10—25 is placed inside the reaction chamber vacuum to obtain an output fast pulse. This pulse and the single photon pulse from photomultiplier generate the delayed coincidence curves which yield the information on the life-time of the atoms and molecules.

The set up is now assembled and is under test. The photomultipliers assembly coupled to the monochromator is under construction and will be installed soon after completion. The gas samples at pressures from one torr to 10^{-3} torr will be supplied to the reaction chamber through a needle valve. The gas feeding system is also complete. The circuits like TAC, fast amplifier, etc. to be used for the measurement have also been fabricated and tested. In view of the requirement of a high voltage, high current electron gun, the construction of a new electron gun has been undertaken. Some castable high temperature, high voltage ceramics has been procured recently. Procelain usable upto 1400°C has also been cast and fired in the laboratory to obtain slabs of desired sizes and shapes (M. B. Das and R. Bhattacharya).

Single-Photon Detection : The work on single photon response of a XP 2020 photomultiplier tube has been continued. The noise distribution and the single electron response of the photocathode indicated that the distribution is caused essentially by single electrons emitted from the photo cathode. Further investigations are being planned to (i) separate comparable noise intensity from the single photon distribution and (ii) find the time-resolution for such responses and single electrons in two photomultipliers used in coincidence (M. B. Das, S. Bose and R. Bhattacharya).

Electron-beam Deflection Pulse Generator : The 200 volt, 10 ns rise time pulse generator previously built for the electron gun to obtain a 1—2 nsec electron beam burst has been modified. In the present scheme, the electron beam is allowed to sweep past a narrow slit of 1 mm width during the fast rising part of the pulse in the horizontal plane giving a burst of beam of duration 1—2 nsec every time it moves past the slit (1—10 KHz rate). During the fly back the beam is suitably lifted up vertically to enable the beam to come back to its starting point without touching the opening of the slit. This has been done using a second pulse properly synchronised to the original pulse. D.C. shift of the beam is effected through two potentiometers (A. Ghosal and S. Bose).

A New Circuit for Fast Coincidence : The avalanche type limiter circuit developed earlier yielded a resolution (FWHM) of 0.5 nsec with NaI(Tl) crystals and ^{60}Co gamma-rays. A three-transistor limiter with 2N 4080 and RCA

40237 has been developed to obtain a very good square pulse when the photomultiplier anode output serves as its input. The rise and fall times of the shaped pulse has been measured to be 2 nsec with a flat top of 100 nsec and without any shape distortion. There is no noticeable over or undershoots. With NaI (Tl) phosphors (38 mm×25 mm) and XP 2020, the resolving time of 0.6 nsec has been obtained for ^{60}Co gamma-rays. No compensator was used in achieving this result (B. K. Sinha, S. Bose and R. Bhattacharya).

High Vacuum Ion-gauge Circuit : In order to measure high vacuum in the range 10^{-5} — 10^{-6} torr or higher the hot cathode ion gauge is preferred to the cold cathode ion gauges. The earlier prototype system developed for the RCA 1949 type ion-gauge in the laboratory has been improved for higher reliability and direct reading facility. The interlocking system protects the gauge from exposure to gas-pressures higher than 1 micron. A RCA 1946 type thermocouple gauge properly calibrated with a McLeod gauge provides the necessary interlock-signal. The ion current is displayed in terms of microns in a digital readout arrangement (A. Ghosal, S. Bose and R. Bhattacharya).

Beam Current Integrator : The prototype developed earlier on the basis of voltage to frequency conversion technique was tested with the VEC beam. The unit, initially designed for linear operation from 10 nA to 10 mA, showed some nonlinearity below 60 nA. It was tested upto a maximum current of 70 nA. On this basis the design of the integrator using the same voltage to frequency conversion technic has been finalised. The other necessary modifications are : (i) Provision for multiple range—(from 10 nA fullscale to 1000 nA fullscale), (ii) continuous digital display of averaged beam current and (iii) digital display of the total charge at any instant directly in micro coulombs (M. K. Karmokar, S. Bose and R. Bhattacharya).

Developmental Works on Electron Gun : The 5 KV, 25 watt stabilised supply for the electron gun necessary to obtain a 1 mA, 2-5 keV electron beam was improved upon to achieve satisfactory longtime operation. A new transformer and a variac controlled variable voltage filament supply has been installed. The unit, after the improvement in the insulation of the gun assembly, gives reliable performance upto 3.5 keV. Further investigations are on to extend it to 5 keV (D. Das and M. B. Das). For the focussing and bending of 5 keV electron beam, necessary modifications have been done for the current stabilizers. They are tested and found to give satisfactory performance (A. Ghoshal and S. Bose).

The Time-Ratio Control Circuit : The Time Ratio Control Circuit, using silicon controlled rectified was extensively studied. The lead voltage was controlled by controlling the TRC frequency. This is obtained from the pulse generator constructed by using a 555-timer. Further experiments are still underway (Sneha Chowdhury).

Scattering Chamber Electronics : The electronics of the scattering chamber installed at VEC has been renovated to facilitate measurements at 8 angles simultaneously. The essential equipments which have been fabricated in the laboratory are : (i) two numbers of 10-500 (dial calibrated) stabilised Bias Supplies for surface-barrier detectors, (ii) six numbers of preamplifiers for those detectors giving an inherent noise width of 11 keV and (iii) a Beam Current integrator (discussed above). The bias supplies have been measured to have a long time voltage stability of 0.01 and ripple content less than 5 mV. The preamplifier when used with Ortec detectors yielded a resolution of 20 keV for ^{241}Am alpha-rays (D. Das, A. Ghoshal, S. Bose and R. Bhattacharya).

BIOPHYSICS DIVISION

Research programmes of the Division are in the fields of Molecular and General Genetics, Membrane Biology and Radiobiology and Genetics of Tissue Culture Cells. Research on diverse aspects of biological electron microscopy could not be invigorated sufficiently because of lack of staff and non-availability of a modern electron microscope. Recently, an appointment in the rank of Reader for Electron Microscopy has been made. The division has also utilised the radiation facilities of the Variable Energy Cyclotron of Bhabha Atomic Research Centre, Calcutta to perform radiobiological experiments.

Molecular and General Genetics

The molecular mechanism of action of the drug furazolidone had been worked out. The results presented below are further additions to the spectrum of genetic effects induced by this drug. Results of the efforts to quantify the drug action at the DNA level have also been presented below.

Prophage λ -Induction by Furazolidone : Furazolidone caused prophage λ -induction in lysogenic *Escherichia coli* (GY 5027 : env A uvr B) cells. With increasing dose of the drug, the number of infective centres per plate increased very slowly upto the dose of 10^1 ng furazolidone/assay and then there was a sharp increase followed by an almost equally sharp fall in the number of infective centres. The maximum induction occurred somewhere between 10^1 and 10^2 ng drug/assay. Furazolidone induced prophage induction was significant and was caused in the absence of any metabolizing mixture. Earlier it was found by us that furazolidone caused filamentation of the treated cells. Mutagenic activity of furazolidone leading to streptomycin-resistance of *Vibrio cholerae* cells has been presented below. The drug thus produces all the phenomena which are known to be produced after activation and induction of Rec A protein or by induction of 'SOS' repair pathway. Further studies are in progress (A. K. Pal and S. N. Chatterjee).

Furazolidone Induced Mutation of the Vibrios to Streptomycin Resistance : The mutagenic potential of furazolidone was detected by us earlier by using the "Rec-test" and also by studying its action on the different repair-deficient mutant of *Escheirchia coli* K-12. Subsequently, the mutagenic action of the drug was directly tested and the results obtained so far have shown that furazolidone induces mutation of *Vibrio cholerae* cells to streptomycin resistance (Str-r). The

bacteria survived a challenging dose of 100 $\mu\text{g/ml}$ of streptomycin. With 7 $\mu\text{g/ml}$ of furazolidone, the mutation frequency increased ten-fold the spontaneous mutation frequency level and the difference was statistically highly significant ($P < 0.001$). Further studies are in progress (S. K. Banerjee and S. N. Chatterjee).

Molecular Mechanism of Action of 5-nitro-2-furylacrylic Acid, a Nitrofuran Derivative : Reports published previously from this laboratory revealed that furazolidone, a broad spectrum antimicrobial compound of the nitrofuran group, inhibited DNA biosynthesis by producing inter-strand cross-links in the DNA. This report presents an account of another nitrofuran derivative, 5-nitro-2-furylacrylic acid (5NFA). The pH denaturation-renaturation treatments on the isolated DNA and subsequent measurements of UV absorbance at 260 nm, yielded results in terms of the percentage reversibly bihelical DNA obtainable from treated or untreated cells. The nitrofuran derivative, 5NFA, has thus been found to produce inter-strand cross-links in the DNA of treated cells. It is, however, comparatively less effective than furazolidone since the same yield could be obtained by treatment with higher dose of 5NFA (S. K. Banerjee and S. N. Chatterjee).

Caffeine and the Repair Genes of *Escherichia coli* : Last years' report described the lethal synergism of caffeine with furazolidone and the molecular basis of caffeine action. This report presents an account of the effect of caffeine on the mutation of repair genes of *Escherichia coli* K-12 and accordingly different repair deficient mutants of this strain were used. It was seen that while the double mutant strain AB 2480 (*uvr⁻ rec⁻*) was most sensitive to furazolidone treatment, the mutant strain AB 1886 (*uvr⁻*) was least sensitive on a comparative scale. The survival of the strain AB 1886 (*uvr⁻*) did not change much when it was treated with 0.05% caffeine in addition to furazolidone. But when the same strain was treated with 0.2% caffeine in addition to furazolidone its survival level came down to that of the furazolidone treated double mutant AB 2480 (*uvr⁻ rec⁻*). Similarly 0.05% caffeine only along with furazolidone could bring down the survival level of the mutant strain AB 2463 (*rec⁻*) to that of the furazolidone treated double mutant AB 2480 (*uvr⁻ rec⁻*). It was noted that the presence of caffeine up to the level of 0.2% could not make any significant change in the survival level of the furazolidone treated double mutant AB 2480 (*uvr⁻ rec⁻*). It is thus obvious that caffeine acted synergistically with furazolidone in killing these repair deficient mutants of *E. coli*. The action of different concentrations of caffeine clearly indicated that while 0.05% inhibited excision repair, at the level of 0.2% it inhibited the excisional as well as the recombinational repairs. These findings on caffeine action in conjunction with furazolidone are in accord with others' observations on caffeine action in conjunction with ultraviolet light (S. K. Banerjee and S. N. Chatterjee).

Standardization of a Rapid Batch Elution Method for DNA Isolation and Purification : The interaction between the phosphate group of nucleic acid and calcium ions on the hydroxyapatite crystals (HAP crystals) appears to play a major role in the adsorption of nucleic acid on HAP crystals. In order to avoid the slower elution rate from the column, we adopted batch elution method to isolate and purify DNA from bacterial cells. For this purpose a slurry of HAP crystals in phosphate buffer contained in a beaker was used. The final DNA fraction obtained by this method contained 0.01% RNA, about 1.0% protein and presented absorbance ratios as $A_{260} : A_{230} : A_{280} = 1 : 0.47 : 0.50$. The isolated DNA, when subsequently tested by HAP chromatography, was eluted in the double stranded fraction. The isolated DNA was thus virtually free from RNA and protein and was completely native (doublestranded). The method offers the unique advantage that it is much more rapid than the Marmur's method, requires only 4-5 hours operation and can be adopted for all types of DNA (plasmid or chromosomal) and for all types of cells (Jayasri Basak, D. Mandal and S. N. Chatterjee).

HAP Chromatographic Study of DNA from Furazolidone Treated *Vibrio cholerae* Cells : DNA is being isolated and purified from drug treated or untreated log phase cells of *Vibrio cholerae* strain OGAWA 153. DNA isolated from drug treated or untreated cells were then sheared by sonication in a cold bath for 80 seconds, subjected to denaturation by keeping in a boiling water bath for several minutes and then quench cooled by an ice-salt mixture. These treatments were standardised to give reproducible and optimum results. The treated DNA was then adsorbed in a thermal column (60°C) by hydroxyapatite crystals and then successively eluted by sodium phosphate buffer (pH=6.8) of molarities (0.12 M Nap+0.1 M NaCl) for 1S-DNA and (0.40 M Nap+0.1 M NaCl) for 2S-DNA. Fractions were assayed for DNA by measuring the absorbance at 260 nm. Practically all the DNA (~100%) from nontreated cells were eluted in the single stranded form. About 82% of DNA from cells treated with 2.0 µg/ml of furazolidone for 1 hr was eluted in the double stranded form, indicating that these DNA's were largely renatured after such quench cooling treatment. This behaviour is diagnostic of the presence of inter-strand cross-links in the DNA's from furazolidone treated cells. Further quantitative characterizations of the inter-strand cross-links produced by furazolidone treatment are in progress (Jayasri Basak and S. N. Chatterjee).

Rapid Screening for Plasmids in *Vibrio Cholerae* Cells : Unlike plasmids in other bacterial cells, *V. cholerae* plasmids have not been studied so far. Investigations have been started for rapid screening of different plasmids in these cells. Initially, plasmids offering resistance to metal ions are being looked for. Sensitivity of the cells to different metal salts and its change, if any, after curing the cells of the plasmids as detected by the conventional agar disc method are being investigated at the first stage (D. Mandal and S. N. Chatterjee).

Membrane Biology

Most of the work presented below were done with model membrane systems, viz., multilamellar and unilamellar liposomes. Goat erythrocytes were used for study of the action of polymyxin-B.

Osmometric Study of Unilamellar Liposomes as Model Membrane System : Our previous reports described the method for preparation and purification of unilamellar liposomes derived by cholate treatment. Also phase transition characteristics of lipids in such unilamellar liposomes, studied earlier, clearly indicated the suitability of using such lipid vesicles as model membrane systems. With a view to gaining further confidence in the use of these vesicles as model membranes, osmometric properties of the unilamellar vesicles *vis-a-vis* multilamellar ones have now been studied. For studying the osmometric properties, unilamellar or multilamellar liposomes entrapping distilled water only were suspended in NaCl solutions of different molarities (M), equilibrated for 2 hrs at room temperature, and then the volume changes, if any, with salt molarity were monitored by measuring absorbance at 450 nm (A_{450}), the reciprocal of A_{450} being proportional to the vesicle volume. The multilamellar as well as unilamellar lipid vesicles or liposomes behaved as good osmometers, the vesicle volume ($1/A_{450}$) varying linearly with the reciprocal of salt molarity ($1/M$), for distinct salt concentration ranges. The multilamellar liposomes behaved as good osmometers over a wider range of salt concentration than the corresponding unilamellar ones for obvious reasons. Also, the liposomes derived from egg lecithin were better osmometers in respect of the above criterion than those derived from dipalmitoyl phosphatidyl choline (DPPC) irrespective of whether they were multilamellar or unilamellar in nature. This study has thus determined the salt concentration range over which the unilamellar model membrane system derived by cholate treatment can and should be used for transport and related studies (Srabani Banerjee and S. N. Chatterjee).

Effect of the Antibiotic, Polymyxin B on the Surface Topography of Erythrocytes : In continuation of previous investigations, Polymyxin B has been found to induce a transformation of goat erythrocytes from the normal biconcave shape to a smooth sphere (spherocyte) through the intermediate stages of crenated disc or spheres (echinocytes) with some reduction in overall size. Since the number of crenations per cell was small and ranged between two and three, the observations obtained by Scanning Electron Microscopy are being reviewed and confirmed by Transmission Electron Microscopy (TEM) of ultrathin sections of polymyxin treated or untreated erythrocytes. Preliminary results obtained so far have revealed the presence of one or two outfoldings or protrusions of the plasma membrane in some of the erythrocytes in section. Further studies are in progress (T. K. Mandal and S. N. Chatterjee).

Dose Dependent Lipid Peroxidation by Ascorbic Acid : The role of ascorbic acid in promoting or preventing lipid peroxidation was extensively stu-

died using the liposomal model membrane system. Lipid peroxidation in egg lecithin liposomes was simultaneously assayed by three methods : (i) estimation of conjugated dienes which is expressed in terms of the ratio of the absorbances at 233 and 215 nm respectively (A_{233}/A_{215}), (ii) iodometric assay of hydroperoxides and (iii) estimation of malondialdehyde (MDA) by the thiobarbituric acid reaction.

The effects of increasing concentration of ascorbic acid on the yields of different lipid peroxidation products (conjugated dienes, hydroperoxides and malondialdehyde) were quite similar. There was no significant increase in lipid peroxidation for ascorbic acid concentration up to $1 \mu\text{M}$. There was a faster rise thereafter with a maximum at about $2.5 \times 10^2 \mu\text{M}$ ascorbic acid concentration and was followed by an almost equally fast decrease at still higher concentrations of the acid. At a much higher concentration ($10^5 \mu\text{M}$) of ascorbic acid, the yield of peroxides came down almost to the level of the control. The actions of ascorbic acid at higher and lower concentrations were apparently anomalous. With a view to explaining this apparent anomaly, experiments were repeated at three different levels of oxygen availability i.e. by allowing the reaction to take place in (i) test tubes (Method A) or (ii) an open petri dish using a thin layer of the reaction mixture (Method B) or (iii) test tubes with constant air bubbling (Method C). The yield of ascorbic acid induced lipid peroxidation product was then found to depend on the availability of oxygen during reaction. Of the three modes of treatment, the oxygen availability was highest in Method C and lowest in Method A. The conjugated dienes (A_{233}/A_{215}) attained the maximum value of i) 0.652 at ascorbic acid concentration of $10^2 \mu\text{M}$ for treatment by the Method A, and (ii) 0.74 at the ascorbic acid concentration of $2.5 \times 10^2 \mu\text{M}$ for treatment by the Method B. For treatment by the Method C, the yield of diene conjugates continued to increase upto the ascorbic acid concentration of $10^3 \mu\text{M}$, when the oxidation index was nearly 0.8. With greater availability of oxygen, the ascorbic acid concentration leading to the maximum yield of conjugated dienes gradually shifted to higher values. An almost similar pattern was exhibited when the yield of MDA was measured under the three modes of treatment with ascorbic acid. The maximum yield of MDA for treatment by the Method C was at least 5-fold greater than the corresponding yield obtained by the Method A (Sanjib Agarwal, Srabani Banerjee and S. N. Chatterjee).

Radiobiology and Genetics of Tissue Culture Cells (RGTC)

Inducible repair in UV irradiated Chinese hamster cells. In order to establish the existence of an inducible repair process in UV-irradiated cultured Chinese hamster (CH) cells, we studied both survival and mutation in such population. From our studies on survival, we got evidence for the inducible repair process and identified the conditions under which such induction could take place. We further corroborated our findings by analysing the

yield of mutants in UV-irradiated population under different conditions of treatments. If the induced repair process was error prone, one would expect that it would make errors during repair, resulting in mutation. So there would be an increase in mutation frequency under the condition of repair induction compared to the condition in which such induction did not take place. It was shown previously that inducible repair comes into play for cells exposed to UV fluence greater than 30 J/m^2 and then treated with caffeine. It is clearly found that caffeine, not normally mutagenic for CH cells did not influence the mutation frequency till 30 J/m^2 of UV exposure. At higher exposure doses, caffeine treatment increased the frequency of mutants significantly, clearly indicating that the repair process induced was error prone (S. B. Bhattacharjee, Satadal Chatterjee and B. Pal).

Tetracycline Induced Mutation : Treatment of cultured CH cells with tetracycline hydrochloride has been found to induce 8-azaguanine resistant mutants in treated population in a concentration and dose dependent manner. However, such induction could be suppressed by treatment with ascorbic acid immediately after the drug exposures. The influence of ultraviolet light on the production of such mutation by tetracycline is currently under study. It has been found that ultraviolet light and tetracycline act synergistically in producing the mutation. Experiments are in progress to understand the mechanism of the interaction (S. B. Bhattacharjee, B. Pal and G. Bhaumik).

Isolation of an UV Non-mutable Mutant of V-79 CH Cells : A mutant of CH cells having the same UV sensitivity as the parent but not mutable by UV light has been isolated from UV exposed cell population. The technique used in the isolation was repeated exposures to gradually increasing doses of UV light, each dose being followed by variable periods of growth at least for 20 generations. The isolated mutant did not differ in its sensitivity to X-rays, N-methyl-N'-nitro-N-nitrosoguanidine (MNNG) and UV light. Even though, the mutant was UV non-mutable, MNNG and X-ray were as efficient in producing mutations in these cells as in the parent CH cells (Satadal Chatterjee and S. B. Bhattacharjee).

Interaction of MNNG and Ultraviolet Light in Cell Killing and Mutation Induction : It has been observed that if cultured CH cells were exposed to MNNG before UV exposures, the UV-sensitivity was drastically affected. But when cells were exposed to UV light before treatment with MNNG, the sensitivity to MNNG was not influenced. When mutations to 8-azaguanine resistance was followed as the end point, the behaviour was similar ; pretreatment with UV did not influence the rate of production of mutation by MNNG. The total number of mutants obtained was a simple summation of the mutants produced by the two agents independently. In case of previous MNNG treatment, the mutation induced by subsequent UV exposure was affected. The total number of mutants was much higher than the sum of the mutant yields by the two agents on independent treatments. Further experiments are in progress to elucidate the phenomena (S. B. Bhattacharjee and N. Bhattacharya).

Influence of Caffeine on Cell Killing by X-rays and MNNG : Caffeine is an inhibitor of post-replication repair for mammalian cells. In order to see the role of caffeine on the survival of X-ray and MNNG treated CH cells, we used caffeine at various non-toxic concentrations for treatment upto 24 hours after X-irradiation and MNNG treatment. It was observed that caffeine did not influence the survival of X-irradiated cells but MNNG treated cells, if incubated with caffeine for 24 hours after the MNNG treatment, gave a decreased survival. Several experiments are now in progress to understand the phenomena (S. B. Bhattacharjee and N. Bhattacharya).

Photodynamic Inactivation of CH Cells : We have already established that visible light exposures induced killing of acriflavine bound CH cells. The kinetics of such inactivation has been determined under various conditions of pH and lux rate of visible light. Further more, differential uptake of dye was used to understand the role of DNA and membrane in the process of inactivation. It was clearly shown that compared to the contribution from DNA, the role of non-DNA components in the inactivation of the cells was more relevant. It was also established that if the production of the singlet oxygen could be suppressed by a chemical treatment, e.g. using sodium azide, one could get a gradual inhibition of cellular killing depending on the concentration of sodium azide. This inactivation has been found to be increased at pH 8.5, corresponding to an increase in the production of singlet oxygen (Tapan Ganguly and S. B. Bhattacharjee).

Cytotoxicity and Mutagenicity of Some Antioxidants : Phenolic antioxidants, butylated hydroxytoluene (BHT) and propyl gallate (PG) are extensively used in foods to retard rancidity. Recently another antioxidant tertiary butyl hydroquinone (TBHQ) has appeared in the market. This is more hydrophilic than BHT and PG and hence could be more useful as food preservative. Though some reports on the mutagenicity of BHT and PG are known, no such information is yet available in case of TBHQ. It thus becomes relevant to study the behaviour of these antioxidants from the standpoint of cytotoxicity and mutagenicity. For this purpose, we have chosen mutation in cultured CH cells as a test system. For BHT and PG also, no data using this system are available. The end point selected for mutation was the resistance of the cells to the drug 8-azaguanine. It has been found that BHT and PG were only slightly cytotoxic, whereas TBHQ influenced cell attachment property severely. The survival curve for BHT had a shoulder upto a dose of 50 $\mu\text{g}/\text{ml}$, with extrapolation number 6 ; for PG, the curve was of single hit type and at about 0.8% survival level, the curve changed slope. The dose at which the change in slope occurred was 100 $\mu\text{g}/\text{ml}$. For TBHQ, the survival curve could be done only upto 1 $\mu\text{g}/\text{ml}$ and no toxicity was observed on the cells. Beyond this concentration, the cells became deformed and detached from the surface of plates. No 8-azaguanine resistant mutant was observed in any of three antioxidant- CH cells (G. Bhaumik and S. B. Bhattacharjee).

Projects Utilising the VEC Facility, BARC, Calcutta

Lipid Peroxidation by Ultraviolet Light and High Energy α -Particles from a Cyclotron : The study of radiation induced lipid peroxidation has important functional significance. In living systems, the end products of lipid peroxidation were reported to exhibit mutagenic and carcinogenic property. Published reports from this laboratory revealed earlier the causation of dose and dose rate dependent lipid peroxidation by far and near ultraviolet light including sunlight. Biological effects depend not only on the dose but also on the quality of radiation used. Accordingly, the earlier studies have now been extended to include the effects of high energy α -particles obtained from the Variable Energy Cyclotron (BARC, Calcutta) *vis-a-vis* 254 nm UV. The cyclotron beam was brought in air through a 3 mil thick Cu-window and was allowed to strike a thin lipid film, which had been kept prior to use in vacuum desiccator. Exposures ranging from few to several seconds were given at 12.7 nA/cm² and 1.27 nA/cm² current densities.

High energy α -particles (16.5 MeV) and 254 nm ultraviolet light produced dose dependent linear increase of lipid hydroperoxides in the dried thin film state. For both types of radiation, an inverse dose rate effect, i.e., a protracted radiation dose was more effective than a shorter, more intense one of larger size, was observed. Ultraviolet light (254 nm) produced higher yields of hydroperoxides in the aqueous liposomal suspension of lipid than in its dried thin film state. Besides demonstrating the production of lipid hydroperoxides by α -particles, another significant contribution of this study was to prove that the presence of any aqueous medium is not necessary for production of lipid hydroperoxides and thus to lend further evidence to the existing hypothesis of the free radical mediated lipid peroxidation (Sanjib Agarwal and S. N. Chatterjee).

α -Particles Induced DNA Strand Breakage : A Quantitative Study : Attempts are being made to devise and develop techniques using hydroxylapatite (HAP) column and other accessories for making a quantitative assay of the number of strand breaks in DNA caused by high energy α -particles. For such purposes, DNA either in the dried thin film state or in solution was exposed to the cyclotron beam (obtained in air through a thin copper window) for different periods of time. Preliminary results obtained are encouraging (Jayasri Basak and S. N. Chatterjee).

TEACHING PROGRAMME

Starting from the 1981-82 session, the Nuclear Physics and the Solid State Physics streams of the Post M.Sc. Associateship Course were combined into one, named the Post M.Sc. (Physics) Course. The Biophysics stream formed the Post M.Sc. (Bioscience) course.

Post M.Sc. (Physics) Course

The course was divided into two parts : (a) Core Courses and (b) Area Courses. Instructions in the core courses were given during the first session (September-January). The following subjects were covered : (i) Mathematical Physics (Teacher : Prof. S. Mukherjee), (2) Classical Mechanics (Dr. B. Dasgupta), (3) Quantum Mechanics (Prof. M. K. Pal), (4) Statistical Mechanics (Prof. S. K. Sinha), (5) Experimental Methods (Drs. A. K. Roy, B. G. Ghosh and D. Basu), (6) Computation and Numerical Methods (Mr. S. Chaudhuri, Bose Institute ; Invited Teacher) and (7) Basic Experiments (Dr. M. L. Chatterjee). Area courses were offered in the following special fields : (1) Nuclear Physics (Teachers : Profs. M. K. Pal, Mrs. D. Pal, P. N. Mukherjee, R. Bhattacharya ; Drs. S. Sen, M. L. Chatterjee, S. K. Ghosh, Mrs. J. Mahalanabis, P. Sen, B. Sethi, D. Basu and S. Roy, Kalyani University), (2) Solid State Physics (Drs. R. K. Moitra, B. K. Chakraborty, G. Roy, B. G. Ghosh, M. Bhattacharya, B. C. Khanra, Sm. S. Ganguli and S. K. Majumdar), (3) Plasma Physics (Profs. J. Basu, Saroj Majumdar, S. N. Sengupta, Drs. B. Dasgupta and T. S. Nag) and (4) High Energy Physics (Drs. Ashok Chatterjee and Triptesh De).

Besides the lecture and the laboratory courses each student did a review work on a topic suggested by an academic member of the institute. The following topics were reviewed by students : (1) Band Theory of Ferromagnetism (Student : S. S. Manna ; Guide : Dr. R. K. Moitra), (2) On-line Techniques for Identification of Nuclear Particles (D. Razi ; Prof. B. B. Baliga), (3) Pion-Nucleon Interaction (R. Bihani ; Dr. Mrs. J. Mahalanabis), (4) Interacting Features of Heavy-Ion Interactions (Md. Qutubuddin ; Prof. Mrs. D. Pal), (5) Valence Fluctuation Phenomena (Alokmooy Dutta ; Dr. B. G. Ghosh), (6) Extension of Effective Medium Theories to Incorporate Fluctuation Effects (Rameswar Gangopadhyay ; Dr. B. K. Chakraborty), (7) Heavy Ion Reactions (S. N. Sarkar ; Prof. S. Mukherjee), (8) X-ray Photoemission : Its application in studying electronic properties of metals and alloys (Sm. Sujata Modak, Dr.

B. C. Khanra), (9) Soft Mode Transition and Critical Phenomena (Purusattam Roy ; Dr. B. K. Chakrabarty), (10) Two Particle Transfer Reactions (Subhra Niyogi ; Prof. Mrs. D. Pal).

12 students joined the course which started on September 14, 1981 and ended on August 31, 1982. 10 students successfully completed. The 1982-83 session started on September 20, 1982 with 14 students.

Post M.Sc. (Bioscience) Course

The session of 1981-82 started with 5 students. The following basic courses were offered : Basic Genetics (Prof. S. B. Bhattacharjee), Basic Microbiology (Dr. G. Bhaumik), Cell Structures and Function (Prof. S. N. Chatterjee), Interaction of Radiation with Matter (Prof. S. B. Bhattacharjee), Chemistry of Biomolecules (Drs. S. K. Ghosh and S. D. Bhattacharya), Basic Bioenergetics (Dr. S. K. Ghosh), Chemical Bonds (Dr. S. K. Majumdar), Biostatistics (Dr. Mrs. A. Poddar), Basic Aspects of Metabolism (Dr. S. K. Ghosh) and Basic Physiology (Dr. Sm. P. Chatterjee, Invited Teacher). The following advanced courses were offered : Method of Crystal Structure Determination (Dr. P. N. Roy), Structural Crystallography (Dr. S. C. Bhattacharya), Protein Crystallography (Dr. S. K. Majumdar), Enzymology and Related Topics (Dr. S. D. Bhattacharyya), Physical Biochemistry (Dr. S. K. Ghosh), Radiation Chemistry (Prof. S. N. Bhattacharya), Radiation Biology (Prof. S. B. Bhattacharjee), Molecular Genetics (Prof. S. N. Chatterjee), Quantum Biology and Conformation (Dr. Sm. S. Guha), NMR Spectroscopy in Biology (Dr. N. Chatterjee), Electron Microscopy (Sri M. L. De, Invited Teacher), Transcription and Translation (Prof. B. B. Biswas, Invited Teacher) and Regulation of Gene Expression (Prof. S. Ghosh, Invited Teacher).

Laboratory courses were offered on the following subjects : (1) Biological Electron Microscopy, (2) Electrophoretic and Chromatographic Methods, (3) Biochemical Methods, (4) X-ray Crystallography and (5) Radiobiological Experiments (Teachers : Profs. S. N. Chatterjee and S. N. Bhattacharya ; Drs. S. K. Ghosh, P. N. Roy, S. C. Bhattacharya, G. Bhaumik and S. K. Banerjee). The topics for review by the students were (1) Principles of Protein Structures as Revealed by Protein Crystallography (Student : Vinay Kumar Pandey ; Guide : Dr. S. K. Majumdar), (2) Determination of Stokes Radii of Proteins by Electron Chromatography (Smarajit Bandopadhyay ; Dr. S. K. Ghosh), (3) Mutation of Cultured Mammalian Cells (Rita Dutta ; Prof. S. B. Bhattacharjee), (4) Various types of DNA Structures and their Biological Functions (Champakali Ayyub ; Dr. S. K. Majumdar) and (5) Plasmids : Isolation, Purification and Characterisation (Debasish Chattopadhyay ; Prof. S. N. Chatterjee).

All the five students successfully completed the course.

The 1982-83 session of the Bioscience Course started with six students,

FACILITIES AND ADMINISTRATION

Library

The library subscribed to 306 journals during the year and received 165 journals through exchange and gift. 1615 new books were added. 904 volumes of journals were bound. 202 books were issued on inter-library loan and 50 books and journals were borrowed from other libraries. The facility was used by 539 members, of which 375 were on the staff of the Institute, 145 on the staff of the VEC Project (BARC), Calcutta and 19 were Post M.Sc. Students. It also extended its Reading Room and Reference facilities to the scientists of other research institutes, in and around Calcutta. The library has acquired one Rank Xerox and one Karl Zeiss Dokumator Microfilm Reader.

Workshop

During the year machine shop and fitting shop altogether completed 454 jobs apart from maintenance work.

Some of the jobs which invite special attention are : Fabricating a housing for Xenon lamp, Faraday cage assembly, Detector holders for scattering chamber, Fabrication of reaction box, H.V. assembly of oscilloscope, Fluorescent screen adopter for electron microscope, Wilson seal movement, Source holder for Ge-detector, and Stainless steel extractor.

Out of 78 jobs completed in glass blowing shop during the year, the following are worth mentioning : 1. repairing glass condenser ; and 2. repair of distillation apparatus including separator.

The electrical section laid about 300 meters of single phase wiring and about 150 meters of 3 phase wiring. 10 fans were repaired. Besides repairing 7 motors, rewinding for 5 motors was done.

The design and drawing section made 8 designs, 60 drawings and 960 tracing jobs besides making about 1700 ammonia prints.

Administration

During the calendar year 1982, 20 persons had been recruited to various posts and 7 employees were promoted to higher posts. Shri D. N. Bhattacharjee took over the charge of the Office of the Registrar of the Institute on 21.10.1982 vice Shri S. R. Acharya resigned.

The following employees retired from the services of the Institute on attaining the age of superannuation : Prof. N. N. Saha, Shri P. C. Saha, Shri M. M. Das, Shri T. N. Misra and Shri A. N. Sinha.

Purchase orders both local and foreign to the tune of Rs. 79.95 lakhs were processed during the year 1982.

The Income and Expenditure Account as on 31st March, 1983 of the Institute is shown below

Pension Scheme as well as the Family Medical Benefit Scheme have been introduced in the Institute during the year 1982. The year 1982 also saw the implementation of the scheme of House Building Advances to the employees of the Institute.

During the year under review the Medical Unit attended to 6,382 cases of illness and declared 21 persons medically fit for appointment.

There was not a single case of hospitalisation during the year 1982.

The year 1982 left a note of sorrow in the premature death of two of our colleagues, Dr. K. P. Chowdhury, Medical Officer and Shri S. K. Mitra, Technician 'B'.

SAHA INSTITUTE OF NUCLEAR PHYSICS

Block 'AF', Sector-I, Bidhan Nagar
Calcutta - 700 064.

INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH, 1983.

Previous Year	Expenditure	Current Year	Previous Year	Income	Current Year
62,50,242.43	To Salaries & Allowance Including Provident Fund Contribution & Gratuity :	73,00,292.66	1,42,436.22	By Balance B/F	284.31
	„ Purchase of Consumable Stores Administrative and other Revenue Expenses As per Schedule—'C'		1,00,000.00	„ Grant-in-aid from Govt. of West Bengal	1,00,000.00
29,57,656.48	„ Balance Transferred to Balance Sheet	44,59,848.90	36,000.00	„ Grant-in-aid from Calcutta University	36,000.00
284.31		2,53,740.02	1,39,72,000.00	„ Grant-in-aid From D.A.E.	1,94,89,000.00
			(—) 38,75,000.00	„ Less Capital Grant	(—) 65,00,000.00
			1,00,97,000.00	„ Less Amount Capitalised	1,29,89,000.00
			(—) 8,72,228.50		(—) 7,99,364.73
			92,24,771.50	„ Less Grant for House Building	1,21,89,635.27
			(—) 3,00,000.00		(—) 3,21,000.00
			89,24,771.50	„ Miscellaneous Source of Income	1,18,68,635.27
			4,975.50		8,962.00
<u>92,08,183.22</u>		<u>1,20,13,881.58</u>	<u>92,08,183.22</u>		<u>1,20,13,881.58</u>

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- Pal A. K. and Chatterjee S. N.—'The Mutagenic Potential of the Drug, Furazolidone'—Proc. Xth All India Biophys. Symp., Lucknow (1982).
- Samanta C.—'Discrepancy between Proton and α -Induced Cluster Knockout Reactions, NP & SSP Symp., Benaras (1982). (Invited Talk)
- Sarkar S., Ganguli K. M. and Bhattacharya S. N.—'Effect of Nitric Acid Concentration on the Extraction Mechanism of Rare Earth (Nd^{3+} , Tb^{3+} and Tm^{3+}) in Tracer Scale by di (2-ethyl hexyl) Phosphoric Acid'—DAE Symp. Nucl. Chem. & Radiochem., Pune (1982).
- Sen P. and Mehta G. K.—'Application of PIXE Technique to Gunshot Residue Analysis and Other Crime Related Problems'—7th Conf. on Appl. of Accelerators in Res. & Industry, Deuton, Texas (1982).
- Sengupta A., Mahapatra, S., Shahnawaz†, Panigrahi N. and Sen P.—'Positron Annihilation Studies in Mixed Crystals KCl : K Br'—IInd Nat. Symp. Positron Annihilation, Madras (1982).
- Shahnawaz†, Mahapatra S.†, Sengupta A. and Sen. P.—'Positron Annihilation Studies in Fe coped SiC Specimens'—IInd Nat. Symp. on Positron Annihilation, Madras (1982).

SEMINARS HELD IN THE INSTITUTE DURING 1982

<i>Speaker</i>	<i>Topic</i>	<i>Date</i>
S. D. Dey*	Quadrupole Mass Spectrometer and its Application to the Study of Ion-Solid Interaction	Jan. '82
Debashis Basu	Surface Analysis by Nuclear Reaction Technique	18.2.82
Prof. J. D. McGervey, CASE Western Research Univ., Cleveland Ohio, U.S.A.	Two Dimensional Angular Correlation Technique for Defect Studies	Feb. '82
Prof. M. Doyama, University of Tokyo, Japan	Defect Studies by Position Annihilation	Feb. '82
Dr. Tapan Guha, Bose Institute	Membrane-Antibiotic Interaction with Special Reference to the Nucleoside Antibiotic, Tunicamycin	5.3.82
Prof. B. K. Bachhawat, Director, IICB Calcutta	The Use of Liposomes as Carriers of Drugs and Enzymes	24.3.82
Dr. M. N. Sinha Roy	K^{δ} -Nucleus Scattering at Low and Intermediate Energy	March '83
P. Sen	Heavy Ion Induced X-ray Emission	March '83
Sudip Ghosh	Pre-Compound Nuclear Reaction	April '82
Dr. J. K. Bhattacharya, I.I.T., Kanpur	To Scale or not to Scale	Aug. '82

*Speakers without address belong to S.I.N.P.

<i>Speaker</i>	<i>Topic</i>	<i>Date</i>
Apurba Roy	Statistics of Self-avoiding Walks on Diluted Lattices	Aug. '82
S. Berko, Brandeis Uni., Massachussetts, U.S.A.	Production of Slow Positron Beams and their use in Fundametal Positronium Physics.	10.9.82
Saswati Dasgupta, University College of Science, Calcutta	Phase Diagram of Antiferromagnets	Oct. '82
Dr. Nikhilesh Kar, Indian Assoc. for the Cultivation of Science, Calcutta.	Photo Emissions from Surface	10.11.82
Chandi Das Mukherjee Calcutta University	Phase Transition in Liquid Crystal	Nov. '82
Dr. Gautam Mukherjee, I.I.T., Pawai, Bombay.	Dyn. Correlation in Electron Gas	9.12.82

SEMINAR LECTURES GIVEN AT OTHER INSTITUTE BY THE MEMBERS OF THE INSTITUTE DURING 1982

<i>Speaker</i>	<i>Topic</i>	<i>Date</i>	<i>Institute</i>
B. K. Chakravarty	Critical Behaviour of Impure Ising Systems	12.1.1982	Phys. Dept., I.I.Sc., Bangalore
N. Chatterjee	NMR Relaxation Time in Liquid and Application	14.1.1982 15.1.1982	Indian Institute of Chemical Biology, Jadavpur.
S. N. Chatterjee	The Role of Electron Microscopy in the Elucidation of the Structure and Function of Biological Membranes	21.1.1982	XIV Annual Conference of The Electron Microscope Society of India, Calcutta
S. B. Bhattacharya	8-Azaguanine Resistant Mutation in Cultured Chinese Hamster Cells—Evaluation of Mutagenic and Carcinogenic Potential of Environmental Agents	15.2.1982	Workshop Conducted by Environmental Mutagen Society of India, BARC, Bombay
B. K. Chakraborty	Critical Behaviour of Impure Ising	24.2.1982	Phys. Dept., I.I.T., Kanpur
S. B. Bhattacharya	Assay of Azaguanine Resistant Mutants in Cultured Chinese Hamster Cells	24.2.1982	7th Annual Conference of Environmental Mutagen Society of India, Madras
D. K. Ghosh	Microwave Spectrum of 2-Fluoro-phenyl isothiocyanate	3.3.1982	University of Texas, Austin
P. Sen	Detection of Axion Through Positron Decay	March '82	Institute of Physics, Bhubaneswar

<i>Speaker</i>	<i>Topic</i>		<i>Institute</i>
S. B. Bhattacharya	Radiation Induced Killing and Mutation of Living Cells	3.5.1982	Seminar on Radiation Phys. Indian Society of Radiation Physics, Calcutta
A. K. Mukherjee	Adiabatic Time-Dependent Hartree-Fock Theory	8.6.1982	Pthysik Zentrum. Bad Honef West Germany
P. Sen	Present Experiments Carried out at VEC Calcutta	Sept. '82	Insitute of Physics, Bhubaneswar
P. Sen	Defect Studies by Positron Annihilation Technique	27.10.1982	Brandeis University, Waltham, Mass., U.S.A.
P. Sen	Proton Induced X-ray Emission (PIXE) Technique and its Application to other Disciplines	12.11.1982	Case Western Reserve University, Cleveland, Ohio, U.S.A.
B. K. Chakrabarti	Critical Behaviour of Impure Ising System	19.11.1982	T.I.F.R., Bombay
P. Sen	Experiments done with Pelletron Accelerator	19.11.1982	National Electrostatic Corporation (NEC), Madison, Wisc., U.S.A.
P. Sen	Study of Neutron Irradiated Molyodenum by Positron Annihilation	30.11.1982	State University of New York at Albany, NY, U.S.A.
B. Ghosh	Structural Phase Transition	4.12.1982	Physik Zentrum, Bad Honnef, West Germany

LIST OF STAFF DURING THE YEAR ENDING ON 31.12.1982

Officiating Director	:	Prof. A. P. Patro
Senior Professor	:	Pof. A. K. Saha

Cyclic Accelerator Division

Professor	:	B. Basu (Actg. Head), B. B. Baliga
Reader	:	P. Sen
Lecturer	:	M. Rama Rao, S. Sen
Engineer SC-1	:	Ratneswar Roy
Research Fellow (B ₂)	:	Sudeb Bhattacharya, T. K. De, A. M. Mondal
Research Fellow (B ₁)	:	Md. Qutubuddin
Technician (G)	:	S. C. Saha
Technician (E)	:	Sanat Kr. Das, R. Sen
Technician (C)	:	Pradipta Kr. Das, Tapan Kr. Das
Technician (B)	:	G. Das
Typist	:	Niranjan Sarkar
Helper (B)	:	G. Maity
Helper (A)	:	Pradip Barua

Electrostatic Generator Division

Professor	:	S. K. Mukherjee (Head), P. N. Mukherjee
Associate Professor	:	Ashim Kr. Sengupta
Reader	:	B. Sethi, M. L. Chatterjee
Lecturer	:	Sudip Kr. Ghosh
Engineer (SC-1)	:	S. C. Mukherjee
Engineer (SB)	:	Sivendu Nath Basu
Research Assistant (B)	:	V. K. Tikku, J. Chatterjee, S. K. Guha Roy
Research Fellow (C)	:	Harashit Majumdar
Research Fellow (B ₂)	:	P. Bhattacharyya, Polash Banerjee, Nihar Ranjan Roy
Research Fellow (B ₁)	:	Padmanava Basu
Technician (F)	:	M. K. Sen Gupta
Technician (D)	:	S. S. Brahmachari, K. P. Panja,

	:	Dipak Banik
Technician (C)	:	H. K. Das, Dipak Kr. Biswas, Rita Das, Jonaki Panja,
Technician (B)	:	A. K. Kundu, B. K. Pramanik
Technician (A)	:	Kanai Pal
Typist	:	N. C. Sarkar
Helper (B)	:	Ganesh Ram
Helper (A)	:	Dulal Ch. Ghosal

Nuclear Chemistry Division

Associate Professor	:	S. N. Bhattacharyya (Actg. Head)
Reader	:	D. K. Bhattacharyya
Lecturer	:	Samir Sarkar, N. R. Das
Engineer (SC)	:	Sunanda Aditya
Research Fellow (B ₂)	:	Parikshit Mondal, Debesh Ch. Maldas, Bichitra Ganguly, Kalyanmoy Ganguly, Amitava De
Research Fellow (B ₁)	:	V. K. Panday
Research Fellow (A)	:	Putul Chattopadhyay, Sumita Basu
Technician (G)	:	M. N. Chandra, H. P. Maity
Technician (E)	:	D. K. Bardhan, K. C. Chakraborty
Technician (C)	:	S. K. Banerjee
Technician (A)	:	K. L. Maity
Helper (C)	:	B. Chandra
Helper (B)	:	Raghu Ram

Mass Spectroscopy and Isotope Separator Section

Professor	:	S. B. Karmohapatro (Head)
Reader	:	S. D. Dey
Lecturer	:	D. Basu
Research Fellow (B ₂)	:	Debabrata Ghosh, Shrinanda Kundu
Technician (G)	:	M. K. Chakraborty
Technician (E)	:	S. K. Guha
Helper (C)	:	Mantu Barua

Solid State & Molecular Physics Division

Professor	:	R. N. Roy (Actg. Head), M. Bose, D. K. Ghosh, A. Mukherji
Associate Professor	:	S. K. Sinha, A. S. Chakravarty, J. K. D. Verma, S. K. Dutta, Ila Mukherjee

Reader		R. K. Das, A. K. Roy, N. Chatterjee, B. G. Ghosh, M. Bhattacharyya, R. K. Moitra
Lecturer	:	R. N. Nandi, Ibha Chatterjee, Sanjukta Ganguly
Engineer (SC-1)	:	Anjali Basu
Research Fellow (C)	:	Gautam Roy
Research Fellow (B ₂)	:	Sumita Sanyal, Amitava Ghosh Roy, Kajal Ghosh Roy, Bijoy B. Bal, Swapan K. Saha, Abu Ismail Jaman, Debasri Roy, S. N. Das, Subrata Basu, P. B. Maity, Suman Kr. Roy, Pranab Chowdhury, Tapan K. Mallick
Research Fellow (B ₁)	:	N. N. Bhattacharyya, Subhasis Mukho- padhyay, Uday Sankar Ghosh, Sachindra Nath Karmarkar, Sumita Bhattacharyya, Subharanshu S. Manna, Sujata Modak, Alok moy Dutta, Purushottam Roy, Alok moy Dutta, Purushottam Roy
Technician (G)	:	P. K. Mukherjee, N. Banerjee, Durdanta Roy, Ashok Mukherjee
Technician (F)	:	Philip Banerjee
Technician (E)	:	D. R. Sikdar, A. Chakraborty, Anita Majumdar, N. C. Saha, J. Das Gupta
Technician (D)	:	Samarendra N. Dutta, Ajoy Kr. Bhatta- charyya
Technician (C)	:	J. Mukherjee, S. Chakraborty, B. N. Basak, Gadadhar Das
Technician (B)	:	Anadi Ram
Technician (A)	:	A. C. Biswas, Anarasi Ram, Ranabir Roy
Lower Division Clerk	:	P. S. Bhattacharyya
Typist	:	Ashoke Kumar Nayak
Helper (C)	:	Ramesh Ch. Das, Chhotelal Ram, G. Dutta, Arjun Jha
Helper (B)	:	G. P. Ram, Baisakhi Ram
Helper (A)	:	Himangusha Bhusan Dhar

Crystallography & Molecular Biology Division

Reader	:	S. D. Bhattacharyya (Actg. Head), Sunil Majumdar, Sudhir Kr. Ghosh, Sephali Guha, C. K. Dasgupta
Lecturer	:	J. K. Dutta Gupta, P. N. Roy, S. C. Bhattacharyya

Research Fellow (C)	:	Aloka Poddar
Research Fellow (B ₂)	:	Tapati Banerjee, Kantilal Majumdar, Chandana Chatterjee, P. T. Muthiah, Rekha Rani Pattanayak, Amit Kr. Jana, Ajit Kr. Basak, Sheikh Abdus Samad, Debashis Majumdar, B. P. Mukhopa- dhyay, Bidyut Roy
Research Fellow (B ₁)	:	Yogendra Sharma, Amit Halder, Samir K. Majumdar, Samarjit Bandopadhyay, Debashis Chattopadhyay
Research Fellow (A)	:	Pabitra K. Dutta
Technician (G)	:	S. K. Ghosh
Technician (E)	:	D. K. Pal, Sunil Ch. Das, Dilip Kr. Mitra
Technician (C)	:	Ashim Chakravarty
Technician (A)	:	S. C. Saha, K. C. Das
Typist	:	Dipali Talukdar
Helper (C)	:	G. M. Saha, S. C. Roy, J. C. Dey

Biophysics Division

Professor	:	S. N. Chatterjee (Head)
Associate Professor	:	S. B. Bhattacharyya
Lecturer	:	Gayaram Bhoumick
Research Assistant (B)	:	Swapan Kumar Banerjee
Research Fellow (C)	:	Tapas Kr. Mondal
Research Fellow (B ₂)	:	Satadal Chattopadhyay, Tapan Kr. Gangopadhyay, Srabani Banerjee, Sanjib Agarwal, Netaipada Bhattacharya, Jayasri Basak
Research Fellow (B ₁)	:	Arun Kumar Pal, Dinabandhu Mondal, Rita Dutta
Technician (G)	:	J. C. Mondal, Bikashendu Bhowmik
Senior Assistant	:	R. N. Chowdhury
Technician (C)	:	P. C. Das, Tirthankar Ghosh, Pratap Sarkar, T. P. Kotal
Technician (B)	:	Ashis Kr. Dutta, A. C. Patro
Helper (C)	:	H. L. Saha
Helper (B)	:	K. C. Digar, R. N. Tewari, Sadhan Farua, Anadi Charan Mallick

Theoretical Nuclear Physics Division

Professor	:	M. K. Pal (Head), H. D. Banerjee, Suproakash Mukherjee, B. Dutta Roy
Associate Professor	:	Dipti Pal

Reader	:	J. Mahalanabis, B. Das Gupta
Lecturer	:	Triptesh De, Ashok Kr. Chatterjee
Research Fellow (B ₂)	:	Tarasankar Nag, Tarun Kanti Roy, Manan Sengupta, Amiya B. Biswas, A. K. Mukherjee, Debapriya Syam, Robin Banerjee
Research Fellow (B ₁)	:	Debashis Gangopadhyay
Research Fellow (A)	:	R. G. Gangopadhyay
Technician 'B'	:	H. N. Biswas
Senior Assistant	:	Jayanta Dutta
Helper (C)	:	L. K. Hazra, S. N. Biswas, R. K. Dubey

Instrumentation Division

Professor	:	R. L. Bhattacharyya (Head)
Associate Professor	:	K. S. Patel
Reader	:	Sneha Chowdhury
Lecturer	:	P. K. Gupta, B. K. Sinha
Research Fellow (B ₂)	:	M. B. Das
Technician (G)	:	B. K. Roy
Technician (E)	:	C. K. Bose, M. K. Karmakar, H. P. Banerjee
Technician (C)	:	Amal Ghoshal
Technician (B)	:	S. C. Das, Dulal Ch. Das
Technician (A)	:	L. K. Das, G. Ranjit
Upper Division Clerk	:	Ram Mohan Moitra

Plasma Physics Section

Associate Professor	:	Jayanta Basu (Head), S. K. Majumdar, S. N. Sengupta
Reader	:	N. K. Majumdar
Research Fellow (B ₂)	:	Snehalata Biswas, Santwana Roychow- dhury, Mrinal Kanti Chakraborty
Technician (F)	:	N. M. Ghosh
Technician (D)	:	P. S. Bhattacharyya
Helper (C)	:	G. C. Das

M.Sc. Nuclear Physics Laboratory

Technician (E)	:	S. K. Banerjee
Helper (C)	:	H. Das

Library

Librarian	:	S. C. Mukherjee
Assistant Librarian	:	A. K. Chatterjee

Technician (E)	:	Maitrayee Dutta
Technician (D)	:	S. K. Bhattacharyya
Technician (C)	:	Nupur Bhattacharyya, Bidyut Kumar Mallick, Maya Dutta, Babulal Ram
Helper (C)	:	B. P. Mitra, T. K. Bera
Helper (B)	:	S. R. Sil, Subrata Chowdhury, R. K. Panigrahi

Workshop

Workshop Superintendent	:	K. K. Guha Thakurta
Engineer (SB)	:	Subhas Ch. Dan
Technician (G)	:	M. N. Saha
Technician (F)	:	A. Das, S. C. Majumdar
Technician (E)	:	S. K. Roy Chowdhury, N. C. Bose, Samir Kanti Kundu, S. L. Dutta, N. N. Das
Technician (D)	:	R. N. Dutta, J. G. Mondal, B. N. Dey, S. B. Chakraborty, B. D. Pal
Technician (C)	:	A. K. Mondal, S. C. Saha, S. K. Dutta Sharma, S. Kar Gupta, R. K. Mondal, K. N. Sinha, A. Chakraborty, K. P. Bagh, N. C. Adhikary, S. Kundu, G. C. Dey, R. N. Chakraborty, Sk. Salauddin
Technician (B)	:	A. K. Saha, Alope Kumar Sarkar, Arup Pollay
Upper Division Clerk	:	B. Banerjee
Helper (C)	:	Suresh Ram
Helper (B)	:	Sukdeo Prosad Ram, K. K. Sinha, P. C. Ghoshal
Helper (A)	:	Santosh Kr. Barman

Medical Unit

Part-Time Attending Physician	:	P. K. Bhar
Technician (F)	:	S. Maity
Compounder	:	Ashoke Kr. Kochar
Helper (B)	:	Sahadev Ram

Administration

Registrar	:	D. N. Bhattacharyya
Administrative & Accounts Officer	:	A. N. Banerjee
Steno-Typist	:	Amallesh Saha, Alok Mitra

Director's Secretariat

P. A. To Director	:	N. K. Sinha
Stenographer	:	B. C. Roy

Helper (C) : D. P. Ram
 Helper (B) : Kishen Ram

Accounts

Chief Accountant : T. K. Das
 Accountant : B. N. Sinha
 Senior Assistant : Swapan Banerjee, N. K. Chowdhury,
 J. N. Saha
 Upper Division Clerk : T. K. Bhattacharyya, Debananda Gupta
 Lower Division Clerk : D. Chatterjee, Mrityunjoy De, Prasanta
 Das, Sankar Dewan
 Senior Typist : Ashutosh Das
 Clerk-cum-Typist : Santosh Kr. Seal
 Senior Cashier : B. M. Roy
 Cashier : J. C. Saha
 Helper (C) : Anadi Ram
 Helper (B) : Santosh Pradhan

Purchase-Stores

Accountant : B. B. Chakraborty
 Senior Assistant : D. K. Dutta Biwas, Biswajit Sinha Roy
 Upper Division Clerk : R. B. Mondal, Pankaj Banerjee, Jagat
 S. Roychowdhury
 Lower Division Clerk : Ashoke Maity, T. T. Dhar Roy
 Technician (E) : S. P. Bhattacharyya
 Senior Typist : S. P. Dutta
 Helper (B) : N. C. Gupta, Sanjib Barua

Establishment

Accountant : A. K. Ghosh
 Superintendent : R. K. Banerjee
 Senior Assistant : M. K. Mukherjee
 Upper Division Clerk : H. N. Mukherjee, Sanjay Chakraborty,
 Asit R. Deb
 Lower Division Clerk : Ashim Sarkar, Chandana Bhattacharyya
 Stenographer : M. K. Basak
 Senior Typist : Dilip Ghosh
 Typist : Biplab Roy
 Helper (B) : Parimal Barua
 Helper (A) : Arun Kr. Bose

Despatch

Superintendent : M. K. Sarkar
 Lower Division Clerk : Tapan Chakraborty, Panchanan Ghosh,
 Gour Hari Majumdar, Dipali Mitra
 Helper (B) : Laloo Ram, Parasan Ram

Building Maintenance

Engineer (SB)	:	S. K. Sarkar
Technician (E)	:	S. B. Roy
Technician (D)	:	Nepal Ch. Mitra, Paresh Ch. Majumdar
Technician (B)	:	P. Singh, S. S. Kundu
Technician (A)	:	S. Nayak
Helper (B)	:	Bhutka Hari, Chhakuli Hari, Pannalal Hari, Moona Hari, Surja Hari, Bhim Hari, Krishna Hari, Samar Kr. Ghosh
Helper (A)	:	Dilip Ram, Ramkanta Ram, S. K. Sabui, Kali Kanta Dey, Kartick Hari, Sakhi Chand Hari, K. P. Roy, Ashit Kr. Mahapatro, Dulal De, Sushil Kr. De, Mongal Ch. Mandal, Samir Kr. Chakraborty, Venarasi Mullick

Security

Security Officer	:	A. N. Chatterjee
Technician (C)	:	G. P. Chatterjee, S. N. Chakraborty
Technician (B)	:	D. N. Talukdar, R. S. Yadav, S. K. Pal, M. Batabyal, R. R. Sinha, B. N. Haldar, Sourendra Mohan Pal, S. B. Banerjee, R. N. Dey, P. K. Biswas, S. K. Gupta, B. L. Das, J. B. Bhattacharyya, H. K. Ghosh, C.S. Bhattacharyya, D. Chatterjee
Technician (A)	:	Krishnandhan Ghosh, Sanat Nath, Adhir Kr. Mitra, K. L. Mukherjee, Chittaranjan Sil, Purnananda Majumdar, Rakhal Ch. Das, Muktipada Mandal, T. L. Roy, Samir K. Das, Swapan K. Mandal
Helper (B)	:	J. B. Singh, R. G. Bahadur, Bhamar Singh, M. B. Singh, Bhatka Bahadur, Ranabir Ram, Makhan Ram
Helper (A)	:	P. B. Thapa, P. A. Bhaduri, Dinu Dutta

Drivers

Driver III	:	A. Simpson, S. C. Maity
Driver II	:	K. N. Paul, Ajoy Sarkar, Rajeswar Sil, Dilip Kr. Das

Other Scientific Members

Pool Officer (CSIR)	:	B. C. Khanra, Bikash Chakraborty, Amit Ghosh, S. K. Datta, C. Samanta
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(D.B)

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