The Review Committee

for the subject area

"Plasma Physics"

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1. Prof. Paul M. Bellan, California Institute of Technology, Pasadena, U.S.A.
2. Prof. A. Surjalal Sharma, University of Maryland, College Park, U.S.A.
3. Prof. AbhijitSen, Institute of Plasma Research, Gandhinagar, INDIA

3rd December 2010

SAHA INSTITUTE OF NUCLEAR PHYSICS

1/AF, Bidhannagar, Kolkata – 700 064

PLASMA PHYSICS DIVISION :

Permanent Members of the Division:

Scientific		Technical		Adm/Auxiliary	
A. N. Sekar Iyengar	Sr. Prof.	Shantanu Chowdhury	Engr.	Dulal Chatterjee	Supdt
Rabindranath Pal	Sr. Prof.	Partha S. Bhattacharya	SO	Ashok Ram	Helper
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M. Sita Janaki	Prof.	Abhijit Betal	SA		
Nikhil Chakrabarti	Prof.	Sib S. Sil	Tech.		
		Dipankar Das	Tech.		

Ph. D. Students (2007 – onwards)-(with guides):

Debjyoti Basu (R.Pal), M. Nurujjaman (A.N.Sekar Iyengar), Anirban Bose (M.S.Janaki) , Subir Biswas (R.Pal), Debabrata Banerjee (M.S.Janaki & N.Chakrabarti), Chandan Maity (N.Chakrabarti), Hari Shakrar Biswas (N.R.Ray) and Jagannath Datta (N.R.Ray).

EQUIPMENTS AND RESOURCES IN THE DIVISION

1. **SINP-Tokamak**
    a. Various types of Magnetic probes
    b. Various types of Langmuir Probes
    c. Time-of-Flight Analyser
    d. Soft x-ray imaging diagnostics
    e. Electron Cyclotron Emmision diagnostics
    f. 2 mm Microwave Interferometer
    g. Hard x-ray detectors
    h. Data Acquisition System

i. 1.2m Visible Spectrometer
j. 0.25m VUV Spectrometer
k. 0.5m Visible Spectrometer

2. **Facility for synthesis of thin films of HDLC** (Hydrogenated Diamond like Carbon) **materials.**
    l. Confocal Micro-Raman Spectrometer
    m. Fourier Transform Infra Red Spectrometer
    n. Atomic Force Microscope
    o. Contact angle Goniometer.
3. **The MaPLE Device** (Linear Magnetized Plasma Device)
    p. 2.45 GHz, 5 kwatt Microwave Source
    q. Spectrum Analyzer
    r. Lock-In Amplifier
    s. Arbitrary Function Generator
4. **Deep Space Plasma Propulsion Experimental Facility**
    t. Glass tube, Expansion chamber, Magnet coils
    u. RF source13.6 MHz, 1250 watt RF Source
    v. Vacuum capacitors, helical antenna, Matching network
    w. Stepper motor driven probe drive
5. **Nonlinear Dynamics Experimental Setup**

RESEARCH ACTIVITIES

The objective of the Plasma Physics Division has been two folds: One is to carry out basic research in theoretical and experimental Plasma Physics and the other is to use plasmas as a tool or technology for applications in other areas such as plasma based -material synthesis, development of propulsion systems, nonlinear dynamics etc. Emphasis has always been on indigenous development of the various systems and subsystems beginning from design.

IMPORTANT RESULTS

A) TOKAMAK RELATED EXPERIMENTAL RESULTS

(a) Ion Acceleration by MHD Activities

Ion acceleration due to large-scale magneto hydrodynamic (MHD) activities in the Saha Institute of Nuclear Physics (SINP) Tokamak is investigated by using a retarding field ion energy analyser looking from the tangential direction. Detection of high energy ions along with the bulk low energy ions seems to have a close connection with electron acceleration due to the electric field of the m/n =2/1 tearing modes.

(b) Intermittency in heat and Particle transport in the Scrapeoff layer

In the SINP tokamak, the plasma density and the temperature have been found to exhibit burst like behaviour. The formation, propagation and decay of long-lived plasma structures are believed to be the cause of this intermittency. Wavelet analysis has shown that the cross-correlation between two probes is also intermittent in time and is connected to the passage of plasma structures. The convected and conducted heat fluxes are also intermittent in nature. The structures decay in density as they move radially outward but their temperature is found to decay more rapidly, as expected from theoretical models.

(c) Radial transport of nonthermal electrons in SINP Tokamak

X-ray bursts from nonthermal electrons (10 keV to 1 MeV) emanating from the core plasma and the limiter are measured simultaneously in runaway dominated discharges in the SINP tokamak using a tangentially viewing NaI(Tl) detector and a detector that views the limiter areas. The radial transport coefficient of the nonthermal electrons has been derived from the cross-correlation function of the two x-ray intensities. Two phases of the plasma discharges with distinct transport of the nonthermal electrons are found in these experiments. The stochastic magnetic field fluctuations obtained from the transport coefficients are found to have a relationship with the autocorrelation functions of the x-ray emissivity signals.

(d) Hard x-ray correlation analysis as a diagnostic tool for the measurement of magnetic turbulence in tokamaks

A diagnostic has been developed for the measurement and characterisation of the magnetic turbulence occurring in the core region of a tokamak. A specially shielded detector looking in the tangential direction has been employed to measure the thin target bremsstrahlung from the core plasma. The thick target bremsstrahlung from the limiter is also recorded at the same time. Auto- and cross-correlation analyses have been shown to yield respectively the stochasticity of the magnetic fluctuations in the core region and the consequent diffusion coefficient of the nonthermal electrons. The measured stochasticity bears a relationship with the diffusion coefficient. Data obtained from internal magnetic probes corroborate the above trend but the hard x-ray measurement data are shown to be more reliable than those obtained from magnetic probes

(e) Improved Confinement due to Current Profile Modification and Suppression of Drift-Alfven Mode by Biased Electrode in SINP-Tokamak

Electrode biasing experiment in the plasma edge is carried out in the normal q regime of the SINP-Tokamak to investigate L-H mode transition. A negative bias is applied to the electrode by a fast switching circuitry. Above a minimum voltage applied H_{α} line intensity decreases and energy confinement time increases compared to without bias case. Detailed investigations shows due to application of the bias toroidal current profile is modified and drift-Alfven mode is suppressed which is believed to cause the improvement of the plasma confinement.

(B) DNTBA (Diamond Nano Technology for Biological Applications)

(a) Laboratory synthesis of a theoretically predicted in 2007 new carbon material called GRAPHANE has been shown to be possible **(b)** Dehydrogenation of our HDLC (Hydrogenated Diamond Like Carbon) sample was possible by irradiation of 3MeV N^+ ion beams and producing crystalline graphitic crystals having applications in science &

technology. **(c)** Biocompatible HDLC coating onto the steel without the need of interfacial layer of Titanium has been done successfully. **(d)** Covalent immobilization of protein onto atomically smooth surface of HDLC material has been done successfully. **(e)** Experimental results show our HDLC film is a wide band gap semiconductor which will be very useful fore storing electrical energy/decontamination of polluted water.

(C) THE MaPLE DEVICE (Magnetized plasma Linear Experimental Setup):

(a) Construction and its Plasma aspects.

The MaPLE (Magnetized Plasma Linear Experimental) device is a low cost laboratory plasma device fabricated in-house with the primary aim of studying basic plasma physics phenomena such as plasma instabilities, wave propagation, and their nonlinear behavior in magnetized plasma regime in a controlled manner. The machine is specially designed to be a versatile laboratory device that can provide a number of magnetic and electric scenario to facilitate such studies. A total of 36 number of 20-turn magnet coils, designed such as to allow easy handling, is capable of producing a uniform, dc magnetic field of about 0.35 T inside the plasma chamber of diameter 0.30 m. Support structure of the coils is planned in an innovative way facilitating straightforward fabrication and easy positioning of the coils. Further special feature lies in the arrangement of the spacers between the coils that can be maneuvered rather easily to create different magnetic configurations. Various methods of plasma production can be suitably utilized according to the experimental needs at either end of the vacuum vessel. At present, characteristics of a steady state plasma generated by electron cyclotron resonance method using 2.45 GHz microwave power have been investigated. Scans using simple probe drives revealed that a uniform and long plasma column having electron density ~ $3–5x10^{10}$ cm^{-3} and temperature ~7–10 eV, is formed in the center of the plasma chamber which is suitable for wave launching experiments.

(b) Parametric Decay of Pumping Waves into two Linear Modes in the MaPLE Device

Parametric decay of the pumping wave into two linear modes of plasma is observed. Experiment is performed in SINP MaPLE device with nitrogen plasma produced by ECR discharge. A low frequency mode alongwith both the lower and upper sidebands are observed. Sideband of the second harmonic is also found. Frequency of the low frequency mode is in the range of drift wave. Frequency of the other mode is in the range of ion cyclotron frequency and its harmonics. Preliminary studies show it may be ion Bernstein wave.

(D) DSPPE (Deep Space Plasma Propulsion Experiment)

(a) Experimental Setup

The objective of the DSPPE is to study the physics involved in the generation of mechanical thrust by a plasma. A main system will consist of plasma generation, heating and plasma divergence in a magnetic nozzle. Hydrogen plasma will be generated by RF source and in the presence of magnetic field will be heated to high energy by another RF source. With suitable configuration of magnetic field (magnetic nozzle, divergence of plasma in decreasing magnetic field) the gyration energy will be converted to linear energy, thereby generating the desired thrust. We have designed and fabricated 9 magnetic coils to provide a maximum magnetic field ~ 3 kGauss (axial) ; pulse duration: 10-20 Seconds, Plasma will be produced in a Quartz vacuum system of length ~1250 mm, outer diameter- 125 mm, using 13.6 MHz. RF source. Some other sub systems of this set up are ready.

(b) A Set Up for the Study of Double Layer:

A pilot experimental setup *has been* constructed for the above study. The RF power 1.25 kW maximum, 13.56 MHz is coupled to the antenna through a matching network. A helicon discharge is created in a quartz tube in an axial magnetic field provided by a Helmholtz coil pair. The plasma diffuses in a larger chamber (50 cm diam., 50cm long). The plasma in this chamber is diagnosed by Langmuir probes movable axially and radially by stepper motor controlled drives. Preliminary data on axial and radial profile have been recorded.

(E) NONLINEAR DYNAMICS EXPERIMENTS

We have shown for the first time in a glow discharge plasma the inverse bifurcation wherein the fluctuations go from chaos to order. The termination of the fluctuations is through a homoclinic bifurcation into an unstable fixed point. At this fixed point we have been able to demonstrate the very interesting results of coherence and stochastic resonance.

(F) THEORY

(a) Relaxation in magnetized plasmas

Relaxation phenomena in plasmas based on the principle of minimum dissipation rate of energy together with invariant magnetic helicity has been invoked to study relaxation in a non-driven as well as driven magnetized plasma in both MHD and two fluid and electron magneto hydrodynamic models. The merit of this model lies in its capability to predict many magnetic configurations such as reversed field pinches, tokamaks, very low-q and ultra low q-configurations, spheromaks, field reversed configurations and solar arcade structures. The model also obtains the pressure, perpendicular current profile, for all these configurations.

(b) Kinetic theory in weakly non-ideal systems.

Exact self-consistent steady state solutions of weakly correlated kinetic-Poisson's system of equations have been obtained as a counterpart of Bernstein Greene and Kruskal (BGK) modes.

(c) Directional Landau damping of wake field potentials

In contrast to the conventional problem of Landau damping that is one-dimensional, the problem of two dimensional Landau damping has been studied in the context of wake potentials produced due to moving charged particles.

(d) Study of transverse shear mode in strongly coupled dusty plasma.

Strongly coupled dusty plasmas are capable of sustaining transverse shear modes even in the fluid state. Generalized hydrodynamic model is utilized to study the linear and nonlinear characteristics of this mode.

(e) Nonlinear excitation of Geodesic acoustic mode in Tokamak plasma

Geodesic acoustic modes (GAMs) are a class of low frequency toroidal modes that are observed in a variety of tokamaks as well as plasma simulations. Simulations of study of edge plasmas provided the initial impetus to the experimental investigations. Observations with Doppler reflectometry and multipin probes have identifed details of spatial structures and spectral characteristics of the GAMs and have stimulated further theoretical and computational investigations to understand the primary excitation mechanism of these modes. In our present investigation it has been shown theoretically that GAMs can be excited by three-wave parametric processes involving drift modes .All these earlier studies (references are given in the published paper) were local theories and for electrostatic drift waves. In this article we first briefy outlined the local analysis for the coherent excitation of GAMs by resonant three-wave interactions. We present a nonlocal theory for the excitations of GAMs by electrostatic drift waves in an inhmogeneous plasma. The theory is then compared with earlier numerical studies and is found to be in good agreement. Furthermore both these studies provide an explanation of the multiple\step-like" eigenmodes observed in ASDEX-U tokamak. Nonlinear Lower-hybrid Oscillations in cold plasma In a fluid description nonlinear lower hybrid oscillation have been studied in a magnetized plasma using Lagrangian variables. An exact analytical solutions with nontrivial space and time dependence is obtained. The solution demonstrate that under well defined initial and boundary conditions the amplitude of the osillations increase due to nonlinearity and then come back to its initial condition again. These solutions indicating a class of nonlinear transient structures in magnetized plasma.

(f) Nonlinear excitation shear field and flow in electron magnetohydrodynamic waves in plasmas

The nonlinear generation of shear field and flow in whistler waves is considered. It is shown that a coherent parametric process, leads to modulational instability of four waves whistler interaction. Growth rates for the flow/field are compared with published simulations result.

LIST OF PUBLICATIONS

2010

1. Viscoelastic modes in a strongly coupled cold magnetized dusty plasma, Debabrata Banerjee, **Janaki Sita Mylavarapu, Nikhil Chakrabarti**, Phys.Plasma, 2010.
2. Hard X-ray Correlation analysis as a diagnostic tool for the measurement of magnetic turbulence in tokamaks. **S.K.Saha, A.K.Hui, S.Chowdhury, Santwana Raychaudhury**, **D.Banik**. Rev.Sc.Instruments 2010
3. Nonlinear Lower hybrid oscillation in cold plasmas, Chandan Maity, **Nikhil Chakrabarti** and Sudip Sengupta, Physics of Plasmas. 17 082306 (2010).
4. Covalent Immobilization of Protein onto a functionalized Hydrogenated Diamond like Carbon (HDLC) substrate, Hari Shankar Biswas, Jagannath Datta, D.P. Chowdhury, A.V.R. Reddy, Uday Chand Ghosh , Arvind Kumar Srivastava and **Nihar Ranjan Ray ,** Langmuir: 2010
5. Comparative study of Runaway confinement in SINP tokamak, R.Narayanan and **A.N.Sekar Iyengar**, Pramana (2010).
6. Emergence of stochastic resonance in Glow Discharge Plasma, Md.Nurujjaman, **A.N.Sekar Iyengar** and P.Parmananda, (IOP) Journal of Physics: Conference Series 208 (2010) 012084.
7. The MaPLE Device of Saha Institute of Nuclear Physics: Construction and its Plasma Aspects, **R. Pal**, S. Biswas, S. Basu, M. Chattopadhyay, D. Basu and M. Chaudhuri, Rev. Sci. Instr. 81, 1 (2010)
8. Shear wave vortex solution in a strongly coupled dusty plasma, M**. S. Janaki and N. Chakrabarti**, Phys. Plasmas 17, 053704 (2010)053704.
9. Density distribution for a weakly non-ideal non-uniform plasma, Anirban Bose and **M.S**. **Janaki**, J. Phys. A, 43 (2010).
10. Parametric Decay of Pumping Waves into two Linear Modes in SINP MaPLE Device, S. Biswas and **R. Pal**, AIP Conference Proceedings (2010).

2009

11. Comparative study of nonlinear properties of EEG signals of normal persons and epileptic patients, Md.Nur Ujjaman, R.Narayanan and **A.N.Sekar Iyengar**, Nonlinear Biomedical Physics, 2009, 3:6
12. Continuous wavelet transform based time-scale and multi-fractal analysis of the nonlinear oscillations in a hollow cathode glow discharge plasma, Md. Nurujjaman, Ramesh Narayanan, **A.N. Sekar Iyengar**, Physics of Plasmas16, 102307 (2009)
13. Coherence resonance in an unijunction transistor relaxation oscillator,Md. Nurujjaman, P.S. Bhattacharya, **A.N. Sekar Iyengar**, Sandip Sarkar, Phys.Rev. E 80, 015201(Rapid Communication) (2009)
14. Non-local analysis of the excitation of the geodesic acoustic mode by beta drift waves. P.N. Guzdar, R.G. Kleva, **N. Chakrabarti**,V. Naulin, J. J. Rasmussen, P. K. Kaw and R.Singh ,Physics of Plasmas.16 052514 (2009).

15. Nonlinear interaction of electron plasma waves with electron acoustic waves in plasmas. **Nikhil Chakrabarti** and Sudip Sengupta, Physics of Plasmas. 16 072311 (2009).
16. Radial transport of the nonthermal electrons in runaway discharges in the SINP tokamak from analysis of hard x-ray fluctuations, A.K. Hui, **S.K. Saha**, **S. Chowdhury, Santwana Raychaudhuri** and D. Banik, Nucl. Fusion 49 (2009) 115025.
17. Structural modifications of diamond like carbon films induced by MeV nitrogen ion irradiation, S.Mathew, U M Bhatta, AKM Maidul Islam, M Mukherjee, **N R Ray** & B N Dev Applied Surface Science 225(9) 2009, 4796-4800.
18. Preparation of DLC thin films on stainless steel and its SEM characterization, K Kumar, S. Banerjee, T K Chini & **N R Ray**, Bull. Mater. Sci. 32(6), 2009, 563-567.
19. Edge Biasing of SINP-Tokamak Plasma in High-q Regime, D. Basu and **R. Pal**, J. Plasma Fusion Res. Series, Vol. 8, 1453 (2009)

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20. Noise invoked resonances near a homoclinic bifurcation in the glow discharge plasma, Md. Nurujjaman, **A. N. Sekar Iyengar**, Punit Parmananda, Phys. Rev. E 78, 026406 (2008)
21. Intermittency in the heat and particle transports in the SINP tokamak scrape-off layer, **S.K. Saha and S. Chowdhury**, Phys. Plasmas 15(2008)012305.
22. In search of Graphane-two dimensional hydrocarbonâ **N R Ray**, A K Srivastava & R Grotzsche, http://arxiv.or/abs/0802.3998 (2008)
23. Excitation of geodesic acoustic modes by ion temperature gradient modes. P.N. Guzdar, **N. Chakrabarti,** R. Singh and P. K. Kaw, Plasma Physics and controlled Fusion. 50 025006 (2008).
24. Geodesic acoustic modes excited by finite beta drift wave, **N. Chakrabarti,** P.N. Guzdar, R.G. Kleva, V. Naulin, J. J. Rasmussen and P. K. Kaw, Physics of Plasmas. 15 112310 (2008).
25. Debye-shielding potential in the presence of pair correlations, Anirban Bose and **M.S. Janaki,** Physics of Plasmas, 15(2008)012109.

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26. Fractal Dimension of the 2001 El Salvador Earthquake Time Series, Md.Nurujjaman, R.Narayanan and **A.N.Sekar Iyengar**, Lect.Notes Phys, Springer Verlag, Berlin, Heidelberg 705, 499-505 (2007)
27. Realization of SOC behaviour in a dc glow discharge plasma,Md.Nurujjaman and **A.N.Sekar Iyengar**, Physics Letters A 360 (2007) 717-721
28. Parametric investigation of nonlinear fluctuations in a dc glow discharge plasma, Md. Nurujjaman, Ramesh Narayanan, **A.N. Sekar Iyengar**, Chaos 17, 043121 (2007).
29. Modification of edge current profile and improved confinement induced by biased electrode in the very low qa (VLQ) discharges of SINP-tokamak, J. Ghosh, **R. Pal**, P. K. Chattopadhyay and D. Basu, Nuclear Fusion 47, 331(2007).
30. Ion acceleration by MHD activity in SINP tokamak **S.Raychaudhuri, S.K.Saha, S.Chowdhury**, D.Banik and A.K.Hui, J. Nepal Phys. Soc.

23(2007)32.

31. Nonlinear excitation of geodesic acoustic modes by drift waves. **N. Chakrabarti** , R. Singh, P. K. Kaw and P. N. Guzdar, Phys. of Plasmas 14, 052308 (2007).
32. Nonlinear electrostatic structures in the presence of correlations, Anirban Bose and **M.S. Janaki**, Physics of Plasmas, 14(2007)063701.
33. Solar Arcades as Possible Minimum Dissipative Relaxed States., R. Bhattacharya, **M.S**. **Janaki**, B. Dasgupta and G.P. Zank, Solar Physics 240(2007)63.

Plasma Physics Division

1.a)Name: **A.N.Sekar Iyengar**
b)Educational background: Ph.D
c)Present designation: Sr.Professor'H'

2. **Academic Profile**
1985: Ph.D(Physical Research Laboratory)
1985-87: Culham Laboratory and Oxford University
1997-88: Joined as faculty at Insitute for Plasma Research
1988-Till Now: Saha Institute for Nuclear Physics

3. **Research/Development**
A. Tokamak Related Activities

a) My basic training is in experimental plasma physics: High temperature plasmas like tokamaks and Reverse field pinches and Low temperature plasmas like Double Plasma Device, Glow discharge plasma etc. After joining SINP, I pioneered Low q_a (where q_a is the edge safety factor) discharge experiments in the SINP tokamak and showed that ours is the only tokamak that can operate in various regimes: Normal q_a ($q_a>2$), very low q_a ($1<q_a<2$) and Ultra low q_a($0<q_a<1$). The advantage of this is that one can carry out experiments relevant to tokamaks and reverse field pinches in a single device. Several interesting results like Setting up of very low q_a discharges, Anomalous ion heating, edge biasing experiments etc were carried out in this area in this device.

b) Another area of work that I pioneered in our tokamak was the investigation of High energy electrons called runaway electrons. This was important because most of the other tokamaks tended to avoid such investigations, but our foray in this area led to some interesting observations one of them being the presence of **negative currents** in the edge region of the tokamak. **For both the above work we had to develop several diagnostics to measure current profile, and the internal Rogowskii probe was unique.**

B. Nonlinear Dynamics Related Activities

Around 1999 I felt that if one had to understand the plasma processes in more detail it was absolutely necessary to explore new techniques of data analysis. In this process I landed into Non linear dynamics- which was almost like an unexplored territory as for as plasma physics was concerned. With this intention we set up an experiment called Complex Dynamics Plasma Experimental System. Though this was primarily meant to do dusty plasma experiments, we had some interesting observations even without dust. This led us to investigate the self excited oscillations in glow discharge plasmas without dust and chanced upon the discovery of chaos to order for the first time in plasma experiments. Then we carried out an experiment which is very fundamental to many areas i.e noise induced effects in non-equilibrium systems- we could obtain coherence and stochastic resonance.

We have also been able to carry out some of the nonlinear dynamics experiments in electronics devices for example the Uni Junction transistor (UJT). We have been able to demonstrate that these devices also exhibit homo clinic bifurcation and noise induced coherence resonance etc.

C. Nonlinear Time Series analysis

This is one area in which we have spent a lot of time and effort in the last ten years or so to understand the behaviour of nonlinear systems. Some of the techniques we have perfected are Wavelet analysis, Empirical Mode Decomposition, Recurrence Plots, Detrended Fluctuation Analysis.

4. Future Plans

a.We have started applying the above mentioned nonlinear techqniques to our tokamak data especially in the low q regime and will be able to carry out a detailed nonlinear dynamical characterization of the tokamak discharges.
b.Modelling of the chaotic oscillations with and without noise in nonlinear systems.
c.Nonlinear dynamical characterization of the plasma fluctuations in the MAPLE device
d.Chaos experiments in dusty plasmas.
e. Synchronization of chaotic oscillations in coupled plasmas

SINP being an institution with interests in basic research in diverse fields we should think of setting up a centre/section at SINP dedicated to study of nonlinear complex systems which will also explore

new techniques of nonlinear time series analysis-something on the lines of Santa Fe Institute, Potsdam, Max Planck Institute for complex systems, Dresden, Germany.

5. Some important Publications in (Tokamak & Non tokamak Plasma Experiments and Nonlinear Time Series analysis).

1. Comparative study of Runaway confinement in SINP tokamak **Accepted for publication (2010)** R.Narayanan and **A.N.Sekar Iyengar**, **Pramana (2010).**
2. Emergence of stochastic resonance in Glow Discharge Plasma, Md.Nurujjaman, **A.N.Sekar Iyengar** and P.Parmananda, **(IOP)Journal of Physics: Conference Series 208** (2010) 012084
3. Comparative study of nonlinear properties of EEG signals of normal persons and epileptic patients,Md.Nur Ujjaman, R.Narayanan and **A.N.Sekar Iyengar**, **Nonlinear Biomedical Physics**, 2009, 3:6
4. Continuous wavelet transform based time-scale and multi-fractal analysis of the nonlinear oscillations in a hollow cathode glow discharge plasma, Md. Nurujjaman, Ramesh Narayanan**,** **A.N. Sekar Iyengar**, **Physics of Plasmas** 16, 102307 (2009)
5. Coherence resonance in an unijunction transistor relaxation oscillator,Md. Nurujjaman, P.S. Bhattacharya, **A.N. Sekar Iyengar**, Sandip Sarkar, **Phys.Rev. E** 80, 015201(Rapid Communication) (2009)(equivalent to PRL)
6. Noise invoked resonances near a homoclinic bifurcation in the glow discharge plasma, Md. Nurujjaman, **A. N. Sekar Iyengar**, Punit Parmananda, **Phys. Rev. E 78**, 026406 (2008)
7. Fractal Dimension of the 2001 El Salvador Earthquake Time Series, Md.Nurujjaman, R.Narayanan and **A.N.Sekar Iyengar**, **Lect.Notes Phys, Springer Verlag**, Berlin, Heidelberg 705, 499-505 (2007)
8. Realization of SOC behaviour in a dc glow discharge plasma,Md.Nurujjaman and **A.N.Sekar Iyengar**, **Physics Letters A** 360 (2007) 717-721
9. Parametric investigation of nonlinear fluctuations in a dc glow dischargeplasma,Md. Nurujjaman, Ramesh Narayanan, **A.N. Sekar Iyengar**, **Chaos** 17, 043121 (2007).

10. Internal Rogowski coil for profile measurements in the SINP tokamak R.Narayanan and **A.N.S.Iyengar, Review of Scientific Instruments 77, 033503 (2006)**
11. Higher Order Statistical analysis of fluctuations in a plasma, R.Narayanan, M.S.Janaki and **A.N.S.Iyengar, Physica Scripta, January (2003)**
12. Anomalous Ion Heating in very low q discharges of SINP tokamak,P.Chattopadhyay, R.Pal, **A.N.S.Iyengar** and J.Ghosh, **Phys. Rev.Letts. 81,3151 (98).**
13. Runaway electron studies in the startup phase of very low edge safety factor discharges in the SINP tokamak, **A.N.Sekar Iyengar,** R.Pal S.Lahiri and A.K.Hui **Nuclear Fusion 38, 1381 (98)**
14 . Electron temperature estimation in SINP tokamak from Soft X ray imaging systems, R.K.Paul, D.Banik,**A.N.Sekar Iyengar** and A.K.Hui,**Review of Scientific Instruments 69 1378 (98)**

Collaborations:

1. Nonlinear dynamics experiments in chemical systems which exhibit the so called B-Z Reaction(with Prof.Samita Basu-CSD).
2. Nonlinear time series analysis of Chemical gas releases during seismic events, EEG signals of rats (with Dr.S.K.Dana, Indian Institute of Chemical Biology-Kolkata,).
3. Comparative Study of Asthamatic persons and Non-Asthamatic persons through nonlinear time series analysis (with Dr.A.Agarwal& Dr.T.P.Sethi, IGIB, Delhi)
4. Nonlinear Time series analysis of Geochemical Oscillations of Radon and Helium gases obtained from Bakreshwar, Andamans and Thatta Pani (with Dr.H.Chowdhury, Dr.D.Ghose, Prof.P.Sen, Prof.B.Sinha, VECC, Kolkata).

A.N. Sekar Iyengar

RABINDRANATH PAL

Senior Professor 'H'

Area of research: **EXPERIMENTAL PLASMA PHYSICS**

Educational Background:

DEGREE	*YEAR*	*GRADE*	*INSTITUTION*
Higher Secondary	1966	I[st] Division *(**Ranked 9th**)*	West Bengal Board of Secondary Edu.
B. Sc. (Hons in Physics)	1969	I[st] Class	Presidency College, Calcutta University
M. Sc. (Pure Physics)	1972	I[st] Class *(**Ranked 2nd**)*	Calcutta University
Ph. D. (Physics**)**	1978		University of Maryland, U.S.A.

Academic Profile:

1.	**Senior Professor 'H'**	Saha Institute of Nuclear Physics, Calcutta	Aug.2008 - Present
2.	**Professor 'G'**	Saha Institute of Nuclear Physics, Calcutta	Feb.2004 - Jul.2008
3.	**Professor 'F'**	Saha Institute of Nuclear Physics, Calcutta	Feb.1999- Jan. 2004
4.	**Associate Professor**	Saha Institute of Nuclear Physics, Calcutta	Aug.1993 - Jan.1999
5.	**Reader**	Saha Institute of Nuclear Physics, Calcutta	Mar.1988 - Jul.1993
6.	**Visiting Scientist**	Institute of Plasma Physics, Hefei, CHINA	Oct.1995 - Dec.1995
7.	**Visiting Res. Associate**	University of Maryland, Maryland, U. S. A.	Dec.1989 - Jan.1991
8.	**Fellow (Faculty position)**	Institute for Plasma Research, Gandhinagar	Jun.1983 - Feb.1988
9.	**Visiting Res. Scientist**	McGill University, Montreal, Canada	Aug.1984 - Nov.1984
10.	**Research associate**	Cornell University, New York, U. S. A.	Oct.1981 - Mar.1983
11.	**Post Doctoral Associate**	Cornell University, New York, U. S. A.	Oct.1978 - Sep.1981
12.	**Research Assistant**	University of Maryland, Maryland, U. S. A.	Jul.1974 - Sep.1978
13.	**Teaching Assistant**	University of Maryland, Maryland, U. S. A.	Aug.1973 - Jun.1974

Academic Awards & Honours:

a) Member of prestigious Phi-Kappa-Phi Society, USA (1973 – 1978)
b) National Science Talent Search Scholar (1966 – 1973) by Govt. of India
c) M.Sc.(Pure Physics) - ranked First Class ***2nd*** in Calcutta University (1972)
d) H. S. – ranked ***9th*** in WB Board of Secondary Education (1966)

List of Important Publications:

i) 'The MaPLE Device of Saha Institute of Nuclear Physics: Construction and its Plasma Aspects', R. Pal, S. Biswas, S. Basu, M. Chattopadhyay, D. Basu and M. Chaudhuri**, *Rev. Sci. Instr.*** *81, 1 (2010)*

ii) 'Anomalous Ion Heating in Very Low q_a Discharges of SINP-TOKAMAK', P. K.Chattopadhyay, R. Pal, A. N. S. Iyengar and J. Ghosh, ***Phys. Rev. Letters*** *81, 3151 (1998)*

iii) 'Spectroscopic Investigation of Surface Flashover Type Anode Plasma in a Magnetically Insulated Ion Diode', R. Pal and D. A. Hammer, ***Phys. Rev. Letters*** *50, 732 (1983)*

iv) 'Suprathermal Field Fluctuations and High Energy Electrons in a Low Density Plasma: A Spectroscopic Investigation', R. Pal and H. R. Griem, ***Physics of Fluids*** *22, 1790 (1979)*

v) 'Studies of an Applied B_theta Magnetically Insulated Ion Diode', R. Pal, D. A. Hammer and M. A. Greenspan, ***J. of Appl. Phys****. 53, 6655 (1982)*

vi) 'Modification of edge current profile and improved confinement induced by biased electrode in the very low q_a (VLQ) discharges of SINP-tokamak', J. Ghosh, R. Pal, P. K. Chattopadhyay and D. Basu, ***Nuclear Fusion 47****, 331(2007)*

vii) 'An Applied B Magnetically Insulated Ion Diode', M. A. Greenspan, R. Pal, D. A. Hammer and S. Humphries Jr., ***Appl. Phys. Letters*** *37, 248 (1980)*

viii) 'Ion Beam Annealing of Semiconductors', R.T. Hodgson,J. E. E. Baglin, R. Pal, J. M. Neri and D. A. Hammer, ***Appl. Phys. Letters*** *37, 187 (1980)*

ix) 'Dependence of Up-Down Asymmetry on the Edge Safety Factor in the Saha Institute of Nuclear Physics-Tokamak (SINP-TOKAMAK)', J. Ghosh, R. Pal and D. Basu, ***Physics of Plasmas*** *11, (2004)*

x) "Setup for potential bias experiments on the Saha Institute of Nuclear Physics Tokamak",- J. Ghosh, R. Pal and P. K. Chattopadhyay, ***Rev. Sci. Instr.*** *70, 4557 (1999)*

xi) 'Runaway Electron Studies in the Start-Up Phase of Very Low Edge Safety Factor Discharges in the SINP-TOKAMAK' - A. N. S. Iyengar, R. Pal, S. Lahiri and S. Mukhopadhyay, ***Nucear. Fusion*** ***__38__***, *1177 (1998)*

xii) 'Detailed Characteristics of an Intense Proton Beam from an Applied B Magnetically Insulated Ion Diode', K. W. Zieher, R. Pal, T. Renk, D. Eisenmann, D. A. Hammer and R. N. Sudan, ***Appl. Phys. Letters*** *40, 874 (1982)*

__Highlights of scientific contribution__:

- In University of Maryland in a theta-pinch machine I showed that strong turbulent electric field fluctuations can be self consistently measured by spectroscopic method. The results, demonstrating an interesting novel method of determining electric field fluctuation level, were published in a paper in PHYSICS OF FLUIDS.
- In Cornell University for the first time I spectroscopically investigated the characteristics and dynamics of the thin layer of surface flash-over type of plasmas produced inside an intense high power pulsed ion diode. Not only it led to a paper in PHYSICAL REVIEW LETTERS, but it proved to be the most important diagnostic for investigating such diodes. In addition, my investigation of a new kind of diode, Applied-B_θ magnetically insulated ion diode, led to another advantageous configuration of generating intense ion beam for inertial fusion. It resulted in several papers, e.g., in APPLIED PHYSICS LETTERS, JOURNAL OF APPLIED PHYSICS, etc.
- In the SINP-TOKAMAK the spectroscopic observations we made on ion heating and its possible cause seemed to be of unique nature. We found stochastic processes in the field of drift Alfven waves is the cause of fast anomalous heating of ions, not the 'dynamo activities' as generally inferred in high current low magnetic field plasmas. The results were published in PHYSICAL REVIEW LETTERS.
- In another experiment electrode biasing seemed to flatten the current profile at the edge causing improved energy confinement, before electric field modification was set up. Our results, reported in NUCLEAR FUSION, provided an unique channel of producing the low-to-high confinement regime.

__Major Developmental Works in Projects of SINP__:

a) For the SINP-TOKAMAK the *DASUP* code, a more-than-ten-thousand-line FORTRAN software, was developed for user friendly GPIB-based basic data acquisition and analysis with PC. The software was extensively used in the tokamak group.

b) For the SINP-TOKAMAK developed several important and sophisticated diagnostics, like Hard X-ray monitor, spectroscopic (visible & VUV) diagnostic, 2-mm Interferometry, etc, a pulsed high voltage, high current power supply for tokamak edge biasing experiment and a pre-ionizing system with microwave.

c) Designed and constructed in-house the large MaPLE (__Ma__gnetized __P__lasma __L__inear __E__xperimental) Device with the objective of studying in a controlled manner some basic plasma phenomena, like plasma instabilities, wave propagation, etc. and their nonlinear behavior, that are quite difficult to study in complex systems like tokamaks, magnetosphere, etc. Its construction and the plasma aspects are reported in a paper in REVIEW OF SCIENTIFIC INSTRUMENTS.

d) To protect the magnet coils of the MaPLE Device from overheating temperature of each coil is monitored electronically using temperature low cost sensor IC chips. Parallel port of PC is cleverly utilized for addressing 36 sensor chips.

The MaPLE Device shown at the left

__Future Research/Development Plan__:

Wave launching experiments in the MaPLE plasma are being carried out at present. Preliminary results obtained in the ion cyclotron frequency regime show nonlinear behavior which will be further investigated for the exact mechanism. Diagnostics available in the machine are still in the preliminary stage. Some sophisticated diagnostics, like optical emission spectroscopy and Laser Induced Fluorescence, are being planned. Additionally, the process of converting the device to a Q-machine is in progress.

1. Name: Santwana Raychaudhuri

Photograph: 

Education:

Year	Degree	University	Subject
1986	Ph.D.	Calcutta	Science (Physics)
1974	M.Sc.	Calcutta	Physics
1972	B.Sc.	Calcutta	Physics (Honours)

Title of Ph.D. Thesis:

Some Studies of Wave Propagation in Plasmas
Thesis Supervisors:
Professor Karl.E. Lonngren, University of Iowa, Iowa City, USA and
Professor S.N.Sengupta, Saha Institute of Nuclear Physics (SINP),Calcutta, India.

Special Awards:

National Science Talent Search Scholarship (NSTS) and
A certificate of merit awarded by the Government of India, 1969.

2. Academic profile including earlier appointments

1. Research fellow, SINP, Calcutta, India after M.Sc up to September 1983.
2. Research Associate, U. of Iowa, Iowa City, USA Oct.1983-Dec. 1985.
3. Research Associate, Hot Plasma Project, SINP April, 1986-October 1987.
4. F**aculty** (at present **Professor G),** SINP, Kolkata, since October 1987.
5. Guest Scientist, Tohoku University, Aug. 2000-Mar. 2001.
6. Visiting Scientist, Kyushu University, Japan, Nov. 2000 & Mar. 2001.
7. Guest Professor Utsunomiya University, Japan, June-Sept, 2003.

3. Essential strength of research/development output:

At present we are engaged in two very important field of research in plasma physics.

1. Tokamak research, which will develop our strength in solving energy problem.
2. Deep space plasma propulsion system will develop our country's strength in solving future rocket propulsion fueling problem.

4. Future research/development plan:

(1) Upgradation of the SINP tokamak: Upgradation of the SINP tokamak data acquisition system as well as revival of various diagnostics systems for the tokamak is in progress.

(2) Deep Space plasma propulsion Experiment (DSPPE): The design and fabrication works of different parts of the helicon device is under progress.
Collaborators: **A.K. Hui, S. K. Saha, S. Chowdhury, M.S.Janaki,**

5. List of important publications starting with recent publications

(1) "Radial transport of the nonthermal electrons in runaway discharges in the SINP tokamak from analysis of hard x-ray fluctuations"
A.K. Hui, S.K. Saha, S. Chowdhury, **Santwana Raychaudhuri** and D. Banik,
Nucl. Fusion 49 (2009) 115025 (7pp)

(2) "Ion acceleration by MHD activity in SINP tokamak"
S.Raychaudhuri, S.K.Saha, S.Chowdhury, D.Banik and A.K.Hui,
J. Nepal Phys. Soc. 23(2007)32.

(3) "Observation of High Energy Ion Tail in the SINP Tokamak Plasma"
S.Raychaudhuri, S.K.Saha, S.Chowdhury, D.Banik and A.K.Hui,
Physics of Plasmas, **13** (2006) 122510.

(4) "Distorted wave for the study of dispersion"
Barnana Pal, **Santwana Raychaudhuri** and Yoshinobu Kawai
Phys. Plasmas, **12** (2005) 12,062306.

(4) "Microwave-generated low-frequency plasma wave excited in the periphery of the evanescent-layer", **Santwana Raychaudhuri**, Md. K-Al-Hasan,Noboru Yugami,Hiroaki Ito and Yasushi Nishida,
Phys. Plasmas, **11** (2004) p4634-4640.

(5) "Ion Temperature Measurement in the Edge Region of SINP Tokamak by a Retarding Field Analyzer": **Santwana Raychaudhuri**,
Contrib. Plasma Phys., 39 (1999) 4, p359-365.

(6) "Studies of tokamak plasma from core to edge region by Langmuir probes":
Santwana Raychaudhuri,
Contributions to Plasma Physics, 36 (1996) S p125-130.

(7) "Observation of drift wave like instability in the tokamak core region"
Santwana Raychaudhuri,
Nuclear Fusion, 35,No.10, 1281-1288 (1995).

(8) "Scattering of ion acoustic solitons", **Santwana Raychaudhuri**, Hong young Chang, Eugene K. Tsikis and Karl E. Lonngren
Phys.of Fluids, 28, 2125-2129 (1985).

1. Name: Nihar Ranjan Ray, Professor (G), PPD, SINP
2. Photograph: 
3. Educational Qualifications:
   BSc (Phys Hons.): R K Mission, College, Narendrapur, CU [1970-73]
   MSc (Physics): Spectroscopy (Spl. Paper): CU [1973-75]
   PhD (Sc): SINP: CU: Title of the PhD Thesis "Some Studies on the Production *of Negative Hydrogen Ions Using Duoplasmatron Ion Source*" [1989]
4. Academic Profile including earlier appointments, awards etc.:
   - i) Research Associate (RA) at SINP: 1989-90
   - ii) Lecturer (C), PPD, SINP: 1990-94
   - iii) Reader (D), PPD, SINP: 1994-99
   - iv) Asso. Prof.(E), PPD, SINP: 1999-2004
   - v) Prof. (F), PPD, SINP: 2004-2008
   - vi) Prof. (G), PPD, SINP: 2008- today
   - vii) Associate Member of TWAS, Trieste, Italy (1996-99)
   - viii) DAAD Fellow (2001)
   - ix) "The INNOLEC LECTURESHIP in Plasma Physics" by the Faculty of Science, Masaryk University, Brno, Czech Republic, August 17, 2007.

5. Essential strength of research/development output:

(i) Indigenous development of flat-top current of 20 msec in SINP-Tokamak by inductive delay method and this work was published along with other co-workers in *J.Fiz. Malayasia* 13, 59 (**1992**)

(ii) Ergodic diffusion of charged particles due to error magnetic field in the SINP-Tokamak was measured and published in a single authorship in *Europhysics Letters* 32(6), 487 (**1995**)

(iii) Indigenous development of a *Time-of-Flight analyzer system* (room no. 101) during the period **1995-1998,** for measuring energy distribution of high energy (~ 25 eV) hydrogen neutrals coming out of the SINP-Tokamak plasma: Output: 3 publications, utilizing this system, in *J. of Phys: D, Review of Scientific Instruments & Measurement Science & Technology*.

(iv) Supervision & completion of a PhD thesis (awarded in 2005 to Dr. K. Bhattacharyya under JU) entitled "*Some Studies on the Asymmetries in the SINP Tokamak Plasma*" (**1998-2005**): Total no. of publications: 3: *Plasma Physics & Control Fusion (2000, 2001) and Journal of Plasma and Fusion Research SERIES 3 (2000)*

(v) Indigenous development of a laboratory at SINP (**room no. 110**) during the X-plan period (**2002-2007**) for the synthesis of nano-carbon materials in thin film form. 100% of the fund (Rs. 90 lakhs) was utilized successfully in this work.

(vi) Indigenous development of a laboratory at SINP (**room no. 3318**) **during the on-going XI-plan (2007-12) program** "*Diamond Nanotechnology for bio-applications (DNTBA*)" for studying biocompatibility, electrochemical nature of the synthesized hydrogenated diamond like carbon (HDLC) thin film (a typical nano-carbon material in thin film form) in application to *substrate material* for biology, *energy material* for hydrogen production from water, *coating material* for medical devices, *electronic material* for light source by doping HDLC with suitable impurities. *Total nos. of on going PhD works in this DNTBA project: 1 (registered under HBNI) + 1 (enrolled under CU); Total nos. of summer projects utilizing the developed facilities under DNTBA project: 6. Total nos. of external users utilizing the developed facilities in room no. 3318 till date: 1 (SINP) + 1 (Presidency College, Kolkata).* ***78% of the project outlay fund (Rs. 325 lakhs) was utilized successfully in this work till date.***

5. Future research/development plan: Current research has found that undoped HDLC material is made of ultrananocrystalline diamond particles having sizes 1-4nm and producing a continuous non-porous carbon thin film; surface of the film is atomically smooth and hydrophobic in nature and as a result biofunctionalization of its surface has been possible; this material has a negative

electron affinity and a wide potential window; this material also has a tunable electrical conductivity while using suitable electrolyte. Based upon current research findings the future research course will be concerned with the fundamental science of nanostructured thin carbon film and the surface systems, which will help in the device applications as mentioned above.

6. List of important publications starting with recent publications:

(i) "*Covalent Immobilization of Protein onto a functionalized Hydrogenated Diamond like Carbon (HDLC) substrate*" by Hari Shankar Biswas, Jagannath Datta, D.P. Chowdhury, A.V.R. Reddy, Uday Chand Ghosh , Arvind Kumar Srivastava and **Nihar Ranjan Ray** (*Under Review in the Journal "Langmuir"* : **2010**)

(ii) "*Structural modifications of diamond like carbon films induced by MeV nitrogen ion irradiation*" by S.Mathew, U M Bhatta, AKM Maidul Islam, M Mukherjee, **N R Ray** & B N Dev
Applied Surface Science 225(9) **2009**, 4796-4800.

(iii) "*Preparation of DLC thin films on stainless steel and its SEM characterization*" by K Kumar, S Banerjee, T K Chini & N R Ray
Bull. Mater. Sci. 32(6), **2009**, 563-567.

(iv) "*In search of Graphane-two dimensional hydrocarbon*" **N R Ray**, A K Srivastava & R Grotzschel
http://arxiv.or/abs/0802.3998 **(2008)**

(v) "*Quantitative Analysis of Hydrogenated Diamond like Carbon Films by Visible Raman Spectroscopy*" A.Singha, A.Ghosh, A.Roy & **N.R.Ray**
Journal of Applied Physics 100(044910) **2006**

(vi) "*Origin of the inversion of up-down potential asymmetry in the magnetized toroidal plasma*" K.Bhattacharyya and **Nihar Ranjan Ray**
Plasma Physics and Controlled Fusion 43, 1157 (**2001)**

(vii) "*Analysis of Spiky Net Toroidal Current in the Magnetized Toroidal Plasma from the point of view of Helicity- Conservation*" by **Nihar Ranjan Ray** and Krishnendu Bhattacharyya
Plasma Physics and Controlled Fusion 42(12), 1321 (**2000)**

(viii) "*Helicity Injection Experiments in the SINP tokamak*"
K.Bhattacharyya & **N.R.Ray**
Journal of Plasma and Fusion Research SERIES 3, 489 (**2000**)

(ix) "*Observation of multiple peaked structures in the Time-of Flight (TOF) spectrum of the SINP tokamak discharge*" by N.R.Ray
Reviews of Scientific Instruments, 17(1), pt-II, 971 (**1999)**

(x) "*A time-of-flight low energy analyzer (TOFLEA) of neutral atoms*"
by **N.R.Ray**
Journal of Physics D: Applied Physics 31(9), 1071 (**1998**)

(xi) "*Generation of synchronized TTL pulses for the operation of a pulse counter*"
by **N.R.Ray**, R.Roy, A.Bal
Measurement Science & Technology 9(2), 283 (**1998**)

(xii) "*Breakdown and predomination experiments in the SINP tokamak*"
by P.K.Chattopadhyay, R.Pal, **N.R.Ray**, P.K.Gupta
Nuclear Fusion 36(9), 1205 (**1996**)

(xiii) "*Ergodic diffusion due to intrinsic magnetic error field in a toroidal discharge*"
by **N.R.Ray**
Europhysics Letters 32(6), 487 (**1995**)

(xiv) "*Production of stable discharge and flat top plasma current in the SINP tokamak by simple inductive delay method*" by **N.R.Ray**, P.K.Chattopadhyay, R.Pal, J.Basu & S.K.Majumdar
J.Fiz. Malayasia 13, 59 (**1992**)

(xv) "*Method for producing neutral and negative hydrogen particles applicable to hot plasma diagnosis*" by **N.R.Ray** & S.N.Sengupta
Reviews of Scientific Instruments 59(10), 2158 (**1988**)

(xvi) "*Production of H^- ion beam using duoplasmatron ion source*" by **N.R.Ray**
Current Science 53(8), 421 (**1984**)

Name : SUJIT KUMAR SAHA

Educational background :

a) Higher Secondary (school leaving) examination in 1969. Obtained First Division. Obtained National Science Talent Search scholarship from the National Council of Educational Research and Training (continued upto the Ph.D. level).
b) Bachelor of Science (B. Sc.) from the University of Calcutta in 1972. Obtained First Class.
c) Master of Science (M. Sc.) from the University of Calcutta in 1974. Obtained First Class and ranked First.
d) Ph. D. from the University of Calcutta in January, 1989 (Thesis submitted in September, 1987). Subject: Studies on ion beam-plasma interaction.

Earlier appointments:

(a) Worked as Research Fellow from May, 1976 to January, 1981 in Saha Institute of Nuclear Physics, Calcutta.
(b) Employed in Department of Physics, Surendranath College, Calcutta from 1981 to 1993 (as Lecturer and later as Senior Lecturer).
(c) Foreign collaborator at Centre d'Etudes Nucleares de Cadarache, Atomic Energy Commission, France(1990-1992).
(d) Employed in Plasma Physics Division of Saha Institute of Nuclear Physics, Calcutta since 1993 (as Reader (1993-1998), Associate Professor (1998-2005), Professor-grade F (2005-2009) and Professor-grade G since 2009).
(e) Visiting Professor in the Department of Energy Engineering, Nagoya University, Nagoya, Japan (April, 2004 - March, 2005)
(f) Research collaborator at the Max Planck Institute for Plasma Physics, Greifswald, Germany from December, 2009 to January, 2010 with DAAD fellowship.

Research/development experience :

(a) Design and construction of an ion beam-plasma interaction set-up and studies of beam-induced instabilities and ion heating (1976-1987).
(b) Study of plasma turbulence and anomalous transport in the Tore Supra tokamak in C.E.N. de Cadarache, France (1990-1992) using infra-red laser scattering technique. Also designed and constructed a computerised and remote controlled fast reciprocating Langmuir probe array diagnostic for edge fluctuation studies in Tore Supra.
(c) Study of edge turbulence and transport in the SINP tokamak since 1993. Also, study of intermittency and plasma structures in the tokamak edge plasma.

(d) Work on fluctuations in the detached plasma in a linear divertor simulator in Nagoya University, Japan.
(e) Construction of several magnetic diagnostics for the SINP tokamak : a hardware unit for the real-time measurement of plasma position in the tokamak using sin/cosine coils, a diagnostic for the measurement of plasma diamagnetism using internal loops, development of Mirnov coil system for MHD studies etc.
(f) Study of hard X-rays and runaway electrons in the tokamak.
(g) Experience of ion source design.
(h) Leadership of a five-year plan project 'Deep space plasma propulsion project' since April, 2007.
(i) Research collaboration with the Max Planck Institute for Plasma Physics, Greifswald, Germany on electric double layer in a linear helicon plasma device VINETA (December, 2009-January, 2010).

Future research/development plan :

(a) To continue the study of the intermittent structures in the edge plasma of the SINP tokamak.
(b) To study the physics of electric double layers in a small experimental setup.
(c) Development of a helicon plasma propulsion experiment.

Recent publications:

1. Radial transport of the nonthermal electrons in runaway discharges in the SINP tokamak from analysis of hard x-ray fluctuations, A.K. Hui, S. K. Saha, S. Chowdhury, Santwana Raychaudhuri and D. Banik, Nucl. Fusion **49** (2009) 115025.

2. Intermittency in the heat and particle transports in the SINP tokamak scrape-off layer, S. K. Saha and S. Chowdhury, Phys. Plasmas **15**(2008)012305.

3. Observation of high energy ion tail in the SINP tokamak plasma, S. Raychaudhuri, S. K. Saha, S. Chowdhury, D. Banik and A. K. Hui, Phys. Plasmas **13**(2006)122510.

4. Intermittent transport in the scrape-off layer of the SINP tokamak, S. K. Saha and S. Chowdhury, Phys. Plasmas **13**(2006)092512.

5. The effect of the rotating helical fields on the plasma edge in the HYBTOK-II tokamak, V. P. Budaev, I. M. Pankratov, S. Takamura, N. Ohno, M. Takagi, H. Matsuno, M. Okamoto and S. K. Saha, Nucl. Fusion **46**(2006)S175.

6. Effect of poloidal velocity shear on the edge fluctuations in the SINP tokamak, S. K. Saha and R. Kumar, Plasma Phys. Contr. Fusion **46**(2004)1065.

7. Temperature fluctuations and turbulent transport at the edge of the SINP tokamak, R. Kumar and S. K. Saha, Nucl. Fusion **43**(2003)622.

Name: M.S. Janaki

Educational Background

Degree	*Institution*	*year*
M.Sc.	Univ. of Calcutta	1985
Post M.Sc.	Saha Institute of Nuclear Physics	1986
Ph.D.	Saha Institute of Nuclear Physics	1994

Academic profile

Research Associate	Saha Institute of Nuclear Physics	April '94-April '96
Lecturer 'C'	"	April '96- Feb. '98.
Reader 'D'	"	Feb. 1998- Aug. 2002.
Associate Professor 'E'	"	Aug. 2002-Aug. 2005.
Professor 'F'	"	Aug. 2005-Aug. 2008
Professor 'G'	"	Aug 2008-till date

Essential strength of research

I have been working on following problems related to theoretical aspects of plasma physics.

Relaxation phenomena in plasmas based on the principle of minimum dissipation rate of energy together with invariant magnetic helicity has been invoked for the first time to study relaxation in a non-driven magnetized plasma in both MHD and two fluid models. The merit of this model lies in its capability to predict many magnetic configurations such as reversed field pinches, tokamaks, very low-q and ultra low q-configurations, sphero maks and field reversed configurations.

Exact self-consistent steady state solutions of weakly correlated kinetic-Poissons system of equations have been obtained as a counterpart of Bernstein Greene and Kruskal (BGK) modes for weakly nonideal plasmas.

In contrast to the conventional problem of Landau damping that is one-dimensional, the problem of two dimensional Landau damping has been studied in the context of wake potentials produced due to moving charged particles.

Future Research My future research plans include studies in the following fields

(1) Dusty plasmas : Non Newtonian and strongly correlated properties. (2) Vlasov-Maxwell equilibria for non force-free magnetic fields. (3) Double layer formation in magnetized plasmas. (4) Kinetic theory of weakly nonideal systems

List of important publications

1. Shear wave vortex solution in a strongly coupled dusty plasma
   M. S. Janaki and N. Chakrabarti, Phys. Plasmas 17, 053704 (2010)053704.

2. Nonlinear electrostatic structures in the presence of correlations.
   Anirban Bose and M.S. Janaki, Physics of Plasmas, **14**(2007)063701.

3. Solar Arcades as Possible Minimum Dissipative Relaxed States.
   R. Bhattacharya, M.S. Janaki, B. Dasgupta and G.P. Zank.
   Solar Physics **240**(2007)63.

4. Shear wave Mach cones in a strongly coupled dusty plasma.
   Anirban Bose and M.S. Janaki, Physics of Plasmas **13**(2006)012104.

5. Directional Landau damping of wake-field potentials.
   Anirban Bose and M.S. Janaki, Physics of Plasmas **12**(2005)102111

6. Variational approach to electron-magnetohydrodynamic equilibria.
   R. Bhattacharyya and M.S. Janaki, Physics of Plasmas **10**(2003)3783.

7. Relaxation in electron-positron plasma: a possibility.
   R. Bhattacharyya, M.S. Janaki and B. Dasgupta
   Physics Letters **315A**(2003)120.

8. Field-reversed Configuration (FRC) as a minimum-dissipative relaxed state
   R. Bhattacharyya, M.S. Janaki and B. Dasgupta
   Phys. Letters A, **291A**(2001)291.

Name: Nikhil **CHAKRABARTI**.

Academic qualifications :

Degree	Year	Class	Subjects	University or Institution
M.Sc. (Phys.)	1987	I	Physics	University of Calcutta
Ph.D. (Phys.)‡	1996	-	Physics	Devi Ahilya Viwavidyalaya. (Worked at Institute for Plasma Research, Gandhinagar.)

‡Title of Ph. D. Thesis : Coherent Structures and their Stability in inhomogeneous magnetized plasmas.

Postdoc/Visiting positions :

Position	Period	Institution
Jr. Research Fellow	August, 1990 - July, 1992.	Institute for Plasma Research, Gandhinagar.
Sr. Research Fellow	August, 1992 - July, 1995.	Institute for Plasma Research, Gandhinagar.
Postdoctoral Fellow	August, 1995 - July 1996	Institute for Plasma Research, Gandhinagar.
Visiting Scientist	August, 1996 - October 1996	Riso National Laboratory, Roskilde, Denmark.
Postdoctoral Fellow	November, 1996 - January, 1998	Institute for Thero. Phys.-I, Univ. Dusseldorf, Germany
Postdoctoral Fellow	March, 1998 - May, 1999	Weizmann Institute of science, Rehovot, Israel
JSPS Fellow	November, 2002 - December, 2003	National Institute for fusion Science, Toki, Japan
Visiting Scientist	October, 2007 - December 2007	Riso National Laboratory, Roskilde, Denmark.
Visiting Scientist	August, 2008 - October 2008	Riso National Laboratory, Roskilde, Denmark.
Visiting Scientist	November, 2009 - December 2009	Riso National Laboratory, Roskilde, Denmark.

Faculty positions :

Position	Period	Institution
Fellow (lecturer)	June, 1999 - April, 2000	Indian Institute of Geomagnetism, Mumbai, India
Reader	May, 2000 - July 2004	Saha Institute of Nuclear Physics, Kolkata, India
Associate Professor	August, 2004 -July 2007	Saha Institute of Nuclear Physics, Kolkata, India
Professor	Since August, 2007	Saha Institute of Nuclear Physics, Kolkata, India

Awards :

- I have receives JSPS postdoctoral fellowship (2002-2004). Worked at National Institute for Fusion Science, Japan.

Strength of Research/developement

Extensive research has been carried out in the areas related to Vortices and their stability in plasmas in order to have ideas on plasma transport. Since, the vortex structure are strongly modified by velocity shear the existing theories have been examined with velocity shear effects and also the stability in presence of velocity shear. I have also worked on the nonlinear processes in drift wave turbulence and the nonlinear aspect of shear flow generation problem in context of low frequency electrostatic instabilities in complex media.

Future Research/developement plan

Turbulent transport is the dominating mechanism for transport across the confining magnetic field in hot plasmas. The Geodesic acoustic mode associated with toroidal device is also an active area where many interesting investigations on transport can be done. My present capability is best suited for further investigations in these areas in order to learn the transport processes in complex systems. I think we have a lot of new ideas in the field of Lagrangian dynamics of exact nonlinear solutions. Also I have ideas to work on dusty plasma and Electron magnetohydrodynamical phenomena on in various nonlinear systems.

Selected Publications

1. M. S. Janaki and **N. Chakrabarti** *Shear wave vortex solution in strongly coupled dusty plasmas* Physics of Plasmas. **17** 053704 (2010).
2. **Nikhil Chakrabarti** and Sudip Sengupta *Nonlinear interaction of electron plasma waves with electron acoustic waves in plasmas* Physics of Plasmas. **16** 072311 (2009).
3. P.N. Guzdar, R.G. Kleva, **N. Chakrabarti**,V. Naulin, J. J. Rasmussen, P. K. Kaw and R.Singh *Non-local analysis of the excitation of the geodesic acoustic mode by beta drift waves* Physics of Plasmas. **16** 052514 (2009).
4. P.N. Guzdar, **N. Chakrabarti**, R. Singh and P. K. Kaw *Excitation of geodesic acoustic modes by ion temperature gradient modes.* Plasma Physics and controlled Fusion. **50** 025006 (2008).
5. **N. Chakrabarti**, P.N. Guzdar, R.G. Kleva, V. Naulin, J. J. Rasmussen and P. K. Kaw *Geodesic acoustic modes excited by finite beta drift wave* Physics of Plasmas. **15** 112310 (2008).
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12. **Nikhil Chakrabarti** and Predhiman Kaw,: *Transient vortex structures in low frequency magnetized plasma turbulence.* Physics Letters A, **226**, 305-309 (1997).

1)**Name and Educational Background** :
Name : SHANTANU CHOWDHURY.
Plasma Physics Division
Educational background :
a)Passed Madhyamik examination (Secondary) in the year 1977 with 73.9% marks.
b) Passed Higher Secondary examination in the the year 1979 with 70.4% marks.
c) Passed Bachelor of Electronics and Telecommunication Engineering from Jadavpur University in the year 1983 with 74% marks.
d) Passed Master of Electronics and Telecommunication Engineering from Jadavpur University in the year 1985 with 78.8% marks.
2) **Academic profile :**
I have joined Saha Institutte of Nuclear Physics in the year 1985 as Engineer –C in Plasma Physics Division. I was promoted to Engineer –D in year 1991.I was promoted to Engineer –E in year 1997.I was promoted to Engineer –F in year 2007.
All through these years and till now I am in Plasma physics division of SINP.
I was sent to Japan in 1986 to take training on Tokamak.
I was operational and maintenance in charge of Tokamak all through these years and the machine is running successfully till now.
I was actively associated with Tokamak developmental and research activity and published several papers. All these will be discussed in next chapters.
I am actively associated with developmental and research activities of the project 'Deep Space plasma propulsion Experiment' to be discussed later.
3) **Essential strength of research/development output**
As mentioned earlier I was in charge of Tokamak Operation and maintenance.
The Research and developmental works related to Tokamak are following:
a) Audio frequency discharge cleaning system which is a repetitive discharge of low plasma currents meant for wall conditioning and to get high vacuum, removing impurities.
b) Slow bank systems to improve duration of plasma discharge. Without slow bank we were getting 3-5 ms discharge. With slow bank we are getting 15-20 ms discharge. Both these systems were used extensively in almost all future experiments of Tokamak.
c) Actively associated with development of electric and magnetic prove diagnostics, Soft x-ray imaging diagnostics, Hard x-ray imaging diagnostics, Electron cyclotron emission diagnostics, visible imaging diagnostics, Ion energy analyzer ,data acquisition system of Tokamak

d) Actively done experiments in Tokamak related to plasma temperature and density measurements, soft x-ray and visible imaging, ion temperature measurement and anomaly, non diffusive transport, MHD phenomena related to transport, hard x-ray emission analysis, physics of runaway discharge in Tokamak etc.

Development works done for the Project submitted and approved in X1th Plan - **Deep Space plasma propulsion Experiment (DSPPE**): The objective of the project is to study the physics involved in the generation of mechanical thrust by a plasma. The important parameter in deep space plasma propulsion is exhaust velocity or specific impulse. Such device will be able to provide that. Hydrogen plasma will be generated by RF source and in the presence of magnetic field will be heated to high energy by another RF source. With suitable configuration of magnetic field the gyration energy will be converted to linear energy, thereby producing required thrust. The design and fabrication works of different subsystems are going on. Eight magnetic coils are designed and fabricated. Quartz glass tube has been procured. Support structure is being fabricated.

The pilot experiment is ready for use. All magnetic coils are fabricated in the Institute. Quartz glass tube is procured and installed. RF source was procured and RF matching network is designed and fabricated in the Institute. Stepper motor driven probe drive is also fabricated in the Institute. Proper RF shielding is given to the device. Some initial experiments to measure plasma temperature and density in the pilot set-up are going on with the help of RF compensated Langmuir probe.

4)Future research/development plan

For DSPPE project the actual experimental set-up has to be installed. The support structure is being manufactured locally. The Quartz glass tube was already procured. The magnetic coils are fabricated. We will procure DC supply for magnet and additional variable frequency RF source for heating of plasma. Helicon plasma will be generated. We will then study diffusion processes, ion transport in diverging magnetic field and try to measure mechanical thrust. We will study physics of Double layer in our pilot experiment. With procurement of another data acquisition and after repairing of certain subsystems of Tokamak we will perform some more experiments related to transport mechanism in Tokamak, turbulence at core and edge of Tokamak and more physics of runaway discharges.

5) **List of important publications starting with recent publications**

a) **Radial transport of the nonthermal electrons in runaway discharges in the SINP tokamak from analysis of hard x-ray fluctuations**. A.K.Hui, S.K.Saha, S.Chowdhury, Santwana Raychaudhuri and D.Banik. **Nuclear Fusion**, Volume-49, Number-11, 115025, November 2009

b)**Intermittency in the heat and particle transports in the SINP tokamak scrape-off layer**-S.K.Saha and S.Chowdhury; **Physics of Plasmas**, vol-15, 012305, Jan 2008 .

c)**Observation of high energy ion tail in the SINP Tokamak plasma-** S.Raychaudhuri, S.K.Saha, S.Chowdhury, D.Banik and A.K.hui ; **Physics of Plasmas**, vol-13 ,122510, Dec 2006.

d)**Intermittent transport in the scrape-off layer of the SINP Tokamak** S..K.Saha and S. Chowdhury ; **Physics of Plasmas**, vol-13, 092512, Sep 2006.

e)**Audio frequency discharge cleaning system for SINP- Tokamak using single turn primary-** P.Ranjan,A.K.Hui,S.Chowdhury,S. Basu,P.S.Bhattacharya,A.Bal,R.Ray and S.K.Majumdar- **Review of Scientific Instruments** , 65(1) ,1994,135