The Review Committee

for the subject area

"Condensed Matter Physics including Surface Physics and Nanoscience"

Members :

1. Prof. S.K. Joshi (Chairman), National Physical Laboratory
2. Prof. Peter Pershan, Harvard University
3. Prof. Michel Pepper, London University
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9. Prof. E.V. Sampathkumaran, Tata Institute of Fundamental Research

31 August – 2 September, 2010

SAHA INSTITUTE OF NUCLEAR PHYSICS
1/AF, Bidhannagar, Kolkata 700064

Experimental Condensed Matter Physics (ECMP):

Permanent members of the Division:

Scientific		Technical		Adm/Auxiliary	
A. Ghoshray	Sr. Prof.	A.K. Bhattacharya	SO	T.K. Sarkar	Superintendent
R. Ranganathan	Sr. Prof.	T.K. Pyne	SO	P.P. Ranjit	Helper
A.I. Jaman	Sr. Prof.	S. Chakraborty	SA		
K.K. Bardhan	Sr. Prof.	A. Chakrabarti	SA		
K. Ghoshray	Prof.	P. Mandal	SA		
C.D. Mukherjee	Prof.	D.J. Seth	SA		
S.N. Das	Prof.	A.K. Paul	Tech.		
I. Das	Prof.	A. Karmahapatra	Tech.		
P. Mandal	Prof.	S. Hembrom	Tech.		
B. Pal	Prof.	P. Das	Tech.		
A. Poddar	Prof.				
B. Bandyopadhyay	Prof.				
C. Mazumdar	Prof.				

Ph. D. Students (2007 – onwards)
R. Sarkar, A. Biswas, S. Mukhopadhyay, B. Pahari, S. Maji, P.R. Varadwaj, T. Samanta, M. Ghosh, A. Pandey, N. Choubey, P. Sarkar, D. Talukdar, D.K. Bhoi, N. Khan, A. Midya, M. Majumder, S. Duttagupta, K. Das

Post doc.
N. Duttagupta, K. Chakrabarti, Papri Dasgupta, Joydip Sengupta

Equipments and Resources in the Division:

1. Liquid nitrogen plant (20 L/hr) and Liquid helium plant (20 L/hr without LN_2 pre-cooling)
2. Room temperature x-ray powder diffraction
3. Pulsed Laser Deposition for thin films
4. Travelling Float Zone Furnace; for preparation of single crystals
5. Argon arc furnace
6. High temperature box and tube furnaces
7. SQUID magnetometer
8. physical properties measurement systems; temperature range 2-300 K
9. AC Susceptibility measurements system at low temperature
10. 14 tesla superconducting magnet
11. 7 tesla superconducting NMR magnet (Temperature range 3.8 - 300 K)
12. 100 MHz NMR spectrometer (Bruker), 400 MHz customized NMR spectrometer
13. Mossbauer spectrometer with low temperature facility
14. Home-built Stark/source modulated microwave spectrometer 10-100 GHz
15. Home-built acoustic spectrometer
16. Home built DC magnetometer
17. AFM equipment

Research Activities:
The objective is to carry out research in experimental condensed matter physics with special emphasis in (i) the design and development of advanced experimental systems suitable for measurements using high pressure, low temperature and high magnetic field, and (ii) to process new materials and study their macroscopic and microscopic properties.

Research in experimental condensed matter physics was conducted in the general areas of conducting nano-composites, rare-earth based intermetallics, perovskites, double perovskites, quasi low-dimensional system, quantum spin chains, strongly correlated systems and nano-crystalline materials.

Important Results:

i) Magnetism/Transport of magnetic and Superconducting oxide materials:
Magnetic, transport, thermoelectric power, and NMR measurements are being made in the newly discovered Fe-base superconductor RFeAsO (R = La, Ce, Pr, Nd, Sm, and Gd). Evidence of strong electron-phonon coupling was observed from normal and super conducting state transport properties of PrFeAsOF superconductor. The resistivity and ^{75}As NMR results of superconducting $CeFeAsO_{0.84}F_{0.16}$ and its parent compound CeFeAsO reveal formation of vortex lattice in the superconducting state. Spin-fluctuation dominated ferromagnetically ordered state was revealed in Co based LaCoPO. Large low field magnetoresistance ([R(H)-R(0)]/R(0) ~ 100%) due to charge order melting was observed in nanocrystalline $Pr_{0.65}(Ca_{0.6}Sr_{0.4})_{0.35}MnO_3$ sample. This is in contrast to the general belief that charge order melting is a high field phenomenon. Magnetic phase transition in $Sm_{0.52}Sr_{0.48}MnO_3$, critical behavior and electronic properties of Sm-Nd-Sr and $La_xSr_{1-x}CoO$ under pressure and field have been investigated. Glassy magnetic behaviour in $La_{0.5}Sr_{0.5}CoO_3$ nanoparticles, orbital ordering in $LaMnO_3$ spin polarised transport, charge ordering and related phenomena in magnetic nanostructures are some of the important findings in manganite/cobaltite system. Large magnetocaloric effect in $Sm_{0.52}Sr_{0.48}MnO_3$, $RMnO_3$ crystals, $NdCeCuO_6$ superconductors was observed. Transport properties of Sr_2FeMoO_6 systems were also reported. Large Energy gap (230 K) in the excitation of Cu^{2+} electron spin in $BaCu_2V_2O_8$ confirms alternating chain model. A small band gap of 25 K at the low energy excitation in $SrNi_2V_2O_8$, (S=1 quasi-one-dimensional antiferromagnet) suggests its ground state as a disordered "spin liquid" Haldane state. A Core-shell model for AFM small particles have been proposed to discuss the increase of magnetization below AFM ordering ~ 20K for both in bulk and nano particles and unconventional relaxation of spinel oxide $CoRh_2O_4$.

ii) Magnetism and transport of intermetallic alloys
Transverse vibrations driven negative thermal expansion behaviour in $GdPd_3B_{0.25}C_{0.75}$, an AFM anti-pervoskite material, magnetism of ordered metallic compound $GdPd_3B_xC_{1-x}$, and the possibility of negative temperature coefficient of resistivity (NTCR) in the absence of chemical/ structural disorder have been studied. Valence fluctuation behaviour in filled/ vacant anti-perovskite compounds, intermediate valency of Eu stimulated by the valence instability of dopant Ce in cubic $Ce_{0.5}Eu_{0.5}Pd_3$ and $Ce_{0.5}Eu_{0.5}Pd_3B_x$ have been reported. Magneto-resistance changes sign upon boron doping in $TbPd_3$ and shows highest GMR ~30% in the series of RPd_3 compounds. Novel method of generating magnetic phase diagram using magneto-caloric effect has been proposed. Evidence of Largest Magnetic Cooling Power was obtained from the Magnetocaloric Effect in Ho_5Pd_2**.** The evaluated value of relative cooling power (RCP) is 6.32 J/cm^3 for a magnetic field change of 5 T. Interplay of RKKY, Kondo and crystal field interactions governs the fascinating ground state in RNi_2Al_5 (La, Ce and Pr). In the heavy fermion compound $CePt_2B_2C$, a suppression of the effect of magnetic correlation, due to the dominance of the Kondo effect over the RKKY interaction was observed. Microstructure, magnetic and Mossbauer studies on spark-plasma sintered (SPS) nano composite comprising Sm-Co-Fe (hard magnet) intermetallic phases and Fe(Co) (soft phase) suggest magnetically single phase behaviour of the SPS magnets. Structural and Magnetic studies on SPS $SmCo_5$/Fe bulk nanocomposite magnet

shows stronger exchange coupling between the hard and soft magnetic phases in $SmCo_5$ with 5 wt % Fe than 10 wt % Fe containing sample.

iii) Microwave spectroscopy:
Conventional microwave spectroscopic studies of organic molecules like phenol and benzonitrile compounds in the gas phase reveals the ground state molecular constants and molecular structures. An indigenously built millimeterwave spectrometer was used to study the rotational spectra of DC discharge produced species like halogen cyanides (XCN, X= Cl, Br, I) and analysis leads to the assignment of many new transitions and determination of accurate rotational parameters and geometry of the molecules.

iv) Non-linear transport in disordered system:
In case of field-dependent conduction in disordered systems, a sample with localised states is found to possess a field-scale. This observation leads to a phenomenological scaling, and to a nonlinearity exponent. The exponents in various systems are found to be integer multiples of a number ~0.08. 1/f-noise measurements reveal that bias exponents as well as noise levels may be good indicators of any changes in conduction mechanisms. The suggested model seamlessly fit the resistance minima data in composites. The higher temperature data are described by the Weibull distribution. An ultra low-noise current source has been developed.

v) Ultrasonic related activity:
Study on the propagation characteristics of ultrasound through material medium has been done and a computational Fourier transform method for the characterization of materials has been proposed. Variations of ultrasound propagation parameters near structural phase transition in β-brass and simulation studies of some model systems have been reported.

List of publications (2007-date)
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List of publications (2007-date)

2010

1. Interplay between Co-3d and Ce-4f magnetism in CeCoAsO, Rajib Sarkar, Anton Jesche, Cornelius Krellner, Chandan Mazumdar, Asok Poddar, Michael Baenitz, Cristoph Geibel, Phys. Rev. B (accepted).

2. Spin glass like behaviour and magnetic enhancement in nanosized Ni-Zn ferrite system, B. Ghosh, S. Kumar, A. Poddar, C. Mazumdar, S. Banerjee, V. R. Reddy and A. Gupta, J. App. Phys. (2010) (accepted).

3. Magnetism and transport studies in off-stoichiometric metallic perovskite compounds $GdPd_3B_x$ (x = 0.25, 0.50 and 0.75), A. Pandey, Chandan Mazumdar, and R. Ranganathan, J. Magn. Magn. Mater, (2010) (accepted).

4. Rotational spectrum of propyne observed in a DC glow discharge and DFT calculation. A.I. Jaman, P. Hemant Kumar and P. R. Bangal, Asian J. Spectroscopy (accepted).

5. Millimeter-wave spectrum of Chlorocyanoacetylene (ClCCCN) generated by DC glow discharge technique, P. R. Varadwaj and A. I. Jaman, Asian J. Spectroscopy (accepted).

6. Critical behavior in single crystalline $La_{0.67}Sr_{0.33}CoO_3$, N. Khan, A. Midya, K. Mydeen, P. Mandal, A. Loidl, and D. Prabhakaran, Phys. Rev. B (accepted)

7. Electron spin dynamics in grain-aligned LaCoPO: An itinerant ferromagnet, M. Majumder, K. Ghoshray, A. Ghoshray, B. Bandyopadhyay, and M. Ghosh, Phys. Rev. B (accepted).

8. NMR study of a magnetic phase transition in $Ca_3CuNi_2(PO_4)_4$: a spin trimer compound: M. Ghosh, K. Ghoshray. M. Majumder, B. Bandyopadhyay and A. Ghoshray, Phys. Rev.**B81**, (2010) 064409.

9. Magnetic properties of the spin trimer compound $Ca_3Cu_2Mg(PO_4)_4$: M.Ghosh, M.Majumder, K.Ghoshray and S. Banerjee, Phy. Rev. **B81**, (2010) 094401.

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12. Reversal of the sign of giant magnetoresistance upon boron filling in RPd_3 compounds (R=Tb, Er): Abhishek Pandey, Chandan Mazumdar and R. Ranganathan, J. Phys.: Conference Series 200 (2010) 032055, Proc. of the International Conference on Magnetism (ICM 2009), 26¨C31 July, 2009, Karlsruhe, Germany.

13. Spin glass-like behaviour in Fe-rich phases of $Sr_2Fe_{1-x}Mn_xMoO_6$ (0.1 < x < 0.4): Asok Poddar and Chandan Mazumdar, J. Alloys Comp. **502** (2010) 15.

14. Exchange bias in $LaFeO_3$ nanoparticles: H. Ahmadvand, H. Salamati, P. Kameli, Asok Poddar, M. Ace, and K. Zakeri, J. Phys. **D**: Appl. Phys. **43** (2010) 245002.

15. Enhanced ferromagnetism in nano-sized $Zn_{0.95}Mn_{0.05}O$ grains: R. N. Bhowmik, Asok Poddar, A. Saravanan, J. Magn. Magn. Mater, **322** (2010) 2340.

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19. ^{93}Nb NMR study of the charge density wave state in $NbSe_2$: K Ghoshray, B Pahari, A Ghoshray, V V Eremenko, V A Sirenko and B H Suits, J. Phys.: Condens. Matter**, 21**, 155701 (2009).

20. Low temperature conductivity in ferromagnetic manganite thin films: quantum corrections and inter-granular transport: Soumik Mukhopadhyay and I Das, J. Phys.: Condens. Matter **21**, 186004 (2009).

21. ^{75}As NMR study of oriented CeFeAsO and $CeFeAsO_{0.84}F_{0.16}$: A. Ghoshray, B. Pahari, M. Majumder, M. Ghosh, K. Ghoshray, B. Bandyopadhyay, P. Dasgupta, A. Poddar, and C. Mazumdar, Phy. Rev. **B79**, 144512 (2009).

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24. Negative pressure driven valence instability of Eu in cubic $Eu_{0.4}La_{0.6}Pd_3$; Abhishek Pandey, Chandan Mazumdar, R. Ranganathan, J. Phys. Condens. Matter **21**, 216002 (2009).

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27. Magnetism in the ordered metallic perovskite compound $GdPd_3B_xC_{1-x}$: Abhishek Pandey, Chandan Mazumdar, R. Ranganathan and S. Dattagupta;, J. Magn. Magn. Mater., **321** (2009) 2311.

28. Effect of Pt on the superconducting and magnetic properties of $ErNi_2B_2C$: Chandan Mazumdar, L.C. Gupta, K. Nenkov, G. Behr and G. Fuchs, J. Alloys Comp., **480** (2009) 190.

29. Magnetism of crystalline and amorphous $La_{0.67}Ca_{0.33}MnO_3$ nanoparticles: R.N Bhowmik, Asok Poddar, R. Ranganathan and Chandan Mazumdar, J. Appl. Phys. **105**, 113909 (2009).

30. Millimeterwave spectrum and ab initio DFT calculation of the C-Gauche conformer of Allyl Isocyanate: A.I.Jaman and P.R. Bangal, J. Mol. Spectrosc. **255**, 134 (2009).

31. Role of external and internal perturbations on the ferromagnetic phase transition in $Sm_{0.52}Sr_{0.48}MnO_3$: P. Sarkar, P. Mandal, K. Mydeen, A. K. Bera, S. M. Yusuf, S. Arumugam, C. Q. Jin, T. Ishida, and S. Noguchi, Phys. Rev. **B79**, 144431 (2009)

32. Effect of uniaxial pressure on metal-insulator transition in $(Sm_{1-y}Nd_y)_{0.52}Sr_{0.48}MnO_3$ single crystals: A. Murugeswari, P. Sarkar, S. Arumugam, N. Manivannan, P. Mandal, T. Ishida, and S. Noguchi**,** Appl. Phys. Lett. **94**, 252506 (2009)

33. Pressure and temperature-induced spin-state transition in single-crystalline $La_{1-x}Sr_xCoO_3$ (x=0.10 and 0.33): K. Mydeen, P. Mandal, D. Prabhakaran, C.Q. Jin, Phys. Rev. **B80**, 014421 (2009).

34. ^{11}B and ^{195}Pt NMR study of heavy-fermion compound $CePt_2B_2C$: R. Sarkar, A. Ghoshray, B. Pahari, M Ghosh, K Ghoshray, B Bandyopadhyay, M Majumder, V K Anand, and Z Hossain, J. Phys.: Condens Matter **21**, 415602 (2009).

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36. Pressure induced critical behavior of Ferromagnetic Phase Transition in Sm-Nd-Sr Manganites: P. Sarkar, S. Arumugam, P. Mandal, A. Murugeswari, R. Thiyagarajan, S. Esaki Muthu, D. Mohan Radheep, Chandryee Ganguli, K. Matsubayshi, and Y. Uwatoko, Phys. Rev. Lett. **103**, 057205 (2009).

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40. Magnetic behavior of binary intermetallic compound YPd_3: Abhishek Pandey, C. Majumdar, R. Ranganathan; J. Alloys Comp. **476** 14 (2009).

41. Millimeterwave spectrum of DC discharge produced ICN in excited vibrational states: P. R. Varadwaj and A. I. Jaman: Ind. J. Phys. **83**,1323, 2009.

42. Magnetic frustration effect in Mn-rich $Sr_2Mn_{1-x}Fe_xMoO_6$ system, Asok Poddar and Chandan Mazumdar, J. Appl. Phys., **106** (2009) 093908.

43. Thermoelectric power of RFeAsO (R = Ce, Pr, Nd, Sm, and Gd), Asok Poddar, Sanjoy Mukherjee, Tamnay Samanta, Rajat S. Saha, Rajarshi Mukherjee, Papri Dasgupta, Chandan Mazumdar, and R. Ranganathan, Physica **C469** (2009) 789.

44. Evidence of disorder induced magnetic spin glass phase in Sr_2FeMoO_6 double perovskite, Asok Poddar , R. N. Bhowmik , I. P. Muthuselvam , J. App. Phys. **106** (2009) 073908.

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48. Inverse magnetocaloric effect in polycrystalline $La_{0.125}Ca_{0.875}MnO_3$, Anis Biswas, Tapas Samanta, S. Banerjee, and I. Das, J. Phys.: Condens. Matter **21**, (2009) 506005.

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50. Relaxation dynamics in small clusters: A modified Monte Carlo approach: Barnana Pal, J. Computational Phys., **227,** 2666 (2008).

51. Modification of the spin state in $Sm_{0.52}Sr_{0.48}MnO_3$ by external magnetic field, P. Sarkar and P. Mandal, Appl. Phys. Lett. **92**, 052501 (2008).

52. Large magnetocaloric effect in $Sm_{0.52}Sr_{0.48}MnO_3$ in low magnetic field, P. Sarkar, P. Mandal, and P. Choudhury Appl. Phys. Lett. **92**, 182506 (2008)

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62. Comparative studies of magnetocaloric effect and magnetotransport behavior in $GdRu_2Si_2$ compound: Tapas Samanta, I. Das and S. Banerjee; J. Appl. Phys. **104**, 123901 (2008).

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77. Re-entrant Spin-Glass Phenomenon in $Ca_2Fe_{1-x}Co_xMoO_6$ ($0.1 \le x \le 0.4$), Asok Poddar and Chandan Mazumdar, AIP Conf. Proc. **1003,** 292 (2008).

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79. Structural, Magnetic And Magneto-transport Studies In Melt-Spun Ni-Mn-Ga Ribbons, N. V. Rama Rao, Babita Ingale, R. Gopalan, V. Chandrasekaran, Niraj K. Chaubey, Asok Poddar, R. Ranganathan, and K. G. Suresh, AIP Conf. Proc. **1003,** 201 (2008).

80. Structural and Magnetic Transition In Mechanically Milled $La_{0.67}Ca_{0.33}MnO_3$, R. N. Bhowmik, Asok Poddar, R. Ranganathan, and Chandan Majumdar, AIP Conf. Proc. **1003,** 106 (2008).

81. Influence of magnetic field on the nature of ferromagnetic to paramagnetic phase transition in $Sm_{0.52}Sr_{0.48}MnO_3$, P. Sarkar, P. Mandal, S. L. Sharath Chandra, V. Ganesan, A.K. Bera, and S.M. Yusuf, Ind. J. Cryogenics **33**, 11 (2008).

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82. Microwave spectrum of trans 3-fluorophenol in excited torsional states: A. I. Jaman, J.Mol.Spectrosc. **245**, 21 (2007).

83. Millimeterwave spectrum of ICN, a transient molecule of chemical and astrophysical interest: A. I. Jaman, J.Phys: Conference Series **80**, 012006 (2007).

84. Correlation between structural, transport, and magnetic properties in $Sm_{1-x}A_xMnO_3$ (A=Sr,Ca): P. Mandal, A. Hassen, J. Appl. Phys. **101**, 113917 (2007).

85. Dielectric anomaly at TN in $LaMnO_3$ as a signature of coupling between spin and orbital degrees of freedom: P. Mondal, D. Bhattacharya, P. Choudhury, and P. Mandal, Phys. Rev. **B76**, 172403 (2007).

86. Magnetization and ^{63}Cu NMR studies on granular FeCu alloys: B. Bandyopadhyay, B. Pahari, and K. Ghoshray, Phys. Rev. **B76**, 214424 (2007).

87. ^{27}Al NMR in grain aligned $PrNi_2Al_5$: A.Ghoshray, R.Sarkar, B.Pahari, K.Ghoshray and B. Bandyopadhyay, J. Mag. Magn. Mat. **310**, 371 (2007).

88. Crystal field calculation of Pr^{3+} in orthorhombic $PrNi_2Al_5$ from ^{27}Al NMR Knight shift: R. Sarkar, A. Ghoshray and K. Ghoshray, J. Phys. Condens. Matter **19**, 086202 (2007).

89. Impurity induced antiferromagnetic order in Haldane gap compound $SrNi_{2-x}Mg_xO_8$: B. Pahari, K. Ghoshray, A. Ghoshray, T. Samanta and I. Das, Physica **B395,** 138 (2007).

90. ^{31}P NMR of trimer cluster compound $Sr_3Cu_3(PO_4)_4$: M. Ghosh, K.Ghoshray, B. Pahari, R. Sarkar and A. Ghoshray, J. Phys. Chem. Solids **68,** 2183 (2007).

91. A Comparative Study of the Magnetic Properties and Phase Separation Behavior of the Rare Earth Cobaltates, $Ln_{0.5}Sr_{0.5}CoO_3$ (Ln=Rare Earth): Asish Kundu, R. Sarkar, B. Pahari, A. Ghoshray and C.N.R. Rao, J. Solid State Chemistry **180**, 1318 (2007).

92. Giant magnetocaloric effect in antiferromagnetic $ErRu_2Si_2$ compound: Tapas Samanta, I. Das and S. Banerjee, Appl. Phys. Lett. **91**, 152506 (2007).

93. Magnetocaloric effect in Ho_5Pd_2: Evidence of large cooling power: Tapas Samanta, I. Das and S. Banerjee; Appl. Phys. Lett. **91**, 082511 (2007).

94. Magnetotransport properties of nanocrystalline $Pr_{0.65}(Ca_{1-y}Sr_y)_{0.35}MnO_3$ (y ~ 0.4,0.3): Influence of phase coexistence: Anis Biswas and I. Das, Appl. Phys. Lett., **91**, 013107 (2007).

95. Magnetic and transport properties of nanocrystalline $Nd_{0.5}Sr_{0.5}MnO_3$: Anis Biswas and I. Das; Journal of Applied Physics **102**, 064303 (2007).

96. Unified description of spin dependent transport in granular ferromagnetic manganites: Soumik Mukhopadhyay and I. Das Phys. Rev. **B76**, 094424 (2007).

97. Low temperature magnetotransport properties in granular ferromagnetic manganites: Soumik Mukhopadhyay and I. Das; Europhys. Lett **79**, 67002 (2007).

98. Smooth crossover from variable range hopping with Coulomb gap to nearest neighbour inter-chain hopping in con-ducting polymer: Sanjib Maji, Soumik Mukhopadhyay, R. Gangopadhyay and A. De; Phys. Rev. **B75**, 073202 (2007).

99. Silica Encapsulated Ni Nanoparticles: Variation of Optical and Magnetic Properties with Particle Size, Soumen Das, Subhendu K. Panda, Prithiwish Nandi, Subhadra Chaudhuri, Abhishek Pandey and R. Ranganathan; J. Nano science and technology **7,** 4447 (2007).

100. Unconventional relaxation in AFM $CoRh_2O_4$ nano particles, R. N. Bhowmik, R. Ranganathan; Phy. Rev. B**75,** 012410 (2007).

101. Enhancement of surface magnetization in AFM nano particles, R.N.Bhowmik, R.Ranganathan; Solid State Commun. **14,** 365 (2007).

102. Structural and magnetic studies on spark plasma sintered $SmCo_5$ /Fe bulk nanocomposite magnets, N.V. Ramarao ,R.Gopalan, M.Manivel Raja, V.Chandrasekaran, D.Chakravarty, R.Sundaresan, R.Ranganathan and K.Hono; J. Magn. Magn. Mater. **312,** 252 (2007).

103. Positron annihilation spectroscopic studies of the influence of heat treatment on defect evolution in hybrid MWCNT-polyacrylonitrile-based carbon fibers, K Chakrabarti, P M G Nambissan, C D Mukherjee, K K Bardhan, C Kim, K S Yang, Carbon **45**, 2777 (2007).

Prof. Amtabha Ghoshray
ECMP Division

1. Ph.D: Physics, 1982, Calcutta University
2. Position held & date of joining SINP (in permanent position): Lecturer, August 10, 1984
3. Academic assignments (Post Doctoral/ Teaching) prior to joining SINP in permanent position

Sl. No.	Position held	Univ./ Inst.	Period
1.	Research Associate	SINP	1982 1984

4. Present position: Sr. Professor (H)
5. Honor: Invited to be a member International Advisory Committee for 19th International Conference on Magnetism (ICM2012) be held in Busan, Korea from July 8th to 13th, 2012.
6. Essential strength of research/development output:

(a) Hydrogen location, mobility and its effect on the electronic properties of the rare earth intermetallics were explored. Ordered arrangement of proton pairs, with H-H separation ~ 1.5 A was reported for the first time in $CeNiInH_x$ and $PrNiInH_x$, (confirmed later by other groups from neutron scattering and by theoretical models).
(b) Occurrence of Co^{3+} and Na^+ charge ordering was reported, for the fist time, in metallic $NaCo_2O_4$ (termed as Curie-Weiss metal). This has an important role in the discovery of superconductivity that occurs on intercalation with water. Cited several times in international journals including <u>Nature</u>, <u>Nature Materials</u>.
(c) Electronic phase separation was first time observed in $Nd_{1-x}Sr_xCoO_3$. Later, a comparative study of the magnetic properties of a few members of the Ln(0.5)Sr(0.5)CoO(3) family with different radii of the A-site cations, $< r(A) >$, in the range 1.19-1.40 A has been made. The variation of the FM/PM ratio with $< rA >$ and size-disorder suggest that electronic phase separation is an inherent feature of this type of cobaltates, with the nature of the different magnetic species in the phase-separated system varying with $< r(A) >$ and size disorder.
(d) Large Energy gap (230 K) in the excitation of Cu^{2+} electron spin in $BaCu_2V_2O_8$ confirms alternating chain model. A small band gap of 25 K at the low energy excitation in $SrNi_2V_2O_8$, a S=1 quasi-one-dimensional antiferromagnet suggests its ground state as a disordered "spin liquid" Haldane state.
(e) Interplay of RKKY, Kondo and Crystal field interaction governs the fascinating ground state in RNi_2Al_5 (La. Ce and Pr). In the heavy fermion compound $CePt_2B_2C$, a suppression of the effect of magnetic correlation, due to the dominance of the Kondo effect over the RKKY interaction was observed.
(f) The resistivity and As-75 NMR results of superconducting $CeFeAsO_{0.84}F_{0.16}$ and its parent compound CeFeAsO reveal important information for this newly discovered Fe-base superconductor. In contrast, on Co based LaCoPO, a spin-fluctuation dominated ferromagnetically ordered state was revealed.
(g) Set up the NMR facility (unique in India) in the high field (2 –7 T), frequency range (10 – 400 MHz) with temperature range 3.6 – 400 K.
(h) Liquid Helium plant was lying unused for couple of years. I have personally trained the technical staffs of the division to run and maintain liquid helium.

7. List of recent important publications:

1. Ghosh M, Ghoshray K, Majumder M, **A. Ghoshray**, et al., NMR study of a magnetic phase transition in $Ca_3CuNi_2(PO_4)_4$: A spin trimer compound, Phys. Rev. **B81**, 064409 (2010)
2. A. Ghoshray, B. Pahari, M. Majumder, M. Ghosh, K. Ghoshray, B. Bandyopadhyay, P. Dasgupta, A. Poddar, and C. Mazumdar, ^{75}As NMR study of oriented CeFeAsO and CeFeAsO$\$_{0.84}F_{0.16}$, Phys. Rev. **B79**, 144512 (2009)
3. Sarkar R, **Ghoshray A**, Pahari B, et al., B^{11} and Pt^{195} NMR study of heavy-fermion compound $CePt_2B_2C$, J. Phys. Condensed Matter **21**, 415602 (2009).
4. Majumder M, Ghoshray K, **Ghoshray A**, et al., Crossover of the dimensionality of 3d spin fluctuations in LaCoPO, Phys. Rev. **B 80**, 212402 (2009)

5. Pahari B, Ghoshray K, Sarkar R, **Ghoshray A**, NMR study of the impurity induced ordered state in the doped Haldane chain compound $SrNi_{1.93}Mg_{0.07}V_2O_8$, Phy. Rev. **B77**, 224429 (2008).
6. **A.Ghoshray**, R.Sarkar, B.Pahari, K.Ghoshray, B. Bandyopadhyay, ^{27}Al NMR in grain aligned $PrNi_2Al_5$, J. Mag. Magn. Mat. **310** 371 (2007).
7. R. Sarkar, **A. Ghoshray** and K. Ghoshray, Crystal field calculation of Pr^{3+} in orthorhombic $PrNi_2Al_5$, from ^{27}Al NMR Knight shift, J. Phys. Condens. Matter **19,** 086202 (2007).
8. Asish Kundu, R. Sarkar, B. Pahari, **A. Ghoshray** and C.N.R. Rao: A Comparative Study of the Magnetic Properties and Phase Separation Behavior of the Rare Earth Cobaltates, $Ln_{0.5}Sr_{0.5}CoO_3$(Ln=Rare Earth), J. Solid State Chemistry **18**0, 1318 (2007).
9. Pahari B, Ghoshray K, Sarkar R, **Ghoshray A**; NMR study of V^{51} in quasi-one-dimensional integer spin chain compound $SrNi_2V_2O_8$; Phy. Rev. B73, 012407 (2006)
10. K. Ghoshray, B. Pahari, B. Bandyopadhyay, R. Sarkar and **A. Ghoshray**. ^{51}V NMR study of the quasi one-dimensional alternating chain compound $BaCu_2V_2O_8$ Phys. Rev. B71, 214401, (2005).
11. **A. Ghoshray**, B. Bandyopadhyay, K. Ghoshray, V. Morchshakov, K. Barner, I.O. Troyanchuk, H. Nakamura, T. Kohara, G.Y. Liu, G.H. Rao, Phase separation in $Nd_{1-x}Sr_xCoO_3$ using Co-59 NMR, Phys. Rev. B69, 064424 (2004).
12. Manna I, Nandi P, Bandyopadhyay B, K. Ghoshray, **A. Ghoshray**; Microstructural and nuclear magnetic resonance studies of solid-state amorphization in Al-Ti-Si composites prepared by mechanical alloying; Acta Materalia 52, 4133 (2004).
13. R. Ray, **A. Ghoshray**, K. Ghoshray and S. Nakamura, ^{59}Co NMR studies of metallic $NaCo_2O_4$ Phys. Rev. B62, 166, (2000).
14. M. Sen, **A. Ghoshray**, K. Ghoshray, S.Sil, Ordered arrangement of proton pairs in the $PrNiInH_{1.29}$ system, Phys. Rev.B53, 14345. 1996

8. Ph.D. students (completed):
1. Co-guide of Dr. B. Bandyopadhyay:
2. Guidance of the thesis of Dr. Mita Sen: Thesis title: NMR investigations in hydrides of rare-earth based ternary intermetallics (Jadavpur University ,1997).
3. Guidance of the thesis of Dr. Ruma Roy: Thesis title: Experimental Investigation on Layered Oxide and Ternary Intermetallic Compound, University of Calcutta, July 2001.
4. Guidance of the thesis of Dr. Rajib Sarkar: Thesis title: NMR study in some ternary intermetallic compounds (Jadavpur Unversity, 2008) .

9 Any other information (academic)
i) Editorial assistance for publication of Collected Works of Prof. Meghnad Saha. Vol 3, 4.
ii) Guest editor J. Alloys and Compounds. 9 August 2001 Vol 326 Published: Elsevier Science, Holland; “Magnmetic Matertrials”, vol. 1003 proceedings of ICMM-2007, published by American Institute of Physics (AIP).
iii) Act regularly as a referee to review papers submitted to Phys. Letters, Phys. Rev.B, J. Magn. Magn. Mat., Pramana, Ind. J. Pure & Appl. Phys. etc.
iv) Acted as a referee on behalf of the Organising Committee ICM 2003, held in Rome, Italy; Satellite- ICM 2006 (QuBS 2006), held in Tokai, Japan.
v) Member: Monitoring Cmmittee for the project proposal “Magnetic Materials for High-Permeabilty GHz-Frequency Indutors” IIT, Delhi: Dept. of information Technology, Govt. of India, New Delhi.
vi) External member for the Ph.D Theses Examination at BUET, Dhaka, Bangladesh, 28 August, 2008.

1. **Name and present position:** R.Ranganathan- Senior Professor.
Education: M.Sc.,-University of Madras (1977)- First class: Ph.D - Indian Institute of technology (IIT)- Madras (1983)

2. **Awards and fellowship:**
   - French govt scholar at CRTBT-CNRS Grenoble (1983-84)
   - RA at University Hamburg (1985-86)
   - UGC visiting associate fellow at CGC- Anna university(1992-93)
   - Invited as Honorary visiting faculty S.N.Bose Institute- Calcutta (2005)
   - Material Research Society of India- Medal (2007)
   - SINP foundation day award (2010): Highest citation category from SINP

3. Research/development out put: **summary -work done at SINP**
"**Physics of magnetism – role of ordered moments in the absence of true long range order" - materials and instrumentation.**

We have undertaken a systematic experimental investigation of disordered magnetic materials to investigate the nature of magnetism in the absence of true long range order. This includes, as a part of the programme, materials synthesis and related instrumentation work. We have carefully identified new systems, covering both alloys and oxides, prepared through structural, quenched, chemical process. We have proposed a new experimental techniques "Enhancement of AC susceptibility" by applying second ac field with different frequency on ac susceptibility measured by the conventional method. This is some what similar to method used in tape recorder where a high frequency signal is mixed with audio signal to ensure greater "fluidity" in magnetic media. This technique is useful to study ferromagnetic materials, domain nucleation, and domain wall motion. We have also developed DC magnetometer using Tchebycheff quadrature method of numerical integration over Fast Fourier Transform (FFT) method. (Rev. of Sci. Instrum. **67** 789 (1996), ibid **68** 2834 (1997). We summarize some of the reported new experimental results as: **(i)** Magnetic glassy behavior coexistence with FM state in disordered magnetic materials have been investigated through a new approach namely, the field-cooled coercivity to observe the progressive freezing of clusters below Curie temperature due to thermal activation and also to estimate the volume fraction of super paramagnetic clusters. (Physical Review B **54** 9267 (1996) – citation: **146).(ii)** It has been found, in general, that most of the work on magnetic oxide materials are focused on perovskite, pyrochlores materials. On the other hand, the author's approach is to focus on spinel oxides as the interest in the spinel oxides stems from the fact that spinel ferrite (nano) particle is an ideal small particle magnetic system whose crystal chemistry can be controlled where as for pure metal particles the crystal chemistry is basically fixed. We have reported (Solid State Communication **103** 269 (1997)& J.Magn.Magn.Materials **202** 359(1999)) the first experimental study for bulk ferrimagnets ($Fe_2Mo_{1-x}Ti_xO_4$), where not only the spin compensation temperature due to two sub- lattice contributions for magnetizations are different under zero field-cooled condition and field cooled process, but also the magnetization with temperature maintains symmetry with reference to the direction of the applied magnetic field. Further, we have reported the increase of magnetization below AFM ordering, unconventional relaxation in AFM nano particle and enhancement of surface magnetization in $CoRh_2O_4$, lattice expansion and magnetism in $MnCr_2O_4$. The Core-shell model suggested by us (Phys. Rev.B 69 054430 (2004) for the AFM spinel oxide has been extended by others to understand the magnetism of nano particle in perovskite materials.(X.G. Li etal Phy RevB **76** 174415 (2007). **(iii)** Further we have also shown the possibility of negative temperature coefficient of resistivity (NTCR) in the absence of chemical / structural disorder, negative thermal expansion (NTE) in AFM pervoskite materials $GdPd_3B_xC_{1-x}$.The importance of NTE arises due to the fact that unlike positive thermal expansion, NTE has different origin in different materials and there is no single unique mechanism to explain the phenomenon of NTE. This work also establishes some synergy between isotropic NTE and NTCR in these magnetic intermetallic compounds. (Applied Phy. Letter **92** 261913 2008, Euro Phy. Letters **84** 47007 (2008). We have also observed negative giant magnetoresistance (GMR) in cubic $TbPd_3$(-30%), which is the highest among the RPd_3 series(Applied Phys. Letter **94** 172509 (2009). The NTE and nano composite work have been cited recently by A.Bojan etal Chem. Matter 21 2886 (2009) and in the recent review articles by I. Betan court and H.A.Davies -Materials Science and technology **26** 5-19 (2010).In our opinion, the above results can be considered as original contributions.

This programme is in collaboration with Dr Arani Chakravarty, Dr Sanjoy Mukherjee ,Dr Anindita Ray, Dr. R.N.Bhowmik, Ms Anulekha Datta, Mr Abhishek Pandey as a part of their thesis work .Also in collaboration with Prof C.Mazumdar for intermetallic alloys and DMRL for composite magnets

4. Future research and development plan:

- **a)** Anti perovskite magnetic materials focusing on low Z elements with out oxygen.
- **b)** Magnetism in small particle including bio magnetic materials- role of core-shell spin structure-Core with different magnetic structure.
- **c)** High Curie temperature intermetallic materials- ZT factor for high TEP materials.
- **d)** Nano composite magnets for high energy product, $(BH)_{max}$, material.
- **e)** Setting up of sensitive magnetization experiments using high magnetic field facilities ~20T at very low temperature.

5. Recent Publication list for the period 2003-2009 (in collaboration with A.Pandey, R.N.Bhowmik, Anulekha Dutta)

No.	Journal	year	Publications
1	Phy. Rev.B	2007,2006,2006,2005,2004,2003,2003	7
2	Applied Physics Letter	2009,2009,2008	3
3	Euro Physics Letter	2008	1
4	J.Magnetism & Magnetic materials	2009,2007,2006,2003	4
5	J.Applied Physics	2009,2003	2
6	J. alloys and compounds	2009,2008,2004	3
7	J.Phys. D: Applied Physics	2008	1
8	J. Nano Science and Technology	2007	1
9	J.Phys. Condensed Matter	2009	1
10	Solid State communication	2007	1
11	Physica C- superconductivity	2009	1

Recent important publications for the period 2003-09 focusing on:

a) intermetallic anti pervoskite materials:
Abhishek Pandey etal Applied Physics Letter **94** 182503 (2009) : Applied Physics Letter **94** 172509 (2009): J.Phys. Cond. Matter **21** 216002 (2009): J. Magn. Magn. Materials **321** 2311 (2009) :J.alloys and compounds **476** 14 (2009): Euro. Phy. Lett. **84** 47007 (2008) : Applied Physics Letter **92** 261913 (2008)

b) small particle magnetism
R.N.Bhowmik etal J.applied Physics **95** 113909 (2009): Phy. Rev. B **75** 012410 (2007) :Phy.Rev B **74** 214417 (2006) :Phy.Rev B 73 144413 (2006) :Phy.Rev B 2005 **72** 094405 (2005):Phys. Rev B **69** 054430 (2004): Phys. Rev B **68** 134433 (2003) .Anulekha Dutta etal Physical Rev B **68** 054432 (2003)

c) composite magnets N.V.Ramarao etal J. Phys. D: Appl. Phys **41** 065001 (2008) : J. Magn. Magn. Mater. **312** 252 (2007):

d) Some of the earlier work: i) focusing on instrumentation: S.Mukherjee etal Review of Scientific Instrument **68,** 2834, (1997): A.Ray etal Review of Scientific Instruments **67**, 789 (1996) **ii) Focusing on cluster glass** S.Mukherjee etal Physical Review B **54 ,**9267 (1996).(citation 146)

KAMAL KUMAR BARDHAN

Date of Birth: January 25, 1952.

Educational Qualification:
Ph.D. (1980, Carnegie-Mellon University, USA)

Present position: Sr. Professor (2008-)

Date of joining SINP : May 5, 1987 (Reader)

Academic assignments prior to joining SINP:

1. Post-doctoral Fellow, Simon Fraser University (1981-85).
2. Pool Officer (CSIR), SINP (1986-87).

Awards: Received $25000 grant from STICHTUNG fund (Schlumberger, USA) for research purpose.

Area(s) of research:

Soft Condensed Matter; Electrical transport properties, including noise, of the disordered systems in general, and composites in particular, with emphasis on non-Ohmic regimes.

Research highlights:

Our work has revealed many new transport properties of the hitherto little explored nonlinear regimes in composites and other disordered systems through application of scaling concepts. We have proposed a three-variable scaling to take in account the applied field (PRL, 1992). Measurement of noise in non-ohmic regimes indicates a very interesting prospect of differentiating transport mechanisms even when usual resistance appears to behave in a similar manner (AIP Conf. Proc. 2005). We have also extended measurements up to electrical breakdown in Composites. It was found that under certain conditions it was actually possible to predict an imminent breakdown - which is of course the goal of any study on breakdown (PRL 1999).

Presently, our efforts are concentrated around a possible scaling formulation of non-Ohmic conduction in disordered systems. The motivation stems from the observation of existence of a field-scale in a disordered sample. Simultaneously, noise measurements are carried out to see its utility in probing various characteristics of electronic processes in disordered systems.

Future research:
We intend to continue efforts as mentioned above.

List of important publications:

Books:

K.K.Bardhan, B.K.Chakrabarty and A.Hansen, Eds. "Nonlinearity and Breakdown in Soft Condensed Matter", Lecture Notes in Physics, V437, 1994, Springer-Verlag.

Selected Papers:

1. S. Yarlagadda, **K. K. Bardhan**, D. Talukdar, K. Chakrabarty, and C. D. Mukherjee, "Resistance minima in conductor-insulator mixtures: Thermal expansion and Weibull distribution", submitted (2010).

2. D Talukdar, R Chakraborty, S Bose, and **K K Bardhan**, "Low noise constant current source for bias dependent noise measurements", submitted (2010).

3. **K. K. Bardhan**, C. D. Mukherjee, and U. N. Nandi, ANoise in non-Ohmic regimes of disordered systems@, AIP Conference Proc. V800, Ed. L. Reggiani et al, New York, 109-117(2005).

4. C. D. Mukherjee and **K. K. Bardhan**, ACritical behavior of thermal relaxation in disordered systems@, ***Phys. Rev. Lett***. 91, 025702 (2003).

5. **K. K. Bardhan** and C. D. Mukherjee, AFinite coherence length of thermal noise in percolating systems@, Phys. Rev. B**65**, 212302 (2002).

6. C. D. Mukherjee, **K. K. Bardhan** and M. B. Heaney, APredictable electric breakdown in composites@, ***Phys. Rev. Lett***. 83, 1215 (1999).

7. **K. K. Bardhan**, "Nonlinear conduction in composites near percolation threshold - beyond the Backbone", Physica A 241, 267(1997).

8. U.N.Nandi, C.D.Mukherjee and **K. K. Bardhan**, "1/f-noise in nonlinear inhomogeneous systems, Phys. Rev. B54, 12903(1996) (12 pages).

9. U.N.Nandi and **K. K. Bardhan**, "Transport in Altered Percolation Systems", ***Europhys. Lett.*** 31, 101(1995).

10. **K. K. Bardhan** and R.K.Chakrabarty, "Identical scaling behaviour of dc- and ac-response near percolation threshold in conductor-insulator mixtures", ***Phys. Rev. Lett.*** 72, 1068(1994).

11. R.K.Chakrabarty, **K. K. Bardhan**, and A.Basu, "Measurement of ac-conductance and minima in loss-tangent, of random conductor-insulator mixtures, J. Phys. conden. matter 5, 2377 (1993).

12. **K. K. Bardhan** and R.K.Chakrabarty, "Non-linear ac-response near percolation threshold and three-variable scaling", ***Phys. Rev. Lett.*** 69, 2559(1992).

13. R.K.Chakrabarty, **K. K. Bardhan**, and A.Basu, "I-V characteristics near the percolation threshold", Phys. Rev. B44, 6773(1991).

14. **K. K. Bardhan**, G.Kirczenow, G.Jackle, and J.C.Irwin, "High temperature staging diagram of the intercalation compounds Ag_xTis_2", J. Phys. C18, L131(1985).

15. G.K.Scott, **K. K. Bardhan**, and J.C.Irwin, "Raman scattering from the orthorhombic charge density wave state of 2H-$TaSe_2$", ***Phys. Rev. Lett.*** 50, 771(1983).

16. M.Kaufman, **K. K. Bardhan**, and R.B.Griffiths, "Thermodynamic model and sum rules for three-phase coexistence near the tricritical point in a liquid mixture", ***Phys. Rev. Lett.*** 44, 77(1980).

Name:- Sailendranath Das
Affiliation:- Experimental Condensed Matter Physics   Designation:- Professor
M. Sc. : Calcutta University   Post M. Sc. Associateship Course: Saha Institute of Nuclear Physics.   PhD: 1990 (Calcutta University),
Joined in Saha Institute as Faculty Member in 1990.
1. Received Foundation Day Award for my work.
2. Referee of the following journals: Nanoletter, J. Appl. Physics, Material Research Bulletin, Solid State Communication, J. Alloys & compounds.

Besides my own laboratory I am in-charge of three other laboratories.
1. *Travelling Solvent Floating Zone Image Furnace*
2. *Mossbauer Spectroscopy Laboratory.*
3. *PPMS (Physical Property Measurement Systems) laboratory.*

Research interest
Mott-Hubbard insulator, Strongly Correlated Electron systems, Transition metal oxides in general. Insulator to metal transition. Superconductivity. Spin, charge and orbital ordering phenomena in low- and three-dimensional transitional metal oxides and their unusual physical properties due to the interplay between these degrees of freedom, colossal magnetoresistance phenomenon, electronic and thermal transport, magnetic, and thermal study at ambient as well as at nonambient conditions (exter nal pressure, magnetic field, electric field, etc). Growth and structural studies of single crystals. Electrical and magnetic properties of of transition metal oxides with nano-scale particle or cluster size. Study of coexisting long-range orders, Magnetocaloric Effect (MCE) in transition metal oxides (manganites, cobaltates, ferrites, etc.)

Research Works
In the present plan period our project involves studies of transport, magnetic as well as thermodynamic properties of novel correlated electron systems exhibiting exotic properties. We have investigated several d-electron systems such as perovskite manganites, cobaltates and ferrates in the form of polycrystals, single crystal, nanoparticles to understand various aspects of their transport and magnetic properties as a function of temperature, field, pressure and doping. We have studied the charge and spin dynamics and role of core-shell spin structure in $Nd_{0.5}A_{0.5}MnO_3$ (A = Sr, Ba) nanoparticles and $La_{0.5}A_{0.5}CoO_3$ (A = Sr, Ca and Ba) nanoparticles. The results reveal the size-induced metal-insulator transition, the decrease of magnetization in nano particles below FM ordering temperature, decrease of Tc in comparison with bulk samples, spin glass or cluster glass-like behavior due to frustration but no remarkable signature of glassy behaviour on magnetoresistance. Magnetocaloric effect was studied in multiferroic manganites $RMnO_3$ (R = Y, Ho, Tb, Dy, Yb) crystals grown by traveling solvent floating zone method. The results suggest that multiferroic manganites exhibits metamagnetic transitions due to the long

range order of R^{3+} ions. The large values of magnetic entropy, relative cooling power, adiabatic temperature change, together with small hysteresis, suggest $RMnO_3$ could be a potential materials for magnetic refrigeration in the low temperature range. The polaron hopping was studied in the charge ordered $R_{1/3}Sr_{2/3}FeO_3$ (R=La,Pr, Nd) and also for R= Sm and Gd) by AC and DC conductivity and thermopower. From dc conductivity measurement we found that the adiabatic small polaron hopping mechanism is valid for R = La, Pr and Nd and non-adiabatic small polaron hopping mechanism is active for R = Sm and Gd but the power law exponent s obtained from ac conductivity measurement indicates overlapping large polaron hopping. Magnetic, electric transport and calorimetric study has been performed on the as-grown, deformed and oxygen annealed samples of icosahedral $Al_{70.4}Pd_{20.8}Mn_{38.8}$ quasicrystals.

In analogy with electron doped superconductor $Nd_{2-x}Ce_xCuO_6$ where the Ce ions attain the tetravalent state we have prepared Ce-doped $RMnO_3$ (R= La, Pr and Nd). In Ce-doped manganite the Mn valency is expected to be Mn^{3+}/Mn^{2+} and this makes a sharp contrast with the case of divalent ion doped manganites. The works received world wide attention as an electron doped manganite. Publications on this subject are well cited. We have studied the metal-insulator transition in $R_{1-x}A_xTiO_3$ (R = Y, Nd; A = Ca, Sr and Ba) and showed that M-I transition occurs due to the mass enhancement. We have also studied electrical transport properties of conducting polymer and polymer nancomposites.

On going research programme

1) We are studying the effect of Ce-doping in $SrCoO_3$, $BaCoO_3$, cell-doubling in $CeBaCo_2O_{5+\delta}$, $YbBaCo_2O_{5+\delta}$ & $GdBaCo_2O_{5+\delta}$ and also the effect of Cr- and Al- doping in $La_{0.5}Sr_{0.5}CoO_3$.

2) To understand the evolution of transport properties with doping and to determine the role of several scattering mechanisms we are investigating the structural transition, electrical transport and magnetic properties of $Ca_{1-x}Sr_xMnO_3$ ($0 \leq x \leq 1$) & $Ca_{1-x}Ce_xMnO_3$ as a function of doping and temperature. (single crystals)

3) Study of multiferroic properties of $RMnO_3$ (R = Y, Ho, Tb, Er, Yb) crystals.

4(a) Development of an automated thermal expansion and magnetostriction measurement system operating in the temperature range 4-300 K under 8 T magnetic field.

4(b) Development of dielectric measurement and electric polarization measurement system with Sawer-Tower process.

List of important publications

1. Applied Physics Letter **96**, 142514 (2010).
2. Applied Physics Letters **92**, 233101 (2008).
3. J. Appl. Phys. 104, 103915 (2008).
4. J. Appl. Phys. **100**, 104318 (2006).
5. J. Mag. Mag. Mater. **300**, 263 (2006).
6. J. Appl. Phys. **95**, 6261 (2004).
7. J. Alloys and Compounds **365**, 94 (2004).
8. J. Alloys and compounds **358**, 17 (2003)
9. J. Appl.Phys. **87**, 2363 (2000).
10. Phys. Rev. **B** 56, 15073 (1997) (127 citations)
11. Z. Phys.**B 104**, 7 (1997).
12. J. Alloys and compounds **326**, 317 (2001).
13. Polymer 37, 4375 (1996)
14. J. Phys. Codens. Matter 6, 10499 (1994)

Future research/development plan

We want to carry out the following programmes in future

1. Study of magnetoelectric effect in multiferroic manganites/chromates.
2. Study of nanocrystalline materials and thin films.
3. Study of pressure-and field-dependent quantum critical phenomena in strongly correlated systems.
4. Study of magnetocaloric effect and magnetic scaling behaviour of novel magnetic material.
5. Setting up a four- mirror TSFZ furnace and developing other methods of growing single crystals. Cutting single crystals.

Prof. Kajal Ghoshray: ECMP division

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Educational background: Ph. D in Physics Calcutta University, 1986

Academic profile: Research Associate at SINP during June, 1986 – February, 1989
Lecturer in the Condensed Matter Physics Division of SINP in March, 1989
Present position: Professor 'G' (from February, 2007)

Awards: Invited as a Guest Scientist at International Institute of Theoretical and Applied Physics (IITAP), Iowa State University, USA during September 1999 – November 1999

Collaborations: Indo-Ukraine Programme of cooperation in science and technology (Project No. DST/INT/UKR/P-2/04): Indian Project Coordinator: Prof. K. Ghoshray
Ukrainian Project Coordinator: Prof V. Eremenko, Director, Institute of Low Temperature Physics and Engineering, Kharkov, Ukraine

Essential strength of research/development: Experimental investigations using nuclear magnetic resonance (NMR) and mgnetization measurements

(1) Investigation of magnetic properties of the low-dimensional systems: extended to the quantum spin chains exhibiting various types of ground states depending on the extent of electron correlation. We have established from ^{51}V NMR in alternating spin chain compound, $BaCu_2V_2O_8$, the existence of large energy gap (230 K) in the low energy excitation of Cu2+ electron spins and a temperature dependent spin gap in Haldane spin chain compound $SrNi_2V_2O_8$.

(2) Effect of geometrical (topological) frustration on the magnetic property in low dimensional quantum spin systems.

(3)Study of the electronic property of the rare earth actinide based intermetallic compounds exhibiting unusual low temperature state, e.g. (a) Unusual pairing states in heavy fermion super conductors, (b) existence of "Hidden Order" etc. due to the competition between the Kondo and the RKKY type exchange interaction.

(4) Electronic and magnetic property ReTmPn (Re= rare-earths, Tm= transition metals and Pn=As, P) based high Tc superconductors. We have shown from NMR, the presence of dominant 2D spin fluctuations in the normal state of LaFePO and in the paramagnetic state of LaCoPO. To explore the role of spin fluctuations on the pairing mechanism, experiments in different members are in progress.

Ph.D. students (completed + ongoing):

1. Co-guide of the thesis of Dr. Mita Sen (1998); Topic: NMR investigations in hydrides of rare-earth based ternary intermetallics
2. Guided the thesis work of Dr. Sourav Giri (1997); Topic: Experimental investigation on some layered compounds with non-collinear magnetic structure
3. Guided the thesis work of Dr. Bholanath Pahari (2009); Topic: Study of the electronic properties of quasi one dimensional antiferromagnets.
4. Guiding the thesis work of Manasi Ghosh (Joined in 2005); Topic: NMR study of quantum antiferromagnets
5. Guiding the thesis work of Mayukh Majumder (Joined in 2008); Topic: Fe-As based high Tc superconductors.

Teaching experience (Post M. Sc):

1. NMR studies in solids (1992-1994)**;** Magnetic properties of solids (1998-1999)**;** NMR and Mossbauer spectroscopy in solid state physics (2000)**:** Magnetism of solids (2004)

Guiding the review work of Post M. Sc students:

1. Magnetic phase transitions in low dimensional systems: Mita Sen (1990)
2. Solid state NMR techniques for the study of surface phenomena: Sourav Giri (1992)

3. Magnetism of thin films and multilayers: Monodeep Chakraborty (1998)
4. Recent trends in heavy fermion physics: Bholanath Pahari (2004)
5. Experimental studies of low dimensional quantum spin systems: Manasi Ghosh (2005)

Future research/development plan:

Strongly correlated systems: e.g. Investigation of the electronic and the magnetic property of (a) Fe-As based high Tc superconductors, (b) Magnetic properties of low dimensional compounds with transition metal clusters, (c) Transition metal oxides exhibiting GMR

List of important publications starting with recent publications:

1. M. Ghosh, **K. Ghoshray**, M. Majumder, B. Bandyopadhyay and A. Ghoshray, NMR study of a magnetic phase transition in $Ca_3CuNi_2(PO_4)_4$: A spin trimer compound, Phys. Rev. **B81**, 064409 (2010).
2. M.Ghosh, M.Majumder, **K.Ghoshray** and S. Banerjee, Magnetic properties of the spin trimer compound $Ca_3Cu_2Mg(PO_4)_4$ from susceptibility measurements, Phy. Rev. **B81**, 094401 (2010).
3. P. Maheshwari[1], Dhanadeep Dutta[1], Sandeep Sharma[1], Kathi Sudarshan[1], Pradeep Pujari[1], M.Majumder, B. Pahari, B.Bandyopadhyay, **K. Ghoshray**, and A. Ghoshray, Effect of Interfacial Hydrogen Bonding on the Freezing/Melting Behavior of Nano-Confined Liquid, J. Physical Chem. **C114**, 1966 (2010). [1]Department of Chemistry, BARC, Trombay, Bombay.
4. M. Majumdar, **K. Ghoshray**, A. Ghoshray, B. Bandyopadhyay, B. Pahari, S. Bannerjee, Crossover of the dimensionality of 3D spin fluctuation in LaCoPO, Phys. Rev. **B80**, 212402, (2009)
5. **K. Ghoshray**, B. Pahari, A. Ghoshray, V. V. Eremenko[1] , V. Sirenko[1] and B. H. Suits[2], ^{93}Nb NMR study of the charge density wave state in $NbSe_2$ J. Phys. Cond. Matter **21** 155701 (2009).
6. A. Ghoshray, B. Pahari, M. Ghoshray, M. Mazumdar, **K. Ghoshray**, B. Bandyopadhyay, P. Dasgupta, A. Poddar and C. Mazumdar ^{75}As NMR study of oriented CeFeAsO and $CeFeAsO_{0.84}F_{0.16}$, Phys. Rev. **B79** 144512 (2009)
7. Alo Dutta[1], T. P. Sinha[1], B. Pahari, R. Sarkar, **K. Ghoshray**, S. Shannigrahi, Dielectric relaxation and electronic structure of $BaAl_{0.5}Nb_{0.5}O_3$: X-ray Photoemission and Nuclear Magnetic Resonance studies J. Phys. Cond. Matter **20** 445206 (2008)
8. B. Pahari, **K. Ghoshray**, R. Sarkar and A. Ghoshray, NMR study of the impurity induced ordered state in the doped Haldane chain compound $SrNi_{1.93}Mg_{0.07}V_2O_8$, Phys. Rev. **B77** 224429 (2008)
9. B. Pahari, **K. Ghoshray**, A. Ghoshray, T. Samanta, I. Das, Impurity induced antiferromagnetic order in Haldane gap compound $SrNi_{2-x}Mg_xV_2O_8$, Physica **B395** 138 (2007).
10. M.Ghosh, **K.Ghoshray**, B. Pahari, R.Sarkar, A. Ghoshray, ^{31}P NMR of trimer cluster compound $Sr_3Cu_3(PO)_4$, J. Phys.& Chem. of Solids **68** 2283 (2007).
11. B. Pahari, **K. Ghoshray**, R.Sarkar, B. Bandyopadhyay and A. Ghoshray, NMR study of ^{51}V in quasi-one dimensional integer spin chain compound $SrNi_2V_2O_8$ Phys. Rev **B73** 012407 (2006).
12. R Sarkar , **K.Ghoshray**, B. Bandyopadhyay and A. Ghoshray , ^{27}Al NMR studies in grain aligned $CeNi_2Al_5$ Phys. Rev. **B71** (2005) 104421.
13. **K. Ghoshray**, B. Pahari , B. Bandyopadhyay, R. Sarkar, A. Ghoshray, ^{51}V NMR study of the quasi-one dimensional alternating chain compound $BaCu_2V_2O_8$, Phys. Rev.**B71** (2005) 214401
14. **K. Ghoshray**, B. Bandyopadhyay, A. Poddar, A. Ghoshray, M D Mukadam[1] and S M. Yusuf[1], Transport and magnetic properties of cobalt doped $CeNiAl_4$, Solid State Comm. **132** (2004) 725. [1]Department of Solid State Physics, BARC, Trombay, Bombay
15. I. Manna[1], P. Nandi[1], B. Bandyopadhyay, **K. Ghoshray** and A. Ghoshray, Microstructural and nuclear magnetic resonance studies of solid state amorphization in Al-Ti-Si composites, Acta Materialia **52** (2004) 4133. [1]Department of Metallurgy, IIT Kharagpur

Other Important academic activity: Act as a referee for PRL and PRB and other Elsevier published journals on a regular basis.

Name: **ABU ISMAIL JAMAN**

Education:

M.Sc. (Physics) (University of Burdwan, 1975) (Session 1971-73)
Post M.Sc. (Saha Institute of Nuclear Physics, 1976-77)
Ph.D (Sc.) (University of Calcutta, 1983)

Academic Profile (at SINP):

1. Scientist 'SB' - July, 1983 – June, 1984
2. Lecturer 'C' - July, 1984 – January, 1987
3. Reader 'D' - February, 1987 – July, 1991
4. Ass. Prof. 'E' - August, 1991 – July, 1997
5. Professor 'F' - August, 1997 – July, 2004
6. Professor 'G' - August, 2004 – July, 2009
7. Professor 'H' - August, 2009 –

Special awards, honours or distinctions:

1. Acted as reviewer of paper for Journal of Molecular Structure, Elsevier.
2. Acting as reviewer of papers of Indian Journal of Physics.
3. Acting as reviewer of papers of Indian Journal of Pure and Applied Physics.
4. Acting as external expert for taking Ph. D thesis viva voce examination (J.U).
5. Acted as an external expert in a committee formed to recruit new people at IISER, Kolkata.

Overseas visits/deputations:

1. Postdoctoral Research Assistant, University of Exeter, U.K. 1985-1986.
2. Visiting Research Associate, University of Illinois at Urbana-Champaign, U.S.A. 1990-1991.
3. Visiting Scientist, Institute for Molecular Sciences, Okazaki, Japan. 1996.
4. Visiting Scientist, Faculty of Science, Okayama University, Japan, Oct.-Dec., 2007.
5. Visiting Scientist, Universidad de Valladolid, Spain, Oct.-Nov., 2010 (Invitation received)

Essential strength of research/development output:

Conventional microwave and millimeter wave spectroscopy of stable and transient molecules

1. Microwave (MW) spectroscopic studies of gas phase rotational spectra of stable molecules leading to the determination of their molecular parameters, structures, conformations, barrier to internal rotations, quadrupole hyperfine structures etc. using conventional MW as well as RF-MW and MW-MW double resonance techniques.
2. Production and characterization of stable and transient molecules of chemical and astrophysical interest using an indigenously built millimeter-wave spectrometer coupled with DC glow discharge facility. This facility was developed and tested successfully in the Xth. plan period.

Measurement of broadband microwave absorption and dielectric properties of materials

Studies on broadband microwave absorption and dielectric properties of low dimensional materials e.g., conducting polymers, nano composites and nano fibres etc. (A new project under the XI th plan programme) has been initiated. A new facility has been set up for the measurement of dielectric constant, dielectric loss, shielding effectiveness and different S-parameters of low dimensional materials in the frequency range 10 MHz-26.5 GHz using a VNA.

Future research/development plan:

1. In the coming years, we plan to extend the frequency range of investigation of the millimeter-wave spectrometer above 100 GHz by incorporating higher frequency Gunn diodes and frequency multipliers. Efforts would be made to produce transient species e.g., free radicals and molecular ions of astrophysical interest and analyze their rotational spectra. A liquid helium cooled bolometer detector is to be installed for this purpose. Spectral data in the higher frequency range help radio-astronomers identify unknown molecules in the interstellar space.

2. The microwave frequency range of the electromagnetic spectrum will be used to study different properties e.g., complex conductivity, dielectric constant, dielectric loss, shielding effectiveness, insertion loss etc. of low dimensional materials. Information regarding dielectric behaviour of various materials will be obtained through measurements of permittivity at microwave frequencies.

List of important publications starting with recent publications:

1. Millimeterwave spectrum and *ab initio* DFT calculation of the *C-Gauche* conformer of Allyl Isocyanate. **A. I. Jaman** and P. R. Bangal. J. Mol. Spectrosc. 255, 134, 2009.

2.Time-resolved Fourier transform emission spectroscopy of laser ablation products. K. Kawaguchi, N. Sanechika, Y. Nishimura, R. Fujimori, T. N. Oka, Y. Hirahara, **A. I. Jaman** and S. Civis. Chem. Phys. Lettt. 463, 38, 2008.

3. Microwave spectrum of *trans* 3-fluorophenol in excited torsional states. **A. I. Jaman**. J. Mol. Spectrosc. 245, 22, 2007.

4. Millimeter-wave spectrum of ICN, a transient molecule of chemical and astrophysical interest. **A. I. Jaman**. J.Phys :Conference Series.80, 012006, 2007.

5.Millimeter-wave spectrum of 2,3-difluorobenzinitrile and ab initio DFT calculations. P.R. Varadwaj and **A. I. Jaman**. J. Mol. Spectrosc. 239, 216, 2006.

6. Assignment and analysis of the rotational spectrum of 3-chlorobenzonitrile. P. R. varadwaj, **A. I. Jaman**, Z. Kisiel and L. Pszczolkowski. J. Mol.Spectrosc. 239, 88, 2006.

7.Millimeter-wave spectrum of ClCN observed in a DC glow discharge and ab initio calculations. P. R. Varadwaj, P. R. Bangal and **A. I. Jaman**. J. Mol. Struct. 780-781, 17, 2006.

CHANDI DAS MUKHERJEE
(b. Feb. 18th , 1955)

Education:

M.Sc. in Physics, Calcutta University.
Premchand Roychand Studentship (Sc).
Ph.D., University of Calcutta.
Thesis on " Some Theoretical Studies on the Chain Ordering and Even-Odd Effect in Liquid Crystals".

Academic Profile

Research Fellow	Physics Department, Calcutta University 1979-84
Research Fellow	SSMP division, S I N P 1985-87
Research Associate	SSMP division, S I N P 1988-91
Permanent position	Lecture - SC, S I N P, January 3, 1992
Present position	Professor – SG

Essential Strength of Research development output:

Stating from my early research career, I have worked on two major projects, viz., **i) Phase transition in Liquid Crystals** which are partially disordered systems; and **ii) Electrical transport properties in disordered systems with special emphasis on composite systems**. Apart from these, I also worked on the field of **Superconductivity**. In order to study the transport properties, we had to do a little bit of developmental work like fabrication of heat chambers, high current constant current source and different types of sample holders etc., which were required for building up the experimental set up. We had to develop the facilities for the preparation of low dimensional systems by using Pulsed Laser deposition technique. For the preparation of carbon nanotubes, we had to fabricate the set up for the thermal chemical vapor deposition chamber. The works carried out in the different fields mentioned above led to the following interesting findings.

For *different liquid crystalline phases*

- The mean-field models put forward by us can predict correctly the nature of the experimental phase diagram as well as the thermo-dynamical behaviour of phase transition.
- Our results corroborate with the *hypothesis* of Gray and the *order of transition* predicted by McMillan, the *'even - odd'* effect, the *dependence* of mesomorphous states on the biaxial parameter etc.
- The molecular mean-field model for a rectangular columnar to hexagonal columnar phase transition is cable to show that a gradual lowering of biaxial with the addition of flexible chain segments can lead to the full phase sequence observed in the case of the HAT series.
- The experimentally observed effect of the chain length on the phase sequence *corroborates* well with our theoretical prediction.

For electrical transport properties of disordered systems

- The sensitivity of 1/*f* noise to conduction mechanism and geometry as observed in our work succeeds in establishing '1/*f* ' noise is a *firm tool* in probing transport properties in disordered systems.
- It is generally observed that when a composite sample is subjected to a high voltage the length of time it takes to relax back to its initial state after the bias is removed is found to depend on the initial voltage. Relaxation time in the composite system in the nonlinear regime found both sub-super- exponential behaviour.

- In the Joule regime, we have observed that the resistance up to breakdown point is described by a universal curve as a function of the applied electric field. Surprisingly the *ratio* of the breakdown resistance to the zero field resistance assumes a *fixed value*, which is independent of volume fraction of the conducting part (p), size and shape of the sample and the external conditions, but depends on the nature of the conductor.
- The thermal relaxation data in Joule region provides unique information concerning the breakdown transition and indicates that the classification of usual thermodynamic phase transition is *inadequate* for explaining this transition.

For Superconductivity

- One of our interesting results is of Superconductivity in low bismuth containing system, which has a *new phase* that sustains bulk superconductivity below 74K.

Future research/development plan:

The electrical response to an applied field *(F)* on the disordered systems is much more complicated than the traditional theories suggested. The interest in this area has increased considerably in recent years because these systems exhibit many exotic properties. Basically these systems are nonlinear because of the presence of localized states in their structure. The time-dependent information comes from the time traces of fluctuations, which are simply not available from the average quantities like resistance or noise power. So we plan to study in future the persistence phenomena from the time domain data for the single and multi component disordered system. We generally use the three-dimensional disordered system, which is not a clean system as there are no fixed directional properties. So we are planning to use low dimensional system like disordered metallic thin film or the composites with carbon nanotubes, which have the directional properties. Some advances have been made in this field, but more effort is needed to understand the underlying mechanism.

List of important publications starting with recent publications:

Positron annihilation spectroscopy studies of the influence of heat treatment on defect evolution in hybrid M W C N T- polyacrylonitrile-based carbon fibers **-** K. Chakrabarti, P.M.G. Nambissan, **C.D. Mukherjee**, K .K. Bardhan, C. Kim, K. S. Yang, *Carbon* **45** (2007) 2777.

Positron annihilation spectroscopy of polyacrylonitrile -based carbon fibers embedded with multi-wall carbon nanotubes. **-** K. Chakrabarti, P.M.G. Nambissan, **C.D. Mukherjee**, K.K. Bardhan, C. Kim, K.S. Yang, *Carbon* **44** (2006) 948.

Critical Behaviour of Thermal Relaxation in Percolating System – C D Mukherjee and K K Bardhan, Phy Rev Lett, **91**, 025702 (2003).

Predictable Electrical Breakdown in Composites **--** C D Mukherjee, K K Bardhan and M B Henay, - Phy Rev Lett, Vol **83**, 1215 (1999).

1/f Noise in Nonlinear Inhomogeneous Systems – U N Nandi, C D Mukherjee and K K Bardhan, *Phys. Rev.*, **B54**, 12903 (1996).

A Computer Simulation Study for the Biaxial Nematic **-** Isotropic Phase Transition **--** C D Mukherjee and N Chatterjee, *Phys. Lett A*, **189**, 86 (1994).

PROFILE

Name

Bilwadal Bandyopadhyay

Academic Profile

1983 M. Sc. (Physics), University of Calcutta, India

1984 Post M. Sc. Associateship Course, Saha Institute of Nuclear Physics, Calcutta

Sept. 1993 Awarded ph. D. Degree in Physics, University of Calcutta

Title of Thesis: Nuclear Magnetic Resonance Studies on Hydrides of Some Intermetallic Compounds

Supervisor: Prof. Nikhilesh Chatterjee, Saha Institute of Nuclear Physics, Calcutta

1993-94 Post-doctoral Research Associate in Solid State and Molecular Physics Division, Saha Institute of Nuclear Physics, Calcutta

1994-96 Post-doctoral Research Fellow in the Department of Physics, Ben-Gurion University of the Negev, Beer-Sheva, Israel

1997-99 Guest researcher in National Institute of Materials and Chemical Research, Tsukuba, Japan, on STA Fellowship awarded by JRDC

1999 Lecturer 'C' in Saha Institute of Nuclear Physics, Kolkata

Present Position

Professor 'F' in Saha Institute of Nuclear Physics, Kolkata

Highlights of Scientific Contribution

The pressure-composition isotherms, hydrogen mobilities and the hydrogen induced changes in electronic properties were studied in hydrides of a number of ternary intermetallic compounds. In one of our compounds, namely CeNiIn, NMR studies revealed that the absorbed hydrogen atoms were paired at a separation of 1.48 Å, which was much closer than the then valid theoretical limit of 2.1 Å. This observation was later confirmed through neutron diffraction studies by another lab, and a spurt of experimental and theoretical activities followed.

Intrinsic magneto-electronic phase separation was revealed in perovskite compounds $Nd_{1-x}Sr_xCoO_3$ ($0.0 < x < 0.5$) through ^{59}Co NMR studies. Depending on the level of doping, there may be a co-existence of paramagnetic and ferromagnetic phases which may not be yielded separately even by x-ray studies. The paramagnetic phase may also consist of more than one type of ionic co-ordinations.

The electronic and magnetic properties including heavy-fermionic and Kondo behavior of various intermetallic compounds have been studied by magnetic and NMR measurements.

Microstructural evolution of ball-milled alloys of Al-Ti-Si and Al-Cu-Nb which are of importance in automobile and aviation industries, have been studied by NMR using different probe nuclei. The results show the formation and co-existence of amorphous and/or nanocrystalline phases at different intermediate stages of milling.

Plan of Future Research

Preparation, characterization and study of electronic and magnetic properties of correlated electron systems including oxides and intermetallic compounds in both bulk and nanocrystalline forms.

Selected Publications

1. Effect of Interfacial Hydrogen Bonding on the Freezing/Melting Behavior of Nanoconfined Liquids
P. Maheshwari, D. Dutta, S. K. Sharma, K. Sudarshan, P. K. Pujari, M. Majumder, B. Pahari, B. Bandyopadhyay, K. Ghoshray, and A. Ghoshray
J. Phys. Chem. **C114** (2010) 4966.
2. Crossover of the dimensionality of 3*d* spin fluctuations in LaCoPO
M. Majumder, K. Ghoshray, A. Ghoshray, B. Bandyopadhyay, B. Pahari, and S. Banerjee
Phys. Rev. **B80** (2009) 212402.
3. ^{11}B and ^{195}Pt NMR study of heavy fermion compound $CePt_2B_2C$
R. Sarkar, A. Ghoshray, B. Pahari, M. Ghosh, K. Ghoshray, B. Bandyopadhyay, M. Majumder, V.K. Anand, and Z. Hossain
J. Phys.: Condens. Matter **21** (2009) 415602.
Phys. Rev. **B79** (2009) 144512.
4. Magnetization and ^{63}Cu NMR studies on granular FeCu alloys
B. Bandyopadhyay, B. Pahari, and K. Ghoshray
Phys. Rev. **B76** (2007) 214424.
5. Microstructural and nuclear magnetic resonance studies of solid state amorphization in Al-Ti-Si composites
I. Manna, P. Nandi, B. Bandyopadhyay, K. Ghoshray and A. Ghoshray
Acta Materialia **52** (2004) 4133.
6. Phase separation in $Nd_{1-x}Sr_xCoO_3$ using ^{59}Co NMR
A. Ghoshray, B. Bandyopadhyay, K. Ghoshray, V. Morchshakov, K. Barner, I. O. Troyanchuk, H. Nakamura, T. Kohara, G. Y. Liu and G. H. Rao
Phys. Rev. **B69** (2004) 064424.
7. NMR study of the electronic state in the dense Kondo compound $CeNiAl_4$
K. Ghoshray, B. Bandyopadhyay and A. Ghoshray
Phys. Rev. **B65** (2002) 174412.
8. Sites and dynamics of hydrogen and deuterium in V-H-D alloys studied by ^{1}H and ^{2}H NMR
B. Bandyopadhyay and S. Hayashi
Phys. Rev. B **60** (1999) 10302.
9. Observation of 'Pake Doublet' in the ^{1}H nuclear-magnetic-resonance spectrum of $CeNiInH_X$
K. Ghoshray, B. Bandyopadhyay, Mita Sen, A. Ghoshray, and N. Chatterjee
Phys. Rev. B **47** (1993) 8277.

Name: INDRANIL DAS

1. Educational background:

Ph. D. Physics 1994 from TIFR (Mumbai) Ph.D. Thesis Title: *Magnetic and 4f-electric Quadrupolar Anomalies in Rare-earth Compounds*; Thesis Supervisor: Prof. R. Vijayaraghavan & Prof. E.V. Sampathkumaran.

2. Academic profile including earlier appointments, awards etc.

[Aug.1988 to Nov.1994 TIFR (Mumbai) Research Scholar], [6/11/1994 to 28/7/2000 Scientist-'D' IUC-DAEF (Indore)], [31/07/2000 to 31/07/2002 Reader 'D' SINP (Kolkata)], [01/08/2002 to 31/07/2006 Associate Prof. 'E' SINP], [01/08/2006 to 31/07/2009 Prof.'F' SINP], [01/08/2009 to Onward Prof.'G' SINP]

**** Recipient of DAE SSPS best thesis award 1994 and***

**** Indian National Science Academy (INSA) Young scientist award 1995.***

3. Essential strength of research/development output:

Research career started at TIFR Mumbai, India. During the Ph.D. work (1988 to1994), contributed significantly in the field of strongly correlated electron system (Kondo effect, Heavy-fermion behaviour, 4*f*-electric quadrupolar effect in rare earth compounds, high T_c superconductivity etc).

About Twenty two years of research experience in experimental condensed matter physics as well as wide experience in low temperature instrumentation, computer automation, cryogen handling, sample preparation by various technique etc. Developed very efficient low temperature laboratory at IUC-DAEF (Indore) and at SINP (Kolkata), with various home made indigenous set-ups including efficient and sensitive 21-sample magneto-transport set-up, unique 4-sample heat capacity set-up, 1.5-300 K 0-8 Tesla etc.

Taken leading role for research in India in the three frontline areas of condensed matter physics; (i) Magnetocaloric effect, (ii) Spin polarized transport in magnetic nano-structure, and (iii) charge order nanocrystalline materials, which have both fundamental and technological interest. Published around 90 research papers in internationally reputed journals. Most of the works not only carried out in India, but the majority of the published works was obtained by the home made set-ups on the samples prepared by the same group.

Recent Major contributions in the field of:

(a) Magnetocaloric effect (Tapas Samanta & I. Das)

* Reported material with Largest Magnetic Cooling Power [APL 91, 082511 (2007)]
* Reported Novel origin of Giant Magnetocaloric effect: Order-Order transition [APL 91, 152506 (2007)]
* Novel method of generating magnetic Phase diagram using magnetocaloric effect [JAP 104, 123901(2008)]
* The observation of Giant Inverse Magnetocaloric Effect in bulk manganite and Particle size induced destabilization of antiferromagnetic state [APL 94, 233109 (2009)]

Besides large number of invited talk within India, in recognition of the contributions in the field of Magnetocaloric effect, received invitation and Presented Invited Talk: "Magnetocaloric effect: Powerful tool to understand various phenomena in magnetic materials" at "Moscow International Symposium on Magnetism" (MISM-2008, June 20-25, 2008, Moscow). Also Chaired the session on Magnetocaloric effect in the international symposium (MISM-2008, Moscow).

(b) Spin Polarized transport in magnetic nano structure (Soumik Mukhopadhyay & I. Das)

* Reported A Novel Phenomenon: Inversion of Tunnel Magnetoresistance due to Pinhole Nanocontacts [PRL 96, 026601 (2006), V. J. Nano Sc. Tech. (2006)], * Anomalous bias dependence of tunnel magnetoresistance [APL 86, 152108 (2005), V. J. Nano. Sc. Tech (2005)], *Giant Enhancement of room temperature Magnetoresistance in Manganite Multilayers [APL 88, 032506 (2006)] * Unified description of spin dependent transport in granular ferromagnetic manganites [EPL 79, 67002 (2007)] [PRB 76, 094424 (2007)], *Reproducing the phase separation scenario in manganite multilayers [EPL 83, 27003 (2008)],

In recognition of the contributions in the field of Spin Polarized transport, received invitation and Presented Invited Talk: Spin polarized transport & novel phenomena in manganite nanostructures, on 10th June 2008 at

"Indo Japan workshop on Novel Magnetic Ordering in Nanostructured Materials (June 10 to June 11, 2008)" at University of Tokyo (Japan). Also delivered invited talk at Tohoku University Sendai, and at ISSP Tokyo (Japan).

(c) Charge order nano materials (Anis Biswas & I. Das)

* Reported Particle size induced destabilization of charge order state [JAP 98, 124310 (2005)], *Reported Charge ordering in nano-particles: First observation [PRB 74, 172405 (2006)], *First observation of electronic phase co-existence in nano-particles and low field melting of charge ordered state by magnetic field [APL 91, 013107 (2007)], *Large low field magnetoresistance & large magnetocaloric effect in manganite [APL 92, 012502 (2008)], * Influence of charge ordering in magnetocaloric properties of nanocrystalline manganite [APL 92, 212502 (2008)],

In recognition of the contributions in the field of Charge order nano materials, received invitation and Presented Invited Talk: on 'Charge Ordering and Related Phenomena of Manganites on Nano-scales' at CIMTEC 2010 – 12th International Ceramics Congress held in Italy on June 6 to 11, 2010.

Guidance for Ph.D. degree: First research scholar (1) Dr. R. Rawat awarded Ph.D. degree in 2001, presently scientist at IUC-DAEF Indore, received *best thesis presentation award, DAE SSPS, 2001. S*econd research scholar (2) Dr. Soumik Mukhopadhyay received Ph.D. degree in 2009. also *received best thesis presentation award, DAE SSPS, 2008 and INSA Medal for young Scientist 2009.* (3) Dr. Anish Biswas: received Ph.D. degree in 2009, at present post-doctoral fellow at the Royal Institute of Technology, Sweden. (4) Dr. Tapas Samanta: received Ph.D. degree in 2010 presently post-doctoral fellow at Italy.

Referee of many journals including Physical Review Letters, Physical Review B, Solid State Communication, Materials Science & Engineering B, Pramana: Journals of Physics etc.

4. Future research/development plan:

Nano structure fabrication and research on Spintronic nano-devices using interconnected UHV systems:

Planning to develop internationally competitive, state-of-the-art laboratory for fabrication of low dimensional structures/ spintronic devices and studies of various spin dependent quantum phenomena. New generation spintronic nano devices will be fabricated in ultra clean UHV condition for research on Tunnel Magnetoresistance (TMR), Giant Magnetoresistance (GMR), Ballistic Magnetoresistance (BMR), etc. It will give a golden opportunity to combine basic scientific interest with an emerging applied research such as (***a) Spin polarized transport in Magnetic tunnel junction, (b) Quantum-well oscillation, (c) Spin-dependent coulomb blockade effect, (d) Spin-dependent resonant tunneling, (e) Spin Hall effect, etc.***.

Research on * Magnetocaloric effect in novel materials, and * Studies on Magnetic Nano materials, Magnetic Thin film, Multilayer, Nano wire etc. also will be continued.

5. List of important publications (recent):

1. Magnetocaloric properties of nanocrystalline $La_{0.125}Ca_{0.875}MnO_3$ [APL 94, 233109 (2009)]
2. Colossal enhancement of magnetoresistance in $La_{0.67}Sr_{0.33}MnO_3$ thin films: possible evidence of electronic phase separation [JPCM 21, 026017 (2009)]
3. Colossal enhancement of magnetoresistance in $La_{0.67}Sr_{0.33}MnO_3$ / $Pr_{0.67}Ca_{0.33}MnO_3$ multilayers: reproducing the phase-separation scenario [EPL 83, 27003 (2008)]
4. Influence of charge ordering on magnetocaloric properties of nanocrystalline $Pr_{0.65}(Ca_{0.7}Sr_{0.3})_{0.35}MnO_3$ [APL 92, 212502 (2008)]
5. Comparative studies of magnetocaloric effect and magneto transport behavior in $GdRu_2Si_2$ compound [JAP 104, 123901 (2008)]
6. Observation of large low field magnetoresistance and large magneto caloric effect in $Pr_{0.65}(Ca_{0.7}Sr_{0.3})_{0.35}MnO_3$ [APL 92, 012502 (2008)]
7. Magnetocaloric effect in Ho_5Pd_2 : Evidence of large cooling power [APL 91, 082511 (2007)]
8. Giant magnetocaloric effect in antiferromagnetic $ErRu_2Si_2$ compound [APL 91, 152506 (2007)]
9. Magnetotransport properties of nanocrystalline $Pr_{0.65}(Ca_{1-y}Sr_y)_{0.35}MnO_3$: Influence of phase co-existence [APL 91, 013107 (2007)]
10. Unified description of spin dependent transport in granular ferromagnetic manganites [PRB 76, 094424 (2007)]
11. Experimental observation of charge ordering in nanocrystalline $Pr_{0.65}Ca_{0.35}MnO_3$ [PRB 74, 172405 (2006)]
12. Negligible Influence of Domain Wall on Magnetocaloric Effect in $GdPt_2$ [PRB, 74, 132405 (2006)]
13. Giant enhancement of room temperature magnetoresistance in $La_{0.67}Sr_{0.33}MnO_3$/ $Nd_{0.67}Sr_{0.33}MnO_3$ multilayer" [APL 88, 032506 (2006)]
14. Inversion of magnetoresistance in magnetic tunnel junctions: effect of pinhole Nanocontacts [PRL 96, 026601 (2006)]
15. Anomalous Bias Dependence of Tunnel Magnetoresistance in a Magnetic Tunnel Junction [APL 86, 152108 (2005)]

Name: Prabhat Mandal
Educational back ground: M. Sc (Physics), Ph. D
Post-doctoral Experience:

Sl.#	Position held	Univ./Inst.	Period	
			From	To
1.	**Research Associate**	**Saha Institute of Nuclear Physics**	**June 05, 1992**	**September, 1993**
2.	**Post Doctoral Fellow (French Govt. fellowship)**	**Grenoble High Magnetic Field Lab (GHMFL), Grenoble, France**	**October, 1993**	**September, 1994**
3.	**UNESCO Short-term Fellowship**	**Grenoble High Magnetic Field Lab (GHMFL), Grenoble, France**	**October, 1994**	**November, 1994**
4.	**Alexander von Humboldt Fellow**	**University of Göttingen Germany, & GHMFL-MPI, France**	**November, 1994**	**June 25, 1996**

Special awards, honors and other information relevant to research activity

1. Received research award from the Third World Academy of Sciences and the Abdus Salam International Centre for Theoretical Physics, Trieste, Italy.
2. My current H-index is 19 and total citation is about 1300
3. Referee of more than 13 journals of International repute such as PRL, PRB, APL and JAP.

Research/development output

Last two decades we are studying doped Mott insulator where the electron-electron correlation driven unusual physical properties such as high-temperature superconductivity, non-Fermi liquid behavior, quantum phase transition, CMR, etc are observed. At present, we concentrate our research activity mainly on CMR oxides (where the interplay between spin, charge and orbital degree of freedom is crucial) and Fe-based pnictide superconductors. Our study on narrowband $Sm_{1-x}Sr_xMnO_3$ (x=0.48) single crystal revealed: (1) Due to the lattice mismatch (site-disorder) between Sm^{3+} and Sr^{2+} ions, the system exhibits a sharp first-order ferromagnetic-paramagnetic transition at around 110 K at ambient condition. (2) Application of external pressure, internal/chemical pressure and magnetic field weaken the first order nature of the transition and the transition becomes second order above a critical strength of these perturbations, i.e., there exists three critical points in the phase diagram. (3) We were able to demonstrate from the critical behavior analysis that the system becomes 3D Heisenberg FM in presence of high pressure.

The effect of high pressure (up to ~21 GPa) on electronic properties of $La_{1-x}Sr_xCoO_3$ (x= 0.10, 0.33) single crystals reveals interesting behavior related to pressure- and temperature-induced spin-state transition. In recent past, we have studied the role of orbital ordering on transport and structural properties in single crystals of $LaMnO_3$ and divalent-doped $LaMnO_3$. A sharp discontinuity in resistivity and volume collapse at 750 K due to the first-order orbital ordering is observed in $LaMnO_3$. The anomalous volume change (determined from the x-ray synchrotron data) in $LaMnO_3$ at the orbital order-disorder transition is quite similar to ice-water melting phenomenon.

Apart from CMR and related materials, we are also investigating transport and magnetic properties of pnictide superconductor $PrFeAsO_{1-x}F_y$. We have shown that this system shows resistivity saturation at high temperatures. Several important parameters in the normal and superconducting state (related to vortex dynamics) have been derived that helps to understand this mechanism of the transition. A phase diagram in the mixed-state has been constructed from the magnetization and resistivity data at high magnetic field.

Future research and development:

1. We would like to set-up a state-of-art single crystal growth facility (to grow high quality single crystals of different transition metal oxides/sulfides and of similar materials) along with differnt microscopic characterization facility. The techniques to be used for this purpose are Float zone, Chemical vapor transport, Czochralski, Bridgman.

2. As the systems we are studying are sensitive to external stimuli like pressure, magnetic and electric field, I have plan to set-up a high pressure facility (hydrostatic, quasi-hydrostatic and non-hydrostatic). We believe that the combination of high pressure and magnetic field will reveal interesting physics in strongly correlated system.

List of some important publications:

1. Magnetocaloric effect in $HoMnO_3$ crystal,
A. Midya, **P. Mandal**, S. Das, S. Banerjee et al: **Appl. Phys. Lett. 96, 142514 (2010)**

2. Role of external and internal perturbations on the ferromagnetic phase transition in $Sm_{0.52}Sr_{0.48}MnO_3$
P. Sarkar, **P. Mandal**, K. Mydeen et al : **Phys. Rev. B 79, 144431 (2009)**

3. Pressure- and temperature-induced spin-state transition in $La_{1-x}Sr_xCoO3$ (x=0.10, 0.33)
K. Mydeen, **P. Mandal**, D. Prabhakaran, and C. Q. Jin: **Phys. Rev. B 80, 014421 (2009**)

4. Pressure induced Critical Behavior of Ferromagnetic Phase Transition in Sm-Nd-Sr Manganites
P. Sarkar, S. Arumugam, **P. Mandal** et al : **Phys. Rev. Lett. 103, 057205 (2009)**

5. Resistivity saturation in $PrFeAsO_xF_y$ superconductors: evidence of strong electron-phonon coupling
D. Bhoi, **P. Mandal**, and P. Choudhury: **Supercond. Sci. Tecnol. 21, 125021 (2008)**

6. Field-induced first-order to second-order magnetic phase transition in $Sm_{0.52}Sr_{0.48}MnO_3$
P. Sarkar, **P. Mandal**, A.K. Bera et al: **Phys. Rev. B 78, 012415 (2008)**

7. Large magnetocaloric effect in $Sm_{0.52}Sr_{0.48}MnO_3$ in low magnetic field
P. Sarkar, **P. Mandal**, and P. Choudhury: **Appl. Phys. Lett. 92, 182506 (2008)**

8. E. Electronic transport in ferroelectromagnetic composites $La_{5/8}(Ba/Ca)_{3/8}MnO_3$
P. Mandal, P. Choudhury and B. Ghosh: **Phys. Rev. B. 74, 094421 (2006)**

9. Transport and magnetic properties of $La_{1-x}Ba_xCoO_3$ ($0< x \leq 0.55$)
P. Mandal P. Choudhury, S. K. Biswas and B. Ghosh: **Phys. Rev. B 70, 104407 (2004)**

10. Effect of Ce doping on structural, magnetic and transport properties of $SrMnO_3$ perovskite
P. Mandal, A. Hassen and A. Loidl : **Phys. Rev. B 69, 224418 (2004)**

11. Volume collapse in $LaMnO_3$ caused by an orbital-disorder transition
T. Chatterji, F. Fauth, B. Ouladdiaf, **P. Mandal** and B. Ghosh: **Phys. Rev. B 68, 052406 (2003)**

12. Transport, magnetic and structural properties of $La_{1-x}M_xMnO_3$ (M=Ba, Sr, Ca) for $0 \leq x \leq 0.20$
P. Mandal and B. Ghosh: **Phys. Rev. B 68, 014422 (2003)**

13. Structural, transport and magnetic properties of pure and La doped $RuSr_2GdCu_2O_8$
P. Mandal, A. Hassen, J. Hemberger, A. Krimmel and A. Loidl: **Phys. Rev. B 65, 144506 (2002)**

14. Resistivity anomaly in the vicinity of structural phase transition in $La_{1-x}Sr_xMnO_3$
P. Mandal, B.Bandyopadhyay, and B. Ghosh: **Phys. Rev. B 64, 180405(R) (2001)**

15. Temperature and doping dependence of thermopower in $LaMnO_3$
P. Mandal: Phys. Rev. B 61, 14675 (2000)

16. Transport Properties of Ce-doped $RMnO_3$ (R = La, Pr and Nd) Manganites
P. Mandal and S. Das: **Phys. Rev B 56, 15073 (1997)**

17. Thermoelectric power of $Bi_2Sr_2Ca_{1-x}Y_xCu_2O_{8+y}$ (x=0-1.0) system
J. B. Mandal, S. Keshri, **P. Mandal**, A. Poddar, A. N. Das, and B. Ghosh: **Phys. Rev. B 46, 11840 (1992)**

18. Effect of carrier concentration on the normal state transport properties and the superconducting transition temperature in the $Tl_2Ba_2Ca_{1-x}Y_xCu_2O_{8+y}$ system
A. Poddar, **P. Mandal**, A. N. Das, B. Ghosh, and P. Choudhury:**Phys. Rev. B 44, 2757 (1991)**

19. Variation of T_c and transport properties with carrier concentration in Y- and Pb-doped Bi-based superconductors
P. Mandal, A. Poddar, B. Ghosh, and P. Choudhury: **Phys. Rev. B 43, 13102 (1991).**

Name : **Chandan Mazumdar**

Present Position : Professor-F,
Experimental Condensed Matter Physics Division
Saha Institute of Nuclear Physics, Kolkata 700 064

Educational background : Ph.D (Physics), 1995, Indian Institute of Technology, Bombay, India

Awards : i) Young Scientist (Physics), 1997, Indian National Science Academy
: ii) Alexander von Humboldt Fellowship, 1997

Research/development output:

Three broad areas of condensed matter physics, *viz*., superconductivity, valence instability and magnetism are of my primary interest. My recent works includes (in collaboration with R. Ranganathan) the observation of negative thermal expansion (NTE) at low temperatures in $GdPd_3B_{0.25}C_{0.75}$ and discovery of negative temperature coefficient of resistivity (NTCR) in $GdPd_3B$, both of which have very unconventional origins. Through a well planed, non-routine experiment, we could show that fluctuation of valence of Eu-ions in $EuPd_3$ by introducing valence fluctuating Ce ions at the Eu site. Using inelastic neutron scattering experiments (in collaborations with scientists abroad), we had shown that low-lying crystal field levels is responsible for magnetic ordering in $PrNi_2B_2C$ that have nonmagnetic, singlet ground state. In our laboratory, we have installed a high-homogeneity large-bore 14 Tesla magnet system to be used in connection with various measuring probes, viz., magnetoresistance, magnetostriction, heat capacity, etc. A special copper hearth has also been designed for arc furnace to draw long, thin rods.

The most notables among my earlier work are the important observation of superconductivity in YNi_4B (Citation 140) and discovery of superconductivity in Y-Ni-B-C system (Citation 579) (in collaboration with TIFR). This work is a milestone in the field of research in superconductivity and magnetism, resulting the creation of a new PACS index (74.70.Dd). Discoveries of another superconductor $Lu_2Ni_3Si_5$, valence fluctuating material $Ce_2Ni_3Si_5$, largest positive magnetoresistance in intermetallic polycrystalline material $Tb_2Si_3Si_5$, and monolayer-thin domain wall in ferromagnetic $SmNi_4B$ are also noteworthy. While working in FU-Berlin, we have also performed the first direct measurement of magnetic structures in thin film form using magnetic x-ray diffraction techniques. We had shown that below the respective magnetic transition temperatures of rare-earths, splitting of valence bands scales linearly with $4f$ moments regardless the material is antiferromagnetic, that devoid any net magnetization, or ferromagnetic.

Future research/development plan:

The future research program include setting up laboratories for 20 Tesla dc field with an aim to further enhance the limit in near future using magnetic pulsed field. A dilution refrigerator and high pressure cells will also be employed to reach extreme corners of phase diagrams. Based on our experiences, emphasis will be given on studying various intermetallic compounds, particularly those of intermetallic perovskite and double perovskite compounds and compare the findings with those obtained in their oxide counter-parts. Although voluminous work may be found on oxide perovskite systems due to their technological importance, hardly any work is reported for intermetallic perovskites. Beside these, we also would like to initiate research on finding new materials having large thermoelectric power (high ZT). Such materials are the key for the development of energy technologies with much reduced environmental impact.

List of important publications :

1. Intermediate valency of Eu in the cubic intermetallic compound $Ce_{0.5}Eu_{0.5}Pd_3$, Abhishek Pandey, Chandan Mazumdar, R. Ranganathan, V.R. Reddy and A. Gupta, *Appl. Phys. Lett.*, **94** (2009) 182503.
2. Crystalline electric field effects in $PrNi_2B_2C$: Inelastic neutron scattering, Chandan Mazumdar, M. Rotter, M. Frontzek, H. Michor, M. Doerr, A. Kreyssig, M. Koza, A. Hiess, J. Voigt, G. Behr, L.C. Gupta, M. Prager and M. Loewenhaupt, *Phys. Rev. **B***, **78** (2008) 144422.
3. Negative temperature coefficient of resistance in a crystalline compound, Abhishek Pandey, Chandan Mazumdar, R. Ranganathan, Molly De Raychaudhury, T. Saha-Dasgupta, Saurabh Tripathi, Dhananjai Pandey and S. Dattagupta, *Europhys Lett.*, **84** (2008) 47007.
4. Transverse vibration driven negative thermal expansion in a metallic compound $GdPd_3B_{0.25}C_{0.75}$, Abhishek Pandey, Chandan Mazumdar, R. Ranganathan, S. Tripathi, D. Pandey and S. Dattagupta, *Appl. Phys. Lett*, **92** (2008) 261913.
5. Polarization-dependent X-ray absorption spectroscopy of RNi_2B_2C (R = Er to Lu): Reduced Ni-3d occupancy in $YbNi_2B_2C$, Chandan Mazumdar, Z. Hu, H. von Lips, M.S. Golden, J. Fink, P.C. Canfield, and G. Kaindl, *Phys. Rev.* **B 64**, *Rapid Commun.*, (2001) 020504(R).
6. $SmNi_4B$: A narrow domain wall ferromagnet, Chandan Mazumdar, R. Nagarajan, L.C. Gupta, B.D. Padalia and R. Vijayaraghavan, *Appl. Phys. Lett.*, **77** (2000) 895.
7. Magnetic splitting of valence states in ferromagnetic and antiferromagnetic lanthanide metals, C. Schüßler-Langeheine, E. Weschke, Chandan Mazumdar, R. Meier, A. Yu. Grigoriev and G. Kaindl, *Phys. Rev. Lett.*, **84** (2000) 5624.
8. Magnetically ordered surface oxide on Gd(0001), C. Schüßler-Langeheine, R. Meier, H. Ott, Z. Hu, Chandan Mazumdar, A.Yu. Grigoriev, G. Kaindl and E. Weschke, *Phys. Rev.* **B 60** (1999) 3449.
9. A new low-temperature phase of Yb metal and its relation to α-Ce, E. Weschke, A. Yu. Grigoriev, C. Schüßler-Langeheine, Chandan Mazumdar, R. Meier, S. Vandré, S. Ram, L. Kilian, G. Kaindl, C. Sutter, *Phys. Rev. Lett.*, **83** (1999) 584
10. Low temperature heat-capacity studies of $RE_2Ni_3Si_5$ (RE = Pr, Nd, Sm, Gd, Tb, Dy, Ho), Chandan Mazumdar, K. Ghosh, R. Nagarajan, S. Ramakrishnan, B.D. Padalia and L.C. Gupta, *Phys. Rev.* **B 59** (1999) 4215.
11. Anomalous magnetoresistance behaviour of $RE_2Ni_3Si_5$ (RE = Pr, Dy, Ho), Chandan Mazumdar, A.K. Nigam, R. Naga-rajan, L.C. Gupta, C. Godart, B.D. Padalia, G. Chandra and R. Vijayaraghavan, *Phys. Rev.* **B 54** (1996) 6069.
12. Positive giant magnetoresistance in antiferromagnetic $RE_2Ni_3Si_5$ (RE = Tb, Sm, Nd), Chandan Mazumdar, A.K. Nigam, R. Nagarajan, C. Godart, L.C. Gupta, B.D. Padalia, G. Chandra and R. Vijayaraghavan, *Appl. Phys. Lett.*, **68** (1996) 3647.
13. Superconductivity in a new ternary nickel silicide: $Lu_2Ni_3Si_5$, Chandan Mazumdar, K. Ghosh, S. Ramakrishnan, R. Nagarajan, L.C. Gupta, G. Chandra, B.D. Padalia and R. Vijayaraghavan, *Phys. Rev.* **B 50** (1994) 13879.
14. Bulk Superconductivity at an Elevated Temperature ($T_C \approx 12K$) in a Nickel Containing Alloy System Y-Ni-B-C, R. Nagarajan, Chandan Mazumdar, Zakir Hossain, S.K. Dhar, K.V. Gopalakrishnan, L.C. Gupta, C. Godart, B.D. Padalia and R. Vijayaraghavan, *Phys. Rev. Lett.*, **72** (1994) 274.
15. Valence state of Sm in $SmRuSn_3$, C. Godart, Chandan Mazumdar, S.K. Dhar, R. Nagarajan, L.C. Gupta, B.D. Padalia and R. Vijayaraghavan, *Phys. Rev.* **B 48** (1993) 16402.
16. Superconductivity at 12K in Y-Ni-B system, Chandan Mazumdar, R. Nagarajan, C. Godart, L.C. Gupta, M. Latroche, S.K. Dhar, C. Levy-Clement, B.D. Padalia and R. Vijayaraghavan., *Solid State Commun.*, **87** (1993) 413.
17. $Ce_2Ni_3Si_5$: A mixed-valence cerium compound, Chandan Mazumdar, R. Nagarajan, S.K. Dhar, L.C. Gupta, R. Vijayaraghavan and B.D. Padalia, *Phys. Rev.* **B 46** (1992) 9009.

1. Name: **Barnana Pal**

Educational qualification: M.Sc. (CU), Post M.Sc. (SINP), Ph.D. (CU).

2. Academic profile:

Scientist 'SB': 27. 8. 1990.
Lecturer 'SC': 05.12.1992.
Reader 'D': 01.02.1997.
Associate Professor 'E': 01.02. 2003.
Professor 'F': 01.08.2007.

3. Essential strength of research:

I. Propagation Characteristics of Ultrasound Through Material medium:

The responses observed in various ultrasonic experiments (e.g. continuous wave(cw), pulse echo, coherent pulse/cw, long pulse etc.) depend on various internal and external parameters. An extensive analysis based on a "propagating wave" model has been made to understand the nature of waveform deformation caused by these factors. The analysis explores the possibility of developing a computational Fourier transform method for the characterization of materials. The proposed method, being a general one, is applicable to different types of waves. As an application, the method has been employed to study the propagation behaviour of ion-acoustic waves in plasma. The propagation parameters and dispersion characteristics obtained from experimentally observed waveforms are found to be in good agreement with the theoretical prediction.

II. Ultrasonic Study of Structural Phase Transitions:

Structural phase transitions are associated with strong anomalies in the acoustic propagation parameters. We intend to study the nature of anomaly observed near structural transitions in different systems. Study on the variation of propagation parameters of 10MHz ultrasound as a function of temperature over a wide temperature region from 240^0C to 490^0C in β'-brass has been done. This system shows order-disorder transition at 468^oC. Temperature variation of attenuation coefficient (α) of longitudinal acoustic wave propagating along [100] and [110] directions shows a small peak around 300^0C. Near the transition temperature, α rises sharply following a relation $\alpha \sim (T_c\text{-}T)^{0.24}$.

To extend our study in liquids we consider aqueous electrolytes. In aqueous electrolytes the mobility of the ions depend on the molar concentration of the solution. Also water as a solvent plays significant role due to hydrogen bonding and network structure. These facts lead to interesting structural properties in aqueous electrolytes. The concentration dependence of velocity and attenuation in NaCl solution at 800KHz, 1MHz and 2MHz ultrasound frequency indicates the existence of structural changes at some specific solute concentrations. There is a possibility for the formation of large size ion-water clusters as indicated by other different experiments reported in the literature. An elaborate study in this regard is in progress.

III. Developmental work:

Growth of large size single crystals from solution:

Study of acoustic properties near structural transitions in different systems requires large size good quality single crystals. To meet our requirement we started developing the facility for growing such crystals. We choose KSCN that exhibit order-disorder transition. Such crystals can be grown from solution using acetone as the solvent. The solubility of KSCN in acetone decreases very slowly with temperature. This enables one to grow high quality crystals by evaporating the solvent. The growth process should be carried out in a closed vessel since the solution is extremely hygroscopic. A special type of growth vessel has been designed and crystals of size ~2.30X2.36X17.7 mm^3 has been grown in ambient conditions. Work is in progress to grow larger crystals.

IV. Simulation studies on some model systems.

Monte-Carlo simulation on different model systems is done with a view to understand the observed physical phenomena from a microscopic point of view. Different systems like Diffusion Limited Aggregate (DLA), Langmuir monolayer, Strongly Correlated Liquids and Lennard-Jones (L-J) clusters have been studied.

In our recent study on the dynamical evolution of two-dimensional Lennard-Jones (L-J) clusters, realistic thermal motion of the particles have been introduced through a modification of the conventional Metropolis algorithm. The proposed algorithm leads to a quick equilibration from the nonequilibrium cluster configuration in a certain temperature regime, where the relaxation time (τ), measured in terms of Monte Carlo Steps (MCS) per particle, vary inversely with the square root of system temperature ($\sqrt{T}$) and pressure (P); $\tau \sim (P\sqrt{T})^{-1}$. From this a realistic correlation between MCS and time has been predicted. In the low temperature regime the system shows the presence of two relaxation times when the particle concentration is greater than a critical concentration. With the sudden decrease in temperature it firstly attains an amorphous structure and then slowly approaches towards an ordered crystalline structure.

Another system of our concern is aqueous electrolytic solution. A realistic model to study the properties of an aqueous electrolyte surface consisting of interacting particles, ions and dipoles, has been developed. The possible interactions existing in the system are charge-charge, charge-dipole, charge-quadrupole and dipole-dipole. The concentration and temperature dependence of the ionic diffusion co-efficient indicates structural phase transition at some specific ionic concentration.

4. Future research/development plan:

A. Ultrasonic study of structural transitions in different solid and liquid systems.
B. Development of Computational Fourier Transform Ultrasound technique.
C. Simulation study on L-J clusrters, aqueous electrolytes and other systems.

5. List of important publications:

1. "Relaxation dynamics in small clusters: A modified Monte Carlo approach", Barnana Pal, Journal of Computational Physics, **227**(2008) pp.2666-2673.
2. "Distorted Waves for the Study of Dispersion", Barnana Pal, Santwana Raychaudhuri and Yoshinobu Kawai*, Physics of Plasmas, **12**(2005)062306.
3. "Ultrasonic pulse propagation in a linear dispersive medium", Barnana Pal and Santwana Raychaudhuri, Journal of Pure and applied Ultrasonics, **26**(2004) 63.
4. "Acoustic attenuation in brass", Barnana Pal, Japanese Journal of Applied Physics, Pt-1, **42**(2003) 5813 .
5. "Elastic stiffness properties of brass near the order-disorder transition – an overview", Barnana Pal, Japanese Journal of Applied Physics, Pt-1, **40** (2001) 5054.

Name: Asok Poddar

Educational background: Ph.D. (Phys), 1994 (Calcutta University)
Awards: i) Nat. Scholarship 1980-82 (C.U)
ii) AvH Post doctoral Fellowship, 1995

Essential strength of research/development output:

My research activities are primarily concerned with strongly correlated electronic systems *e.g.* double perovskite compounds, colossal magnetoresistance material, high-T_c superconductors (HTSC), *etc.*, as well as conducting nano-composite systems. While exploring the basic physics of the technologically important half-metallic double perovskite compounds exhibiting substantial low field magneto-resistance around room temperatures, we observe evolution of anti-ferromagnetism below the randomly frozen spin glass state in the doped Sr_2FeMoO_6 system. This is quite an interesting behaviour as it goes contrary to the popular belief. Furthermore, in the nano-metric $(Sr/Ca)_2FeMoO_6$ samples, we have found the signature of disorder enhanced quantum interference effects at low temperatures. To facilitate diverse types of experimental measurement, we have also designed and fabricated (using the SINP & VECC workshop facilities) variable temperature insert for measurements of various physical parameters *viz*. magneto-resistivity, Hall voltage, thermo-electric power, specific heat, *etc*. in the temperature interval 2-300K, and in the magnetic field range 0-10 Tesla. My earlier research work under Alexander von-Humboldt fellowship deals with the improvement of the quasi-crystallinity in the icosahedral $Al_{70.4}Pd_{20.8}Mn_{8.8}$ that causes a drastic increase in resistivity accompanied by a very small decrease in the electronic specific heat coefficient. This leads to a significant reduction in the electronic density of states suggesting only a very small fraction of Mn atoms carries magnetic moment while the majority being non-magnetic. One of the noteworthy research work during my doctoral research is the establishment of "*two dimensional character of the Thallium based HTSC***"**. Another interesting result, that may also be mentioned, is the observation of dome-shape like phase diagrams (T_c versus *p*-hole concentration per Cu-ion) for $Tl_2Ba_2Ca_1Cu_2O_8$ systems.

Future research/development plan:

The physics of ordered and disordered magnetic oxides have attracted a world wide attention from basic theory, novel experiment and application point of view. In these materials, appropriate correlations between lattice, spin and electronic structure are yet to be established properly. An important characteristic of these materials is the presence of several competing interactions of comparable energy scales similar to that found in many heavy fermion systems. In this context, it would be of interest to study the phase diagram of the selected oxides of potential interest and some of those heavy fermion systems through different measurements of their physical properties (*e.g.*, electrical, thermal, thermodynamic and magnetic properties) under extreme physical situations *viz*. low temperatures (mK), high magnetic field and high pressure.

Another important propertiy that is of current interest is the exciting and technologically important phenomemon of multi-ferroelectricity as these materials are useful in making magnetic sensor, solid state fuel, and spintronic devices. In this context, we propose to synthesize multi-ferroic materials by mechanical milling as well as chemical routes. Since multiferroicity is connected to both electronic (ferroelectric) and magnetic (ferro/antiferromagnetic) properties of a material, attempt will also be made to formulate the origin of multi-ferroelectricity by correlating with structural, magnetic, dielectric and magnetotransport (magnetoresistance, magnetoimpedance) properties of the materials.

<u>Selected list of important publications starting with recent ones</u>:

1. Spin glass-like behaviour in Fe-rich phases of $Sr_2Fe_{1-x}Mn_xMoO_6$ (0.1≤x≤0.4), Asok Poddar and Chandan Mazumdar, *J. Alloys Comp*. **502** (2010) 15.
2. Enhanced ferromagnetism in nano-sized $Zn_{0.95}Mn_{0.05}O$ grains, R. N. Bhowmik, Asok Poddar and A. Saravanan, J. Magn. Magn, Nater. 322 (2010) 2340.
3. Exchange bias in $LaFeO_3$ nanoparticles, H. Ahmadvand, H. Salamati, P. Kamell, Asok Poddar, M. Acet and K. Zakeri, J. Phys. D. Appl. Phys. 43 (2010) 245002.
4. Magnetic frustration effect in Mn-rich $Sr_2Mn_{1-x}Fe_xMoO_6$ system, Asok Poddar and Chandan Mazumdar, *J. Appl. Phys*., **106** (2009) 093908.
5. Evidence of disorder induced magnetic spin glass phase in Sr_2FeMoO_6 double perovskite, Asok Poddar , R. N. Bhowmik , I. P. Muthuselvam , *J. App. Phys*. 106 (2009) 073908.
6. Thermoelectric power of RFeAsO (R = Ce, Pr, Nd, Sm, and Gd), Asok Poddar, Sanjoy Mukherjee, Tamnay Samanta, Rajat S. Saha, Rajarshi Mukherjee, Papri Dasgupta, Chandan Mazumdar, and R. Ranganathan, *Physica C*, **469** (2009) 789.
7. Electrical transport properties and magnetic cluster glass behaviour of $Nd_{0.7}Sr_{0.3}MnO_3$ nanoparticles, B. Roy, Asok Poddar and S. Das, J. Appl. Phys. **100**, 104318 (2006)).
8. Electrical transport, magnetic and thermal properties of icosahedral Al-Pd-Mn quasicrystals, Asok Poddar, S. Das, D. Plachke and H. D. Carstanjen, *J. Mag. and Mag. Mater.* 300, 263 (2006).
9. Effects of Magnetic Impurity Co on Stripe phase of $(Bi/Tl)_2(Sr/Ba)_2CaCu_2O_{8+\delta}$ Superconductors, Asok Poddar and B. Chattopadhyay, *Euro. Phys. J. B* 35, 69 (2003).
10. Effects of Co-substitution on superconductivity and transport in $Tl_2Ba_2Ca_{1-x}Y_x(Cu_{1-y}Co_y)_2O_{8+\delta}$ system : Asok Poddar, Bidisa Bandyopadhyaya and Biplab Chattopadhyay, *Physica C* 390, 120 (2003).
11. Effect of annealing conditions on the physical properties of $Nd_{0.67}Sr_{0.33}MnO_{3-\delta}$, W. Schnelle, Asok Poddar, P. Muruguraj, E. Gmelin, R. K. Kremer, K. Sasaki and J. Maier, *J. Phys: Cond. Matter* 12, 4401 (2000).
12. High field magnetotransport properties of $La_{2/3}Sr_{1/3}MnO_3$ and $Nd_{2/3}Sr_{1/3}MnO_3$ systems, P. Mandal, K. Bärner, L. Haupt, Asok Poddar, R. von Helmolt, AG. M. Jansen and P. Wyder, *Phys. Rev. B* 57, 10256 (1998).
13. Vortex fluctuations in $YBa_2Cu_3O_{6.5}$ single crystal: Evidence for 2D→3D crossover, Asok Poddar, R. Prozorov, Y. Wolfus, M. Ghnovker, B. Ya. Shapiro, A. Shaulov and Y. Yeshurun, *Physica C: Supercondcutivity and its Applications* 282-287 (PART 3), 1299 (1997).
14. Irreversible magnetization in thin YBCO films rotated in external magnetic field, R. Prozorov, Asok Poddar, E. Sheriff, A. Shaulov and Y. Yeshurun, *Physica C* 264, 27 (1996).
15. Thermoelectric power of $Tl_2Ba_2Ca_{1-x}Y_xCu_2O_{8+y}$ (x=0-0.6) samples, S. Keshri, J. B. Mandal, P. Mandal, Asok Poddar, A. N. Das and B. Ghosh, *Phys. Rev* ***B*** 47, 9048 (1993).
16. Thermoelectric power of $Bi_2Sr_2Ca_{1-x}Y_xCu_2O_{8+y}$ (x=0-1.0) samples, J. B. Mandal, S. Keshri, P. Mandal, Asok Poddar, A. N. Das and B. Ghosh, *Phys. Rev. B* 46, 11840 (1992).
17. Effect of carrier concentration on the normal transport properties and the superconducting transition temperature in the $Tl_2Ba_2Ca_{1-x}Y_xCu_2O_{8+y}$ system, Asok Poddar, P. Mandal, A. N. Das, B. Ghosh and P. Choudhury, *Phys. Rev. B* **44**, 2757 (1991).
18. Variation of T_c and transport properties with carrier concentration in Y- and Pb-doped Bi-based superconductors, P. Mandal, Asok Poddar, B. Ghosh and P. Choudhury, *Phys. Rev.* **43**, 13102 (1991).
19. Hall effect of Bi-Sr-Ca-Cu-O and Tl-Ba-Ca-Cu-O systems, P. Mandal, Asok Poddar, A. N. Das, B. Ghosh and P. Choudhury, *Phys. Rev.* ***B*** 40, 730 (1989).
20. Magnetoresistance and thermoelectric power of the Bi-Sr-Ca-Cu-O system, P. Mandal, Asok Poddar, A. N. Das, A. Chakraborty, B. Ghosh, P. Choudhury and S. K. Lahiri, *Phys. Rev. B* 38, 9205 (1988).

SURFACE PHYSICS DIVISION (SPD):

Permanent Members of the Division

Scientific	Technical	Adimistrative/Auxiliary
M. K. Sanyal, Senior. Prof. & Head	Avijit Das, Sc. Officer	Mukul Das, Superintendent
P. Chakraborty, Senior. Prof.	Subir Roy, Sc. Officer	Harendra Nath Jana, Helper
D. Ghose, Senior. Prof.	Sushanta Banerjee, Sc.Officer	Gobardhan Jana, Helper
S. R. Bhattacharyya, Prof.	Souvik Banerjee,Sc.Assistant	
T. K. Chini, Prof.	Gautam SarkarSc. Assistant	
S. Banerjee, Prof.		
M. Mukherjee, Prof.		
S. Kundu, Prof.		
S. Hazra, Prof.		
K. S. R. Menon, Associate Prof.		
S. Bhunia, Associate Prof.		

Post-Doctoral Fellows (2007 onwards)

Mrinmay Kumar Mukhopadhyay, Subarna Mitra, Subhendu Mondal and Sayanee Majumdar

PhD Students (2007 onwards)

Amarjeet Singh, Debi Prasad Datta, Sudeshna Chattopadhyay, Atikur Rahman, Indranil Sarkar, Subhrangshu Mukherjee, Puneet Mishra, Bishwajit Saha, Smita Mukherjee*, Rupak Banerjee, Sirshendu Gayen, Binita Ghosh, Arjun Das, Suman Mondal, A. K. M. Maidul Islam, M. H. Mondal, Jayanta Kumar Bal, Satyaranjan Halder, Nupur Biswas*, Paramita Chatterjee, Sanjay Kumar Mahatha, S. A. Mallick, Abhisakh Sharma, Bishnudas Ghosh, Tanushree Samanta, Pabitra Das, Manjula Sharma, Mrinal Kanti Bera, Santanu Maiti, Amaresh Metya, Jayanta Das, Shyamal Mondal, Anuradha Bhattacharya

(* have joined Applied Material Science Division from 2010)

Major Equipment and Resources in the Division

1. Rotating anode x-ray laboratory for reflectivity and diffuse scattering
2. Versatile x-ray facility for diffraction and scattering
3. Scanning Probe Microscopes (Three)
4. UHV Scanning Probe Microscope
5. XPS-UPS facility
6. Environment SEM facility
7. SQUID magnetometer
8. SIMS facility
9. 200KeV high current Ion implantation facility
10. 30KV Ion accelerator facility
11. Broad beam high current ion etching facility (Installed February, 2010)
12. Molecular Beam Epitaxy (MBE) for Si-Ge
13. Magneto/Optic Transport properties of organic nanostructures
14. Facility for semiconductor characterization (PL, DCXRD, ECV, I-V, C-V, Hall)
15. Cathodoluminescence (CL) microscopy facility (Installed March, 2010)
16. Low energy Nanocluster ion beam facility (Installed May, 2010)
17. Angle Resolved Photoemission system for the development of spintronics materials
18. MOCVD facilty for growing III-V semiconductor nanostructures (to be completed)

Research Activities:

Surface physics division (SPD) is pursuing basic research in the frontline areas of synthesis, characterization and study of physical properties of surfaces and interfaces of ultra thin films and nanomaterials. The molecules situated at the surfaces and interfaces dictate properties of nanomaterials in most cases and the number of these molecules increases as the size of particles gets reduced. Hence physics of surfaces and interfaces is essential to carry out research in nanoscience and nanotechnology. In the last two plan periods (IXth and Xth) SPD has set up some advanced experimental facilities and generated a strong research base in this area through significant funding from Department of Atomic Energy (DAE), keeping in focus the futuristic developments and the fast pace of progress in the fields of nanoscience and surface physics. Faculty members of SPD, with their diversified fields of expertise, work in a unified manner sharing a common interest to understand the role of surfaces and interfaces in nanomaterials. A new Center for Nanoscience and Surface Physics (CENSUP) has been created in SPD to promote national and international scientific exchanges involving cutting-edge research on nanoscience and surface physics.

Important Results:

i) Morphology and structure of surfaces/interfaces – X-ray scattering and Scanning Probe Microscopy studies:

One of our primary research activities is to understand growth mechanism of various nano-structured materials through studies of morphology and structure of grown materials using various x-ray scattering techniques like reflectivity, grazing incidence diffraction and diffuse scattering and using scanning probe microscopy (SPM) techniques. We are also utilizing SPM techniques to investigate elastic properties, chemical changes in thin films and to study wetting property of surfaces and edges. In addition to facilities available in our division, we use various synchrotron and neutron scattering facilities for this purpose. We also use scanning and transmission electron microscopy techniques some times to get additional information.

We use various techniques to grow these films like magnetron sputtering for metallic systems, MBE and MOCVD for semiconductors, spin-coating for polymer and Langmuir-Blodgett growth for organo-metallic systems. For example, we have carried out x-ray scattering study to understand structure and morphology of monolayer of thiol-capped gold nanoparticles on the water surface and associated restructuring when these monolayer films are transferred to a solid substrate by Langmuir techniques. We have also studied formation and ordering of gold-nanoparticles through chemical reaction at the water-toluene interface. We have developed a method to study the swelling dynamics of water soluble polymer films using X-ray and neutron reflectivity techniques. We observed that the dynamics are strongly affected by the interaction of the substrate surface. To understand the driving force behind growth of different initial structures and their evolution with time, and its implication in different properties, especially transport properties and electronic structure, a systematic study has been initiated with Si surface having various passivation. For example, Au on Si shows inter-diffusion dominated growth while Ag on Si shows wetting/dewetting dominated growth.

ii) Modification of surface morphology and properties by ion beam:

Ion implantation is known to be an effective method for improving the surface properties of materials, such as hardness, elastic modulus, and wear and corrosion resistance. The defect generation, solution hardening and precipitate hardening are thought to be the main mechanisms to promote the surface hardening. We are studying the near-surface mechanical properties by a depth-sensing nano-indentation technique. The improved bonding at the interface of the film/substrate by implantation is measured by the scratch test.

We have carried out Ion implantation and sputtering related activities to modify materials properties like ion beam mixing and pattern formation on surfaces. We have shown that an initially rough surface has a profound influence on the ion-beam induced pattern formation. We are investigating the pattern formation with different degrees of pristine surface roughness as a function of ion fluence, angle of ion incidence, substrate rotation and temperature. The data will improve the continuum theories for better understanding of the underlying mechanisms. Nanopatterned structures are thought to provide functional architectures for future opto-electronic devices. With this view in mind, our study concerns the study of luminescence and surface plasmon from nanostructured patterned semiconducting and metallic films/particles grown on such patterned substrate. At present, employing a high resolution scanning electron microscope coupled with a cathodoluminescence (HRSEM-CL) system that allows simultaneous recording of spectroscopic and imaging information with sub micron spatial resolution, the role of nanostructured amorphous silicon phase on the fast electron excitation induced luminescence from ion patterned silicon surface ripples is being investigated. We have also initiated a new program for the production, characterization and investigation of novel properties of deposited nanocluster films.

Another area of research is ‘metal quantum dots in glasses’ for synthesizing novel photonic materials for switching applications. Various metal nanocluster-glass composites that we synthesized by ion implantations have provided significant third-order dielectric susceptibility ($\chi^{(3)}$) in the picosecond time domains. We are employing Z-scan and ARINS techniques for nonlinear optical measurements. Optical nonlinearity has been explained to be due to two-photon absorption in the nanocomposite glasses.

iii) Secondary Ion Mass Spectrometry (SIMS)

MCs_n^+ molecular ions (n = 2,3,. . .) in SIMS offers a significantly higher detection sensitivity compared to MCS^+ ions and has a potential relevance in quantification without the aid of 'standards'. We have recently explored the formation mechanisms of these molecular ion complexes through their emission kinematics and measurement of instantaneous local surface work function changes of the sputter-emission sites. The MCs_n^+-SIMS method has been successfully used for direct compositional analysis of surfaces and interfaces of low-dimensional structures including MBE grown Si/Ge multilayer and $Si_{1-x}Ge_x$ alloy structures.

iv) Electrical and magnetic properties of nano-materials

We have found novel electronic transport properties in conducting polymer (Polypyrrole) nanowires. Low temperature transport study of these nanowires having low electron densities have exhibited characteristics of charge density waves observed in structurally ordered materials. A switching transition to highly conducting state has been observed above a threshold voltage, which can be tuned by changing the diameters of the nanowires and the temperature. Negative differential resistance and enhancement of noise have been observed above the threshold.

Magnetization measurements with conventional low temperature magnetometry and with polarized neutron scattering have been performed on a multilayer stack of noninteracting monolayers of gadolinium ions formed by the LB technique. This system is showing clear signature of two-dimensional ordering of spins.

v) Structure – property correlations at the surfaces of strongly correlated materials

Since 2005, we have initiated a program on the structure-property correlations at the surfaces of strongly correlated materials. Our studies have been focused on the surfaces of oxide materials in the form of single crystals, micro/nano particles and on the epitaxially grown thin films, as well as on low dimensional surfaces and metal/semiconductor surfaces and overlayers. We are interested in studying the surface structure and morphologies, electronic structure and magnetism at the surfaces. We have been employing various tools for studying the surface properties including electron and x-ray spectroscopic techniques, scattering techniques as well as spectro-microscopic techniques. We have been successful in elucidating the electronic structure and magnetic structures and their structural and morphological origins at some of the strongly correlated material surfaces. Interesting new results in the antiferromagnetic domain structures at the surface of Nickel Oxide (NiO) were obtained in a study with the help of x-ray magnetic linear dichroism (XMLD) technique using a Photoemission Electron Microscopy (PEEM) system. The surface electronic structures of low dimensional materials such as Graphite, MoS2 etc are being explored using Angle-resolved Photoemission Spectroscopy (ARPES) along with their surface structural studies.

vi) Electron spectroscopy of novel materials

As surface properties are strongly dependent on the nature of the interaction, understanding of the nature of interaction between the substrate and the polymer chains becomes a key issue. We have developed a state of the art XPS/UPS facility in our lab during 2004 in this direction. Problem comes with the fact that these polymers are insulators and gets charged when exposed to the X-rays. We have developed a novel method namely controlled neutralization technique (CNT) to understand charging and neutralization in polymers. Later we have developed another technique to use this charging to understand structure of organic multi layers. Orientation of polymer chains on a substrate is a direct outcome of polymer substrate interaction. Near Edge X-ray Absorption Fine Structure (NEXAFS) which is a synchrotron based technique is one of the best tools to study the interaction and the orientation of the molecules simultaneously. We are using this technique along with XPS to understand chemical nature of the substrate and the polymer molecules with their mutual interaction

vii) Growth of compound semiconductor nanostructures

We have recently initiated a research program in the areas of semiconductor materials and devices, especially in the area of III-V and II-VI compounds. Particularly, we are interested in epitaxial growth of such compounds and different low dimensional nanostructures using Metalorganic Vapor Phase Epitaxy (MOVPE) system and chemical vapor deposition (CVD) methods, and characterization of these materials using optical and electrical methods. A MOVPE system, aimed at growing Ga-In-Al-As-P system is at its last phase of installation to pursue this research interest. We have also built a CVD system for growing ZnO thin films, nanowires and other type of self organized hierarchical nanostructures. Vertically aligned as well as randomly oriented nanowires of ZnO have been successfully grown by varying the controlling parameters in the CVD process.

List of Publications (2007 – date)

2010

1. Study of neutralization kinetics in charged polymer-metal nanocomposite systems by photoemission spectroscopy, S. Mukherjee and M. Mukherjee, J. Electron Spectrosc. Relat. Phenom. (Spl. issue: Charging Issues in Electron Spectroscopies) 176, 35 (2010).

2. Growth and stability of Langmuir-Blodgett films on OH-, H-, or Br-terminated Si(001), J. K. Bal, S. Kundu and S. Hazra, Phys. Rev. B 81, 045404 (2010).

3. Evolution of interdiffused Gaussian-shape nanolayer in Au-Si(111) system at ambient condition, J. K. Bal and S. Hazra; *Defect Diffus. Forum* **297-301**, 1133 (2010).

4. Correlation between local structure and refractive index of e-beam evaporated (HfO_2-SiO_2) composite thin films, N. C. Das, N. K. Sahoo, D. Bhattacharyya, S. Thakur, N. M. Kamble, D. Nanda, S. Hazra, J. K. Bal, J. F. Lee, Y. L. Tai and C. A. Hsieh; *J. Appl. Phys.* **108**, 023515 (2010).

5. Angle-resolved Photoemission Spectroscopic (ARPES) Facility for Surface Electronic Structure Characterization, S. K. Mahatha and K. S. Menon, Current Science 98, 759 (2010).

6. Effect of self-affine fractal characteristics of surfaces on wetting, S. Sarkar, S. Patra, N. Gayathri and S. Banerjee, Applied Physics Letters 96, 063112 (2010).

7. Anomalous magnetic behavior of CuO nanoparticles, V. Bisht, K. P. Rajeev and S. Banerjee, Solid State Communications 150, 884 (2010).

8. Probing Ar ion induced nanocavities/bubbles in silicon by small-angle x-ray scattering, K. Suresh, M. Ohnuma, Y. Oba, N. Kishimoto, P. Das and T. K. Chini, Journal of Applied Physics 107, 073504 (2010).

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11. Thermal fragmentation of nano-size clusters on surfaces, P. V. Kashtanov, R. Hippler, B. M. Smirnov and S. R. Bhattacharyya, Europhys. Lett. 90, 16001 (2010).

12. Stability of a deposited liquid cluster, P. V. Kashtanov, R. Hippler, B. M. Smirnov and S. R. Bhattacharyya, J. Experimental Theoretical Phys. (JETP) 110, 521 (2010).

13. Electronic structure, optical, and dehydrogenation catalytic study of $(Zn_{1-z}In_z)(O_{1\ x}N_x)$ Solid Solution, Maitri Mapa, Kumarsrinivasan Sivaranjani, Deu S. Bhange, Biswajit Saha, Purushottam Chakraborty, Annamraju Kasi Viswanath, and Chinnakonda S. Gopinath, *Chemistry of Materials* **22**, 565 (2010)

14. Ion Beam Synthesis of Metal_Quantum Dots for Photonic Applications, Binita Ghosh and Purushottam Chakraborty, *Journal of Surface Investigation. X-ray, Synchrotron and Neutron Techniques* **4**, 518 (2010).

15. Anti-Resonant Interferometric Nonlinear Spectroscopy (ARINS) Study of Metal Nanocluster-Glass Composites, Binita Ghosh, Purushottam Chakraborty, B P Singh and T Kundu, *Journal of Physics: Conference Series* **185** 012010 (2009).

16. Effect of Ionic Environment on the Transport of Cesium ion in alkali chloride solutions from Radio Tracer Studies, H Chakrabarti and S Kundu, Accepted, Applied Radiation and Isotopes, June17, 2010, Ref.: ARI5072,

17. A Novel attempt to calculate the velocity correlation coefficients in ternary electrolyte solution", H Chakrabarti and S Kundu, Accepted, Journal of Solution Chemistry, .Ref. JOSL1144R2, April 7, 2010,

18. Strong temperature and substrate effect on ZnO nanorod flower structures in modified chemical vapor condensation growth, S.R. Haldar, A. Nayak, T.K. Chini, and S. Bhunia, Curr. Appl. Phys. 10, 942 (2010)

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20. Surface morphology and composition of films grown by size-selected Cu nanocluster, A. Majumdar, M. Ganeva, D. Koepp, D. Datta, P. Mishra, S. R. Bhattacharyya, D. Ghose and R. Hippler, Vacuum 83, 719 (2009).

21. Negative capacitance in Wigner crystal forming polymer nanowires, A. Rahman and M. K. Sanyal, Appl. Phys. Lett. 94, 242102 (2009).

22. Surface and interfacial structural characterization of MBE grown Si/Ge multilayers, Biswajit Saha, Manjula Sharma, Abhisakh Sarma, Ashutosh Rath, P.V. Satyam, Purushottam Chakraborty, Milan K. Sanyal, Appl Surf Sci. 256, 547 (2009).

23. Growth and melting of silicon supported silver nanocluster films, S. R. Bhattacharyya, D. Datta, I. Shyjumon, B. M. Smirnov, T. K. Chini, D. Ghose and R. Hippler, J. Phys. D: Appl. Phys. 42, 035306 (2009).

24. Production and deposition of energetic metal nanocluster ions of silver on Si substrates, D. Datta, S. R. Bhattacharyya, I. Shyjumon, D. Ghose and R. Hippler, Surf. Coat. Technol. 203, 2452 (2009).

25. Study of thickness dependent density in ultrathin water soluble polymer films, M. H. Mondal, M. Mukherjee, K. Kawashima, K. Nishida and T. Kanaya, Macromolecules 42, 732 (2009).

26. Anti Resonant Interferometric Nonlinear Spectroscopy (ARINS) Study of Metal Nanocluster-Glass Composites, B. Ghosh, P. Chakraborty, B. Singh and T. Kundu, Journal of Physics: Conference Series **185** 012010 (2009).

27. Ripple formation on Silicon by medium-energy ion bombardment, T. K. Chini, D. P. Datta and S. R. Bhattacharyya, J. Phys.: Condensed matter 21, 224004 (2009).

28. Effect of initial target surface roughness on the evolution of ripple topography induced by oxygen sputtering of Al films, P. Mishra and D. Ghose, Journal of Applied Physics 105, 014304 (2009).

29. Morphological evolution of films composed of energetic and size-selected silver nanocluster ions, S. R. Bhattacharyya, D. Datta, T. K. Chini, D. Ghose, I. Shyjumon and R. Hippler, Nucl. Instrum. Meth. in Phys. Res. B 267, 1432 (2009).

30. Photoluminescence from Si : effect of ripple microstructures induced by argon ion irradiation, T. K. Chini, D. P. Datta, U. Luchhesi and A. Muecklich, Surf. Coat. Technol 203, 2690 (2009).

31. Atmospheric pressure induced atomic diffusion into solid crystal, J. K. Bal and S. Hazra, Phys. Rev. B 79, 155405 (2009).

32. Time-evolution growth of Ag nanolayers on differently-passivated Si(001) surfaces, J. K. Bal and S. Hazra, Phys. Rev. B 79, 155412 (2009).

33. Rapid thermal annealing effect on amorphous SiCO:H film deposited by CH4/Ar dielectric barrier discharge plasma: Surface Morphology and Chemical evaluation, A. Majumdar, S. R. Bhattacharyya and R. Hippler, J. Appl. Phys. 105, 094909 (2009).

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35. The use of grazing incidence X-ray scattering techniques to probe chemical reactions at the liquid–liquid interface: the formation and ordering of gold nanoparticles, M. K. Sanyal, Journal of Materials Chemistry 19, 4300 (2009).

36. Electronic Structure and Catalytic Study of Solid Solution of GaN in ZnO, M. Mapa, K. S. Thushara, B. Saha, P. Chakraborty, C. M. Janet, R. P. Viswanath, C. M. Nair, K. Murti and C. S. Gopinath, Chemistry of Materials 21, 2973 (2009).

37. Enhanced Nonlinear Optical Responses in Metal-Glass Nanocomposites, B. Ghosh, P. Chakraborty, B. P. Singh and T. Kundu, Applied Surface Science 256, 389 (2009).

38. Gold Nanoparticles at the Liquid-Liquid Interface: X-ray Study and Monte Carlo Simulation, S. Kubowicz, M. Hartmann, J. Daillant, M. K. Sanyal, V. V. Agrawal, C. Blot, O. Konovalov and H. Mohwald, Langmuir 25, 952 (2009).

39. Ion beam sputtering induced nanostructuring of polycrystalline metal films (Invited Article), D. Ghose, J. Phys.: Condensed Matter. 21, 224001 (2009).

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NAME: Milan Kumar Sanyal (DOB: 6 January 1954)
Ph. D. (1987) University of Bombay

Academic profile :

Prof. Sanyal (MKS) joined the faculty of the Saha Institute of Nuclear Physics (SINP) in 1995. He presently is a Senior Professor and Head of Surface Physics Division. He is also the Director of the institute. He was working as Scientific Officer in Bhabha Atomic Research Centre from 1977 to1995 before joining this institute. MKS did his postdoctoral research in Physics Department of Brookhaven National Laboratory (BNL) as a Research Associate from 1989 to1992.

AWARDS :

- J.C. Bose Fellow
- Fellow, Indian National Science Academy.
- Fellow, Indian Academy Sciences.
- Fellow, The National Academy of Sciences, India.
- Fellow, Asia-Pacific Academy of Materials
- Fellow, West Bengal Academy of Science and Technology, India
- Medal of Material Research Society, India 2000.
- First prize in the Fifth Colloquium for Young Physicists (1987) Indian Physical Society.
- N.S. Satya Murthy memorial Young Scientist award of the Indian Physics Association, 1987.

Essential strength of research / development output

MKS started his research work in the field of grazing incidence scattering of x-rays and neutrons to probe the structure of surfaces and interfaces during his stay in BNL. One of the prime contributions of MKS is to develop basic understanding of specular and diffuse scattering process from a liquid surface (Phys. Rev. Lett. 66, 628 (1991)). The developed formalism and experimental techniques of this paper has been used extensively to study varieties of liquid-vapour and liquid-liquid interfaces and this work is the most cited one in the field of scattering study of liquid surface. He has recently used this technique to probe nanoparticle formation in liquid-liquid interfacial reaction (Phys. Chem. C 112, 1739 (2008)). MKS developed a research group to work in the field of surface physics involving nanomaterials and low dimensional systems in SINP. This research group in SINP has obtained novel results on structure, growth mechanism and properties of metal-organic multilayered films deposited using Langmuir–Blodgett (LB) techniques and of ultrathin polymer films. Another recent finding by MKS is a novel electronic transport property of conducting polymer (Polypyrrole) nanowires. Low temperature transport study of these nanowires having low electron densities have exhibited characteristics of charge density waves (Adv. Mater. 19, 3956 (2007)) observed in structurally ordered materials. MKS and his collaborators have also performed conventional magnetization and polarized neutron scattering measurements on a multilayer stack of gadolinium ions formed by the LB technique to understand two-dimensional magnetic ordering.

Future research/development plan

Prof. Sanyal will continue to work in the fields of surface scattering to understand ordering of various nanomaterials on liquid and solid surfaces. He is also actively involved in structural studies of various semiconductor quantum structures. MKS will continue to work on novel electronic transport properties of organic nanostructures and plans to extend this work in the field of organic photovoltaic systems. His group is also spending considerable amount of time in development of synchrotron based material research in the country. This group have set up a surface scattering and magnetic scattering beamline in INDUS-2 synchrotron at Raja Ramanna Centre for Advanced Technology, Indore, India. They have also set up an “Indian Beamline” in Photon Factory synchrotron, Japan.

List of important publications

1. Small-angle x-ray scattering study of the aggregation of gold nanoparticles during formation at the toluene-water interface, M. K. Bera, M. K. Sanyal, L. Yang, K. Biswas, A. Gibaud and C. N. R. Rao, Physical Review B 81, 115415 (2010).
2. Negative capacitance in Wigner crystal forming polymer nanowires, A. Rahman and M. K. Sanyal, Appl. Phys. Lett. 94, 242102 (2009).
3. Suppression of Mn photoluminescence in ferromagnetic state of Mn-doped ZnS nanocrystals I., Sarkar, M. K. Sanyal, S. Takeyama, S. Kar, H. Hirayama, H. Mino, F. Komori and S. Biswas, Phys. Rev. B 79, 054410 (2009).
4. Nanopattern formation in self-assembled monolayers of thiol-capped Au nanocrystals R. Banerjee, S. Hazra, S. Banerjee and M. K. Sanyal, Phys. Rev. E 80, 056204 (2009).
5. Anomalous effect of biased oscillating field on the switching behaviour: Modulating friction of charge carriers in nanowires, A. Rahman and M. K. Sanyal, EPL 88, 47009 (2009).
6. Formation and ordering of gold nanoparticles at the toluene-water interface M. K. Sanyal, V. V. Agrawal, M. K. Bera, K. Kalyanikutty, J. Daillant, C. Blot, S. Kubowicz, O. Konovalov and C. N. R. Rao, J. Phys. Chem. C 112, 1739 (2008).
7. Reversible buckling in monolayer of gold nanoparticles on water surface M. K. Bera, M. K. Sanyal, S. S. Pal, J. Daillant, A. Datta, G. U. Kulkarni, D. Luzet and O. Konovalov, EPL 78, 56003 (2007).
8. Novel switching transition of resistance observed in conducting polymer nanowires, A. Rahman and M. K. Sanyal, Adv. Mater. 19, 3956 (2007).
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10. Low erosion behaviorof polystyrene films under erbium ion implantation, M. Bhattacharya, M. K. Sanyal, T. K. Chini and P. Chakraborty, Appl. Phys. Lett. 88, 071902 (2006).
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14. Formation of rectifier with gold nanoclusters, S. Pal, M. K. Sanyal, N. S. John and G. U. Kulkarni, Phys. Rev. B 71, 121404(R)(2005).
15. Ripple structure of crystalline layers in ion-beam-induced Si wafers, S. Hazra, T. K. Chini, M. K. Sanyal, J. Grenzer and U. Pietsch, Phys. Rev. B 70, 121307(R) (2004).
16. Transition from two-dimensional to three-dimensional melting in Langmuir-Blodgett films, M. K. Mukhopadhyay, M. K. Sanyal, A. Datta, M. Mukherjee, T. Geue, J. Grenzer and U. Pietsch, Phys. Rev. B 70, 245408 (2004).
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20. Determination of small fluctuations in electron density profiles of thin films : layer formation in polystyrene film, Sanyal, M.K., Basu, J.K., Datta, A. and Banerjee, S., Europhys. Lett. 36, 265 (1996).
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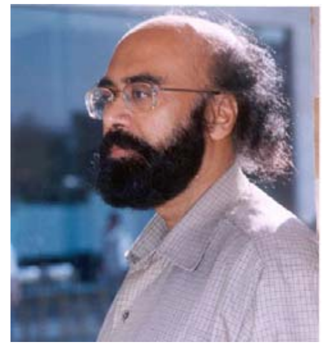
1. **Name**: **Purushottam Chakraborty**

   Qualifications: M.Sc. (Physics), Ph.D. (Calcutta University)



2. **(a) Academic Profile including earlier appointments**:

   Senior Professor 'H' (since Aug 2009), SINP
   Professor 'G' (2005 - 2009), SINP
   Professor 'F' (Aug 2000 – Aug 2005), SINP
   Associate Professor 'E (Feb 1995 – Aug 2000), SINP
   Reader 'D' (Feb 1989 – Jan 1995), SINP
   Lecturer 'C' (Feb 1986 – Jan 1989), SINP
   Scientist 'B' (July 1983 – Jan 1986), SINP
   Ph.D. Fellow, SINP, Kolkata, India (September 1977 to June 1983)

(b) Postdoctoral Visits

Department of Materials, Imperial College, London, **UK** (June 13-22, 2010), Department of Physics, Newcastle University, Newcastle, **Australia** (November-December 2008), Visiting Professor, Osaka Electro-Communication University, Osaka, **Japan** (March 1-31, 2008), Physics Department, University of Pretoria, **South Africa** (2007- 2008), Physics Department, Padova University, **Italy** (1993 – 1994), Universite Laval, Quebec, **Canada** (1994 – 1995), Friedrich-Schiller University, Jena, **Germany**, Bielefeld University, **Germany** (November 1993), Maria Curie Sklodowska University, Lublin, **Poland** and the Polish Academy of Sciences, **Poland** (September 1987), ICTP, **Italy** (June -August 1987), FOM-Institute for Atomic and Molecular Physics, Amsterdam, **Netherlands** (1984-1985)

(c) Selected Awards and Professional Honors

- Appointed as '**Adjunct Honorary Professor of Physics**', University of Pretoria, **South Africa** (2010)
- Delivered an invited talk at the *Special Broadcasting Service (SBS)*, **Sydney Radio**, Australia (November 30, 2008)
- **Elected Fellow**, West Bengal Academy of Science and Technology
- **Most Eminent Mass Spectrometrist of India**, awarded by the Indian Society for Mass Spectrometry (ISMAS) for meritorious and significant contributions in SIMS
- Felicitated with **Gold Medal** by Dr. Anil Kakodkar, Chairman, Atomic Energy Commission, Government of India (January 27, 2003)
- Honorary Member in the Council of the NANOAFNET (Nanosciences African Network) in 2008
- Recipient of the "**Mouat Silver Medal**" of Calcutta University (1988)
- **ICTP Research Fellowship** (1992-94)
- '**Rashbehari Ghose Foreign Travelling Fellowship**' awarded by Calcutta University (1984)
- **'Premchand Roychand Scholarship'** (PRS), awarded by Calcutta University (1979)

(3) Essential strength of research/development output

Essential strength of research comes from my wide experience and expertise in the area of **Atomic Collisions in Solids**; to be precise in '**ion-beam analysis of materials**' in all complexities. Of my earlier works, the most notable was the **design and fabrication of an indigenous SIMS (Secondary Ion Mass Spectroscopy) instrument** during 1978-83 as a part of my Ph.D. work. Broadly, my research encompasses from the 'fundamentals of inelastic ion-surface collisions in sputtering' to the 'applications of SIMS' in elemental/compositional analysis of materials like metallic/semiconductor multilayers, interfacial alloys, quantum wells, self-assembled quantum dots, etc. Recently, we have made significant advances in materials quantification by introducing MCs_n^+ (n=1,2,3…) mode of SIMS analysis that circumvents the 'matrix effect'. We have been successful in understanding the complex formation mechanisms of MCs_n^+ molecular cluster ions and in using MCs_n^+-*SIMS* method for making compositional analysis of quantum structures and interfacial alloys without the aid of calibration standards.

Another major area of my research is the fabrication of '**X-UV mirrors'**, '**optical waveguides'** and '**ion beam induced metal glass nanocomposites**'. **We were amongst the first pioneering groups involved in the fabrication of aspherically curved mirrors for x-uv imaging applications.** Recently, we have synthesized 'metal quantum dots in glasses' by ion implantations and achieved significant nonlinear optical responses (large optical Kerr susceptibility with fastest temporal responses). Our work has remarkable impact on photonic materials for switching applications.

I took a major role in commissioning our new state-of-the-art MBE machine and have prime responsibility in running this facility. I have been one of the principal investigators in working on **Molecular Beam Epitaxy** (MBE) - grown Ge quantum dots, Si/Ge multilayers and $Si_{1-x}Ge_x$ alloys.

(4) Future research/development plan

(a) Complete quantitative chemical analysis of surfaces/interfaces using a combined SNMS-SIMS

In view of performing a complete quantitative chemical analysis of interfaces, major up-gradation of the existing SIMS facility with a combined SIMS-SNMS and ion imaging is under execution. The use of elemental/molecular SNMS signals will allow the absolute depth calibration.

(b) Installation of a 20 keV RHEED gun and Sb/B dopant cells in the existing MBE system.

The upgradation of the existing MBE system with a new complete 20 keV RHEED gun assembly will allow us to monitor RHEED oscillations and electron diffraction patterns characterizing real-time surface crystallography of the growing epitaxial films. Sb and B effusion cells are being assembled in view of elemental boron and antimony doping of MBE Si and SiGe structures for device applications.

(c) Silver diffusion in SiC and pyrolytic graphite at elevated temperature

Work on the PBMR (pebble bed modular reactor) materials concerns the optimization in the design parameters of multilayer-coated HTGR (high temperature gas cooled reactor) nuclear fuel particles through study of diffusion kinematics of fission fragments in SiC and graphite at high temperatures. It is an ongoing collaborative work with the Physics Department, University of Pretoria, South Africa

5. Few Important publications

- Ion Beam Synthesis of Metal-Quantum Dots for Photonic Applications, Binita Ghosh and Purushottam Chakraborty, *Journal of Surface Investigation, X-ray, Synchrotron and Neutron Techniques* ***4**, 518–524 (2010)*
- Enhanced nonlinear optical responses in metal–glass nanocomposites, Binita Ghosh, Purushottam Chakraborty, B.P. Singh, T. Kundu, *Appl Surf Sci* **256**, 389 (2009)
- Surface and interfacial structural characterization of MBE grown Si/Ge multilayers, Biswajit Saha, Manjula Sharma, Abhisakh Sarma, Ashutosh Rath, P.V. Satyam, Purushottam Chakraborty, Milan K. Sanyal, Appl Surf Sci. **256**, 547 (2009)
- Secondary emission of MCs_n^+ molecular ions under the joint influence of electropositive and electronegative elements, Biswajit Saha, Subhendu Sarkar, Purushottam Chakraborty and Hubert Gnaser, *Surface Science* **602**, 1061 (2008)
- Secondary ion mass spectrometry of MCs_n^+ molecular ion complexes, Biswajit Saha and Purushottam Chakraborty, *Nucl. Instrum. Meth. In Phys. Res*. B **258**, 218 (2007)
- Linear and nonlinear optical absorption in copper nanocluster-glass composites, Binita Ghosh, Purushottam Chakraborty, Satyabrata Mahapatra, C. Vijayan, P. Deshmukh and P. Mazzoldi, *Materials Letters* **61**, 4512 (2007)
- Interface-dominated Growth of a metastable novel alloy phase, Subhendu Sarkar, Alokmay Datta, Purushottam Chakraborty and Biswarup Satpati, *Journal of Materials Research* **20**, 2639 (2005)
- Energetics of MCs_n^+ molecular ions emitted from Cs^+ irradiated surfaces, Subhendu Sarkar Purushotam Chakraborty and Hubert Gnaser, *Phys. Rev.* **B 70**, 195427 (2004)
- Ion Beam Analysis of Surfaces and Interfaces of Condensed Matter Systems (*Book*), Ed.: Purushottam Chakraborty, Nova Science publishers, Inc. New York (2002)
- Metal nanoclusters in glasses as nonlinear photonic materials, P. Chakraborty, *J. Mater. Sci.* **33** (1998) 2235
- Interfacial diffusion in a double quantum well structure, S. Sarkar, P. Chakraborty, M. K. Sanyal, B. M. Arora, and F. Caccavale, *Surf. Interface Anal.* **29**, 659 (2000)
- Secondary ion mass spectrometry and near-field studies of Ti: $LiNbO_3$ optical waveguides, F. Caccavale, P. Chakraborty, A. Quaranta, I. Mansour, G. Gianello, S. Bosso, R. Corsini and G. Mussi, *J. Appl. Phys*. **78,** 5345 (1995)
- Chromium diffusion in lithim niobate for active optical waveguides, J. M. Almeida, G. Boyle, A.P. Leite, R.M. De La Rue, C.N. Ironside, F. Caccavale, P. Chakraborty and I. Mansour, *J. Appl. Phys*. **78,** 2193 (1995).
- Layered Synthetic Microstructures as Optical elements for the Extreme Ultraviolet and Soft X-rays, Purushottam Chakraborty, *International Journal of Modern Physics* **B 5** 2133 (1991)
- Automatic e-beam deposition of multilayer soft x-ray coatings with laterally graded d-spacings, M. P. Bruijn, P. Chakraborty, H. van Essen, J. Verhoeven and M. J. van der Wiel, O*ptical Engineering* **25,** 916 (1986)

1. **Name: Debabrata Ghose**

2. **Present Position:** Senior Professor 'H'
3. **Academic qualification:** Ph.D. in Physics, University of Calcutta (1984)

4. **Earlier appointments:**

Sl. #	Designation	Years spent
1.	Scientist 'B'	1983 - 1986
2.	Lecturer 'C'	1986 - 1990
3.	Reader 'D'	1990 - 1995
4.	Associate Professor 'E'	1995 - 2000
5.	Professor 'F'	2000 - 2005
6.	Professor 'G'	2005 - 2009
7.	Senior Professor 'H'	2009 - ....

5. **Essential strength of research/development output:**

Over the past years we have studied various phenomena related to energetic ion bombardment of solids. Some of the important highlights are described below.

Formation of self-organized nanoscale pattern has potential applications in electronic, magnetic and optical devices fabrication. Ion beam sputtering of materials is a top down process where morphology can spontaneously develop with well-ordered periodicity over a large area of the surface. We are the first to report periodic ripple structure formation on polycrystalline metal films by grazing incidence sputtering. The critical angles of ripple rotation were experimentally measured for a number of ion-target combinations. It was shown that the initial surface roughness can accelerate the ripple formation via the activation of shadowing instability.

It is known that ion beam implantation modifies the near surface mechanical properties, especially, hardness and elastic modulus. This we have measured by nanoindentation technique for Cr^+ implanted Si and O_2^+ implanted Al film. We also noted that the friction coefficient changes dramatically due to ion bombardment.

The bombardment induced light emission set-up was developed to study the oxygen dependence of the yield of excited sputtered species such as the transient phenomena from elemental metals and alloys as well as from semiconductor surfaces. It was shown that Fe was preferentially oxidized than Ni in the FeNi surface under oxygen environment.

In the studies of slow multiply charged ion – surface interaction phenomena, we provided new experimental data of potential electron emission from Al and Cu single crystal targets. In another experiment, we measured the potential sputtering of Ar^{q+}-Pt thin film combination. The data substantiate the Coulomb explosion model of sputtering.

6. Future research/development plan:

(i) Formation and characterization of Si nanodots using broad-beam high current ion source.

(ii) Synthesis of Si-nanocrystals (NCs) and Ge-NCs using the negative ion implanter as these NCs are thought to be the promising light emitting sources.

(iii) Studies of refractory metal silicides and SiGe alloys formed by direct Si ion implantation into Ta and Ge single crystals, respectively.

7. List of recent publications:

1) IBS nanostructuring of thin polycrystalline metal films (Invited Article)
   - D. Ghose, *J. Phys: Condensed Matter.* **21**, 224001 (2009).
2) Formation and characterization of perpendicular mode Si ripples by glancing angle O_2^+ sputtering at room temperature
   - S. A. Mollick and D. Ghose, *J. Appl. Phys.* **106**, 044309 (2009).
3) Effect of initial target surface roughness on the evolution of ripple topography induced by oxygen sputtering of Al films
   - P. Mishra and D. Ghose, *J. Appl. Phys.* **105**, 014304 (2009).
4) The rotation of ripple-pattern in ion sputtered thin metal films
   - P. Mishra and D. Ghose, *J. Appl. Phys.* **104**, 094305 (2008).
   - Nanoindentation of single-crystal Si modified by 100 keV Cr^+ implantation - P. Mishra, S. R. Bhattacharyya and D. Ghose , *Nucl. Instrum. and Meth. B* **266**, 1629 (2008).
   - The energy dependence of sputtering induced ripple topography in Al film - P. Mishra and D. Ghose, *Nucl. Instrum. and Meth. B* **266**, 1635 (2008).
5) Role of initial surface roughness on ion induced surface morphology
   - P. Karmakar, S. A. Mollick, D. Ghose and A. Chakrabarti, *Appl. Phys. Lett.* **93**, 103102 (2008).
6) Formation of nanoripples in Al films during O_2^+ sputtering
   - P. Mishra and D. Ghose, *Phys. Rev. B* **74**, 155427 (2006).
7) The hardness study of oxygen implanted aluminium thin films
   - P. Mishra and D. Ghose, *Surface & Coatings Technology* **201**, 965 (2006).
10) Electrical characterization of oxygen-induced nanosized ripples on aluminium thin films by conductive atomic force microscopy
   - P. Mishra, P. Karmakar and D. Ghose, *Nucl. Instrum. and Meth. B* **243**, 16 (2006).

Name Dr. Sangam Banerjee
PhD from: Indian Institute of Science,Bangalore
Year of PhD: 1993
Joined Institute: August 1997
Joined Institute: As lecturer "C"
Promoted to D: August 1999
Promoted to E: August 2003
Promoted to F: February 2007
No. publication in refereed journal : Seventy five (**75**)
Articles in Conference Proceedings: Twenty one (**21**)
Articles in Books: Two (**2**)

Areas of research:

- ***Development of** new analysis schemes for grazing incidence x-ray reflectivity.* And, use these schemes on real system to understand the growth kinetic study of these material (ultra thin films).
- ***SPM beyond topography*** :Developing new scanning probe microscopic (SPM) technique to *use SPM beyond topography* such as: elastic measurement, chemical changes, fabrication of nano-structures, electrical and magnetic measurements at nano-scales.
- ***Electrical and magnetic properties of nano-materials*** such as dilute magnetic system (DMS), graphene etc. and metallic alloys and transition metal oxides
- ***Magnetocaloric Effect (MCE)*** of certain rare earth intermetallic compounds and manganates based compounds.
- ***Nano-bio Sensors*** some preliminary work on magnetic property of Ferretin has be reported and some preliminary work on non-enzymatic base glucose sensors are being developed

Talks delivered in International Conference/Workshop/Schools- 9
Invited talk and courses in National workshops and conferences: 22
Invited Seminars Abroad: 18
Organisational work: Organized and ***Convener*** for NN DasGupta memorial workshop on microscopic technique (Sept. 19^{th} – 22^{nd}, 2000, SINP) organized by Microscopic Society of India.
Academic award & Honours:

- **Chairing Sessions in International Workshop:** European Material Research Society 2003 Spring Meeting, Strasbourg (France) June 10-13, 2003. Symposium M
- **Scientific committee member in International Conferce:** European - Material Research Society (E-MRS 2005, May 31—June 3) Symposium P.
- **Nominated for Theoretical Physics Seminar Circuit (TPSC) – 2002 –2003, Category B – Senior Faculty**
- **Invited and participated as a Judge for promotion case of a faculty (Asst. Prof.) in Montpellier University, France- *February 2001***
- ***Japan Science and Technology Agencies Fellowship (STA, Japan) 1999***

Out of 75 papers published only some 25 selected publications in international refereed Journals is below:

1. *Effect of self-affine fractal characteristics of surfaces on wetting,* S. Sarkar, S. Patra, N. Gayathri and **S. Banerjee**, *Applied Physics Letters* **96**, 063112 (2010).

2. *Magnetocaloric properties of nanocrystalline* $La_{0.125}Ca_{0.875}MnO_3$, A. Biswas, T. Samanta, **S. Banerjee**, and I. Das, *Appl. Phys. Lett.* ***94**, 233109 (2009)*

3. *Change in the room temperature magnetic property of ZnO upon Mn doping,* **S. Banerjee**, K. Rajendran, N. Gayathri, M. Sardar, S. Senthilkumar and V. Sengodan*., Journal of Applied Physics* **104**, 043913 (2008)

4. *Electronic Properties of Nano-graphene Sheets Calculated using Quantum Chemical DFT,* **S. Banerjee** and D. Bhattacharyya, *Computational Material Science* **44** 41–45 (2008)

5. *Enhancement of ferromagnetism upon thermal annealing in pure ZnO,* **S. Banerjee**, M Mandal, N. Gayathri and M. Sardar. *Appl. Phys. Lett.* ***91****, 182501 (2007)*

6. *Magnetocaloric effect in Ho5Pd2: Evidence of large cooling power* T. Samanta, I. Das, and **S. Banerjee**, *Appl. Phys. Lett.* ***91****, 082511 (2007)*

7. *Imaging distribution of local stiffness over surfaces using atomic force acoustic microscopy,* **S. Banerjee,** N. Gayathri, S. R. Shannigrahi, S. Dash, A. K. Tyagi and B. Raj, *J. Phys. D: Appl. Phys.* **40**(8), 2539 (2007).

8. *Detecting onset of chain scission and crosslinking of γ-ray irradiated elastomer surfaces using frictional force microscopy* **S. Banerjee,** N. K. Sinha, N. Gayathri, D. Ponraju, A. K. Tyagi and B. Raj, *J. Phys. D: Appl. Phys.* **40**(3), 834 (2007).

9. *Physics and chemistry of photocatalytic titanium dioxide: Visualization of bactericidal activity using atomic force microscopy,* **S. Banerjee**, Judy Gopal, P. Muraleedharan, A. K. Tyagi1 and Baldev Raj, *Current Science,* ***90****(10), 1378 (2006)*

10. *Enhanced conductivity in graphene layers and at their edges,* **S. Banerjee**, M. Sardar, N. Gayathri, A. K. Tyagi, and Baldev Raj, *Applied Physics Letters* ***88****, 062111 (2006)*

11. *Conductivity landscape of highly oriented pyrolytic graphite surfaces containing ribbons and edges,* **S. Banerjee**, M. Sardar, N. Gayathri, A. K. Tyagi, and Baldev Raj, *Physical Review B* ***72****, 075418 (2005)*

12. *A comparative study of contact resonance imaging using atomic force microscopy,* **S. Banerjee**, N. Gayathri, S. Dash, A. K. Tyagi, and Baldev Raj *Applied Physics letters,* ***86,*** *211913 (2005)*

13. *Layering of ultrathin SiO_2 film and Study of its growth kinetic,* N. Gayathri and **S. Banerjee**

Applied Physics letters, ***84****(25) 5192 (2004)*

14 *Growth kinetic study of sputter deposition: Ag on Si/SiO_2,* **S. Banerjee** and S. Kundu *Surface Science* ***537****, 153 (2003)*

15. *Point contact spectroscopy of $Al_{70}Pd_{30-x}Mn_x$ quasicrystals,* Gayathri N, **S. Banerjee** and R. Goswami, *J. Phys. C: condensed Matter* ***15****, 2317-2326 (2003)*

16. *Evidence of swelling of SiO_2 on thermal annealing,* **S. Banerjee**, S. Chakraborty and P. T. Lai

*Appl. Phys. Letts ,****80****(17), 3075 (2002)*

17 *Study on the effect of plasma treatment on TiN films in N_2/H_2 atmosphere using x-ray reflectivity and secondary ion mass spectroscopy,* **S. Banerjee**, A. Gibaud, D. Chateigner, S. Ferrari, C.Wiemer and D.T. Dekadjevi *Appl. Phys. Letts ,****80****(3), 512 (2002)*

18. *Study of Ag porous film using x-ray reflectivity and pattern formation using Atomic Force Microscope* **S. Banerjee**, S. Mukherjee and S. Kundu *Eur. Phys. J.: App. Phys.* ***17****(2), 99 (2002)*

19. *Friction induced microstructure growth* S.Pal and **S. Banerjee** *J. Phys.-D:,Appl. Phys,* ***34****, 253 (2001)*

20. *Study of interdiffusion in thin Fe film deposited on Si(111) by x-ray reflectivity and secondary ion mass spectrometry* **S. Banerjee**, G. Raghavan and M. K. Sanyal, *J. Appl. Phys.* ***85****(10) 7135 (1999)*

21. *Effect of oxidation process on the interface roughness of gate oxides on silicon x-ray reflectivity study* **S.Banerjee**, Y.J.Park, D.R.Lee, Y.H.Jeong , K.B.Lee, S.B.Yoon and W.J.Cho, *Appl. Phys. Lett.* ***72*** *(4), 433 (1998)*

22. *X-ray reflectivity study of Ge-Si-Ge Films* **S Banerjee**, M K Sanyal , A Datta , S. Kanakaraju and S.Mohan

Phys. Rev. B ***54****, 16377 (1996)*

23. *Structural and electrical transport properties of Al-Cu-Cr quasicrystals* **S Banerjee**, R Goswami, K Chattopadhyay and A K Raychaudhuri, *Phys. Rev B* ***52*** *(5) 3220 (1995)*

24. *Low temperature magnetoresistance of □ - phase $Fe_xNi_{80-x}Cr_{20}$ near the critical composition for ferromagnetism,* **S Banerjee** and A K Raychaudhuri, *Phys. Rev B* ***52*** *(5) 3453 (1995)*

25. *A phase-sensitive superhetrodyne ultrasonic spectrometer,* **S Banerjee**, M K Gunusekaran and A K Raychaudhuri, *Meas. Sci. Technol. 1 , 505 (1990)*

1) Name Satyaranjan Bhattacharyya

Educational background

:(i) B.Sc. (Honours) (Bacheler) degree in Physics from the University of Calcutta (1980)

(ii) M.Sc.(Postgraduate or Master) degree in Pure Physics from the University of Calcutta (1982)

:(iii) Post M.Sc. Associateship Course (1983-84) of Saha Institute of Nuclear Physics, Calcutta, India.

:(iv) Ph.D. in Physics from the University of Calcutta (1993) for the thesis entitled *Studies on topographical modifications of solid surfaces due to energetic ion bombardment*

2) Academic Profile (Earlier appointments, Academic Assignments, Awards)

a) Earlier Appointments

(i) Lecturer ‘C’, Saha Institute of Nuclear Physics (1996-98)
(ii) Reader ‘D’, Saha Institute of Nuclear Physics (1998-2002)
(iii) Associate Professor ‘E’, Saha Institute of Nuclear Physics (2002-06)
(iv) Professor ‘F’, Saha Institute of Nuclear Physics (2006-09)
(v) Professor ‘G’, Saha Institute of Nuclear Physics (2009 - to date)

b) Academic Assignments

(i) Post Doctoral Research Associate, Saha Institute of Nuclear Physics (1993-95)

(ii) Post Doctoral Fellow, Physics Dept., University of Bielefeld, Germany (1995-96)

(iii) Nominated scientist from India in the INSA-DFG Exchange Programme, deputed for a visit to Institut für Physik, Universität Greifswald, Germany for three months (1999-2000)

(iv) Visiting Scientist in Max-Planck Institute for Plasmaphysics, EURATOM Association, Munich (Garching), Germany for three months (2005-06)

(v) Nominated scientist from India in the INSA-DFG Exchange Programme, deputed for a visit to Hahn-Meitner-Institute, Berlin, Germany for three months (2005-06)

c) Awards

(i) Obtained Premchand-Raychand Scholarship (P.R.S) (1987) in Science and the Mouat Medal of the University of Calcutta.

(ii) Obtained a certificate of merit for the best oral presentation of a paper in the Symposium on Crystal Growth, Solution and Morphology held in Jan. 8-9, 1990, Anna University, Madras, India.

(iii) Awarded (as Principal/Project Investigator) the approval from DST, India for Joint Research Project entitled “*Nanostructuring surfaces by ion sandblasting*” under Indo-Italian Program of Cooperation in Science and Technology for 2002.

3. Essential strength of research/development output

The researches that are undertaken mainly fall in the ion-solid interaction studies. The following topics of the studies have been carried out.

1. Energy dependence of sputtering yields of GaAs bombarded by mass analysed $^{40}Ar^{+}$, $^{84}Kr^{+}$ and $^{132}Xe^{+}$ ions. This work showed that spike effect in sputtering has a projectile dependent component apart from energy dependence as proved for higher masses projectiles. This investigation is considered as one of the pioneering works for spike effect of sputtering for

compound semiconductors. (A detailed discussion on this aspect is found in a work by J.B. Malherbe, CRC Crit. Rev. Solid State & Materials Sci. vol. 19(2) (1994) p.55)

2. Surface morphology studied for metals, semiconductors and insulator (glasses) bombarded by energetic ions (keV range). Cone formation on metals for normal incidence and ripple formation on Si, GaAs and glasses for oblique incidence. Energy dependent wavelength of nanoscale ripples has been predicted. Ion beam mixing and interface alloying of thin films have been studied using medium energy keV ions of inert gases.

3. Light emission from ion bombarded solid surfaces was studied for metals, semiconductors and insulators. Relative sputtering and desorption yields were measured from Si surfaces under polyatomic and highly charged ions respectively.

Apart from these researches, I was involved in one of the biggest projects of SINP namely, *High Current Isotope Separator and Ion Implanter* in 9th five-year plan. In 11th five-year plan, a sub-project (*Low Energy Nanocluster Ion beam facility for novel film deposition and characterization*) under CENSUP has been executed in my leadership.

4. Future research/development plan

Currently we are involved in a new emerging field of investigating novel properties of nanoclusters and of the films composed by nanoclusters deposition. We are particularly interested in morphology, composition, structure and properties like thermodynamic, magnetic etc. of nanoclusters to be deposited using our newly installed system. In this respect we have already started strong collaborations with theoreticians and experimentalists of world's leading groups in this filed and got interesting results depicted in our recent publications.

5. List of important publications starting with recent publications

1. P.V. Kashtanov, R. Hippler, B.M. Smirnov and S.R. Bhattacharyya, "Thermal fragmentation of nano-size clusters on surfaces", *Europhysics Lett.* **90**, 16001 (2010).
2. S. R. Bhattacharyya, D. Datta, I. Shyjumon, B. M. Smirnov, T. K. Chini, D. Ghose and R. Hippler, "Growth and melting of silicon supported silver nanocluster films", *J. Phys. D: Appl. Phys.* **42**, 035306 (2009).
3. T. K. Chini, D. P. Datta and S. R. Bhattacharyya, "Ripple formation on Silicon by medium-energy ion bombardment", *J. Phys.: Condensed matter* **21**, 224004 (2009).
4. D. Datta and S. R. Bhattacharyya, "Ion beam induced mixing of co-sputtered Au-Ni films analysed by Rutherford backscattering spectrometry", *Appl. Surf. Sci.* **255**, 2075 (2008).
5. C. Linsmeier, K. Ertl, J. Roth, A. Wiltner, K. Schmid, F. Kost, S. R. Bhattacharyya, M. Baldwin and R. P. Doerner, "Binary beryllium–tungsten mixed materials", *J. Nucl. Mater.* **363-365**, 1129 (2007).
6. J. Deiwiks, G. Schiwietz, S. R. Bhattacharyya, G. Xiao and R. Hippler, "Evidence for enhanced desorption of hydrogen atoms from a Si(100) surface induced by slow highly-charged ions", *Nucl. Instrum. and Meth. B* **248**, 253 (2006)
7. A. Toma, F. B. De Mongeot, R. Buzio, G. Firpo, S. R. Bhattacharyya, C. Boragno and U. Valbusa, "Ion beam erosion of amorphous materials: evolution of surface morphology", *Nucl. Instr. and Meth. B* **230**, 551 (2005)
8. T. K. Chini, M. K. Sanyal and S. R. Bhattacharyya, "Energy dependent wavelength of the ion induced nanoscale ripple", *Phys. Rev. B* **66**, 153404 (2002)
9. S.R. Bhattacharyya, U. Brinkmann and R. Hippler, "Investigation of relative sputtering yields from ionoluminescence of Si", *Appl. Surf. Sci.* **150,** 107 (1999)
10. S.R. Bhattacharyya, D. Ghose and D. Basu, "Mass and energy dependence of the sputtering yield of Gallium Arsenide", *Nucl. Instr. & Meth. B* **47**, 253(1990)
11. S.R. Bhattacharya, D. Ghose, D. Basu and S.B. Karmohapatro, "Surface topography of Ar^+ bombarded GaAs(100) at various Temperatures", *J. Vac. Sci. & Technol. A* **5**, 179 (1987)

1) **Name :** Tapas Kumar Chini

Educational background :

- Passed B. Sc. (Honours in Physics) (Bachelor) degree in Physics from the University of Calcutta (1980-1983).
- Obtained M. Sc. (Postgraduate or Master) degree in Physics from the University of Calcutta (1983-1985).
- Obtained Ph. D. degree in Physics from the University of Calcutta (1994) for the thesis entitled "*Studies on the Ion impact phenomena in solids*".

2) **Academic profile :**

- **Academic assignments (Post Doctoral / Visiting position/ Awards etc.)**

Sl. #	Position / Award	Univ. / Inst.	Period	
			From	To
(i)	Awarded MONBUSHO Scholarship	Nagoya Institute of Technology, Nagoya, Japan	October ' 1993	March ' 1995
(ii)	Postdoctoral Fellow	Saha Institute of Nuclear Physics, Calcutta	June ' 1995	July ' 1997
(iii)	Postdoctoral Fellow	University of Houston, USA	August ' 1997	December ' 1997
(iv)	Senior Postdoctoral Fellow	Institute of Physics, Bhubaneswar	April ' 1998	March ' 2000
(v)	Awarded AIEJ (Japan) Research Scholarship	Nagoya Institute of Technology, Nagoya, Japan	December ' 2001	March '2002
(vi)	Visiting Scientist	Universidad Carlos III De Madrid, Spain	November 1 ' 2005	November 30 ' 2005
(vii)	Guest Scientist	Institute of Ion Beam Physics and Materials Research, FZR, Germany	December 1 ' 2005	March 31 ' 2005

- **Earlier Appointments :**

a) Reader 'D' in Saha Inst. Nucl. Phys. (March 21, 2000 to January 31, 2003).
b) Associate Professor 'E' in Saha Inst. Nucl. Phys. (February 1, 2003 to January 31, 2007).
c) Professor 'F' in Saha Inst. Nucl. Phys. (February 1, 2007 to January 31, 2010).
d) Professor 'G' in Saha Inst. Nucl. Phys. (February 1, 2010 to till date)

3) **Essential strength of research / development output :**

Studies on the physical synthesis of low dimensional novel surface and interfaces of semiconductor material (mainly silicon) is one aspect of our research. The other aspect relates the search for a structure-physical property relation based on the knowledge obtained after detail morphological, structural and compositional analysis using electron microscopy and scanning probe microscopy. With this view in mind, our first kind of studies involve the experimental investigation of dynamics and microstructure of ion-beam induced ripple pattern growth on silicon surface using medium energy inert gas ion beam. From the fundamental point of view, our studies on ion-beam induced nanoscale patterning have impact onto many fields, from nonequilibrium Physics to Applied Mathematics. From technological point of view, the ability of tuning the pattern morphology by varying the ion beam parameters has opened up the possibility of using such patterned surface as a template for growing new electro-optic and magnetic devices or in the application of nanofluidic systems and in Biotechnology. In the second kind of experiment, we demonstrate porous like light (visible, ultraviolet and infrared) emitting behaviour from such ion-induced ripple patterned amorphous silicon when excited by photon or electron beam, i.e., observation of photoluminescence (PL) or cathodoluminescence (CL) and this initiates a possibility of establishing a structure physical property relation of the system we are using.

4) Future research plan :

Nanopatterned structures are thought to provide functional architectures for future opto-electronic devices but the challenge lies in analysing the local electronic defects arising out from various kinds of defects or imperfections in the crystal structure with very high spatial resolution. In our future research plan, we will basically concentrate on establishing a structure – physical property correlation which in the present case concerns the study of luminescence and surface plasmon from nanostructerd patterned semiconducting and metallic systems. The scanning electron microscope (SEM) has versatile capability because the interaction of a focused nm size electron beam with a specimen can be monitored in a variety of ways, allowing topographical, chemical, optical and electrical information to be obtained at a high spatial resolution. Cathodoluminescence (CL) within a high resolution (HR) SEM are among the most versatile and widely used techniques for electronic materials characterisation. The site specific spectroscopy and imaging data obtained from CL technique will be valuable to develop our understanding of local electronic structure in mesoscopic length scale.

5) List of important publications starting with recent publications :

i) K. Suresh, M. Ohnuma, Y. Oba, N. Kishimoto, P. Das, T. K. Chini, "Probing Ar ion induced nanocavities/bubbles in silicon by small angle x-ray scattering", *J. Apl. Phys.* **107** (2010) 073504.

ii) T. K. Chini, D. P. Datta, S. R. Bhattacharyya, "Ripple formation on Silicon by medium energy ion bombardment", *J. Phys.: Cond. Matter* **21** (2009) 224004.

iii) T. K. Chini, D. P. Datta, S. Facsko, A. Mücklich, "Room temperature photoluminescence from the amorphous Si structure generated under keV Ar-ion-induced surface rippling condition", *Appl. Phys. Lett.* **92**, (2008) 101919.

iv) D. P. Datta and T. K. Chini, "Coarsening of ion-beam-induced surface ripple in Si: Nonlinear effect vs. geometrical shadowing", *Phys. Rev B* **76** (2007) 075323.

v) D. P. Datta and T. K. Chini, "Spatial distribution of Ar on the Ar-ion-induced rippled surface of Si", *Phys. Rev B* **71** (2005) 235308.

vi) D. P. Datta and T. K. Chini "Atomic force microscopy study of 60-keV Ar-ion-induced ripple paterns on Si(100)", *Phys. Rev B* **69** (2004) 235313

vii) S. Hazra, T. K. Chini, M. K. Sanyal, J. Grenzer and U. Pietsch, "Ripple structure of crystalline layers in ion beam induced Si wafers", *Phys. Rev B* **70** (2004) 121307(R) .

viii) T. K. Chini, F. Okuyama, M. Tanemura, and K. Nordlund "Structural investigation of Ar-ion-induced surface ripples in Si by cross-sectional transmission electron microscopy", *Phys. Rev B* **67** (2003) 205403.

xi) T. K. Chini, M. K. Sanyal, and S. R. Bhattacharyya, "Energy dependent wavelength of the ion induced nanoscale ripple", *Phys. Rev B* **66** (2002) 153404.

NAME **SATYAJIT HAZRA**

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URL http://www.saha.ac.in/surf/satyajit.hazra
Phone 91 33 2337 5346 (ext: 4219)
DoB 10 December, 1967

EDUCATIONS

1996: Ph.D. in Science, Jadavpur University
1990: M.Sc. in Physics, University of Calcutta; 1st class
1988: B.Sc. with Hons. in Physics, University of Calcutta; 1st class
1985: H.S. in Science, WBCHSE; 1st division
1983: Madhyamik, WBBSE; 1st division

RESEARCH POSITIONS

2007- ….. : Professor F, Saha Institute of Nuclear Physics
2004-2007: Associate Professor E, Saha Institute of Nuclear Physics
2000-2004: Reader D, Saha Institute of Nuclear Physics
1998-2000: Postdoctoral Fellow, Universite du Maine, Le Mans, France
1997-1998: Postdoctoral Fellow, Saha Institute of Nuclear Physics
1992-1997: Research Fellow, Indian Association for the Cultivation of Science

HONOURS

Delegation member for Indo-US Workshop on Nanotechnology, USA, Nov. 2001
National Merit Scholarship by University of Calcutta on the basis of B.Sc. result

PUBLICATIONS

Journals: 47 [Total citation: 524, Average citation: 11, *h*-index: 13; for details see http://www.saha.ac.in/surf/satyajit.hazra/cite.htm]
Conference: 37; Chapter of Books: 2; Others: 2

SELECTED PUBLICATIONS

Growth and stability of Langmuir-Blodgett films on OH-, H-, or Br-terminated Si(001),
J. K. Bal, S. Kundu and **S. Hazra**; *Phys. Rev. B* **81**, 045404 (2010).

Nanopattern formation in self-assembled monolayers of thiol-capped Au nanocrystals,
R. Banerjee, **S. Hazra**, S. Banerjee and M. K. Sanyal; *Phys. Rev. E* **80**, 056204 (2009).

Time-evolution growth of Ag nanolayers on differently-passivated Si(001) surfaces,
J. K. Bal and **S. Hazra**; *Phys. Rev. B* **79**, 155412 (2009).

Atmospheric pressure induced atomic diffusion into solid crystal,
J. K. Bal and **S. Hazra**; *Phys. Rev. B* **79**, 155405 (2009).

Interfacial role in room-temperature diffusion of Au into Si substrates,
J. K. Bal and **S. Hazra**; *Phys. Rev. B* **75**, 205411 (2007).

Effect of metal ions on monolayer collapses,
S. Kundu, A. Datta and **S. Hazra**; *Langmuir* **21**, 5894 (2005).

Ripple structure of crystalline layers in ion beam induced Si wafers,
S. Hazra, T. K. Chini, M. K. Sanyal, et. al; *Phys. Rev. B* **70**, 121307(R) (2004).

Tunable absorption of Au-Al_2O_3 nanoceramic thin films and its morphology,
S. Hazra, A. Gibaud and C. Sella; *Appl. Phys. Lett.* **85**, 395 (2004).

Particle layering in the ceramic-metal thin film Pt-Al_2O_3,
A. Gibaud, **S. Hazra**, C. Sella, et. al; *Phys. Rev. B* **63**, 193407 (2001).

Growth mechanism of Langmuir-Blodgett films,
J. K. Basu, **S. Hazra** and M. K. Sanyal; *Phys. Rev. Lett.* **82**, 4675 (1999).

Properties of unconventional lithium bismuthate glasses,
S. Hazra, S. Mandal and A. Ghosh; *Phys. Rev. B* **56**, 8021 (1997).

Structure and properties of nonconventional glasses in the binary bismuth cuprate system,
S. Hazra and A. Ghosh; *Phys. Rev. B* **51**, 851 (1995).

HIGHLIGHTS OF RESEARCH/ DEVELOPMENT OUTPUT

- Understanding of ***interfacial dynamics and its effect on nanolayer*** using **GIXS** and **SPM** techniques.
  - Si surface passivated or terminated differently, shows interesting behavior towards nanolayer.
    - When nanolayer is made of **Au**, which ***reacts easily*** with Si, then ***openness and blocking*** (due to growth of native oxide layer) nature of passivated Si surfaces ***control the interdiffusion***. Formation and movement of interdiffused nanolayer at room temperature is a clear signature of ***atmospheric pressure induced atomic diffusion into solid crystal*** and provides unique ***concept of inherent pressure inside a crystal structure***. Such diffusion also depends on the crystal structure and ***freeness*** of the diffusing atoms.
    - When nanolayer is made of **Ag**, which ***form sharp interface*** with Si, then ***surface free energy, surface mobility, and surface instability*** of the passivated Si surfaces ***govern and control the growth and evolution of wetted-dewetted structures*** of Ag on Si with or without epitaxy.
    - When nanolayer is made of **Cu**, then the passivated Si surface and its dynamics ***control both the interdiffusion and the wetting-dewetting behavior***.
    - When nanolayer is made of **metal-organic molecules**, which have ***hydrophilic headgroups and hydrophobic tails***, then ***hydrophilic, hydrophobic or coexisting nature*** of the terminated Si surfaces ***control the structure*** of the **Langmuir-Blodgett** films.
- Understanding of the ***growth mechanism*** of *Langmuir-Blodgett films* and lay out a way in which its *head-group* can be ***manipulated***.
- Shown the ***effect of metal-ions*** on *monolayer collapse* and proposed the ***growth mechanism*** of *collapsing Langmuir monolayer*.
- Demonstration of ***underlying ripple-like modulation*** in *ion-beam modified Si surface* using nondestructive **GIXD** technique and its ***correlation with top surface*** as reviled by AFM.
- Determination of ***morphology*** of **nanocermet** films using **GISAXS** (laboratory and synchrotron sources), and observation of ***substrate induced layering*** and ***cumulative disordered structure***. Demonstration of ***linear dependence of absorption peak position with volume fraction of metal*** in nanocermet films.
- ***Formation*** of *unconventional glassy systems,* determination of their ***structure*** and ***physical properties***.

o Development of complementary expertise namely **SPM** for imaging top surface in ***real space*** and **GIXS** for mapping surface and interfaces in ***reciprocal space***. This has been done by setting up **ambient SPM** first, then **VT-UHV-SPM** after gathering experience. While working with GIXS here as well as in different synchrotron facilities not only helped in setting up **versatile XRD** here but also helped to develop **SINP beamline** in INDUS-2 synchrotron source.

FUTURE RESEARCH/ DEVELOPMENT PLAN

- Understanding the role of ***interfacial interaction*** *in the growth of* **organic-inorganic mesostructured films** by the process known as ***evaporation induced self-assembly*** **(EISA)**. Growth of ***one dimensional objects*** on such mesostructured templates. Study of ***individual and collective properties***, with emphasis on ***transport*** (both conventional and local) and ***optical*** properties, of such interesting nanoobjects to find out and/or to test **basic physics of low dimensional systems**.
- Controlling the ***self-organization and electronic properties*** of **molecular and macromolecular systems** on surfaces is among the most challenging quests of **molecular and organic electronics**. To date, **STM** and its spectroscopic mode, **STS** in clean environment and control temperature are the major tools to study various molecular systems to ***access molecular conformation, their organization and electronic states***, which can be complemented with other experimental and theoretical tools.
- ***Adsorption/desorption and self-diffusion*** of atoms can produce interesting structure on a surface. Study of ***topography and electronic structures***, using **STM** and **STS** in clean environment and control temperature; essentially enable us to understand the ***underlying fundamental interactions*** other than direct manifestation.

o Development of dedicated **SAXS/GISAXS facility** to determine the morphology of mesostructured films and its evolution from solution state.

o Attachment of a growth chamber with a provision of growth at variable temperature, with the existing **VT-UHV-SPM** system for the study of ***self-organization and electronic properties*** of **molecular and macromolecular systems**. Also attempt will be made to develop a dedicated **LT-STM** system.

Name: Manabendra Mukherjee

Academic profile including earlier appointments

MSc. Physics, Calcutta University, Kolkata,1983.

PhD. Indian Association for the Cultivation of Science, Kolkata, 1989.

Subject: Theoretical atomic collision physics.

Post Doc. Indian Association for the Cultivation of Science, Kolkata, 1989-1996.
(Synthesis and characterisation of nanocomposite materials)
Instituto de Estructura de la Materia, CSIC, Madrid, Spain, Sept.'96-Feb.'98
(Inelastic Neutron Scattering)
National Synchrotron Radiation Research Center, Taiwan, Mar.'98-Feb.'99
(Photoelectron spectroscopy using synchrotron radiation)
Surface Physics Division, Saha Institute of Nuclear Physics, Mar.'99-Mar.'00
(Surface Physics and Nanomaterials)

Permanent Position

Reader D, Mar.'00 - Jul.'03, **Associate Professor E,** Aug.'03 – Feb '07, **Professor F,** Feb '07 – till date

Essential strength of research/development output:

For more than a decade now, we are dealing with polymers. It is needless to say that this material has become an essential article from birth to death of our life. A large majority of application of polymers are in the form of thin films applied on some substrate surface. Therefore it is extremely important to know their structure and how the nature and interaction of the substrate influences the structure and dynamical behaviour of the films coated on them. Towards this objective we investigate surface and interface properties of polymers and other organic materials such as Langmuir-Blodgett films.

We have developed a method to study the swelling dynamics of water soluble polymer films using X-ray and neutron reflectivity techniques. We have demonstrated that the dynamics are strongly affected by the interaction of the substrate surface. We have also shown that tiny modifications like presence a small amount of nanoparticles in the films or a minute change in the nature of solvent which does not reflect in the structural properties can produce a strong difference in the dynamical behavior in swelling of the polymer films. In other words we have shown that swelling dynamics is a very sensitive probe to study small but important changes in the behaviour of polymer films.

The application of swelling has a vital ramification in the area of drug delivery and their application in the medical research. Protein is a natural polyelectrolyte and of prime importance for the drug delivery application. We are presently working with synthetic polyelectrolytes and proteins. We have observed several interesting behaviors that are unique to the charge centers present in the polymer backbone unlike neutral polymers.

As surface properties are strongly dependent on the nature of the interaction understanding of the nature of interaction between the substrate and the polymer chains becomes a key issue. We have developed a state of the art XPS/UPS facility in our lab during 2004 in this direction. Problem comes with the fact that these polymers are insulators and gets charged when exposed to the X-rays. We have developed a novel method namely controlled neutralization technique (CNT) to understand charging and neutralization in polymers. Later we have developed a technique to use this charging to understand structure of multi layer films. Orientation of polymer chains on a substrate is a direct outcome of polymer substrate interaction, we have ventured into this field as well. Near Edge X-ray Absorption Fine Structure (NEXAFS) which is a synchrotron based technique is one of the best tools to study the interaction and the orientation of the molecules simultaneously. We are using this technique along with XPS to understand chemical nature of the substrate and the polymer molecules with their mutual interaction and orientation.

It is necessary to have a theoretical background regarding the electronic density of states (DOS) or X-ray excitations to avoid doubts in the interpretation of the valence band XPS/UPS and NEXAFS data. In this direction we perform the density functional theory (DFT) simulations of DOS and NEXAFS transitions using STOBE package for completeness of our study.

Future research/development plan:
After about a decade of basic studies with polymers, we have decided to use our understanding towards applied research as an additional area of our activities. We have chosen the modern field of organic semiconductor devices for this purpose. We have recently installed a UHV preparation chamber with the XPS/UPS facility. This will enable us to develop organic semiconductor materials in UHV and study them in situ without breaking the vacuum. NEXAFS study of such systems will be done at synchrotron facilities.

List of important publications starting with recent publications

Study of neutralization kinetics in charged polymer-metal nanocomposite systems by photoemission spectroscopy, S. Mukherjee and **M. Mukherjee**, *J. Electron Spectrosc. Relat. Phenom. (Spl. issue: Charging in Electron Spectroscopies)* **176,** 35 (2010).

Onset Kinetics of Thermal Degradation of Ultrathin Polyacrylamide Films, S. Mukherjee, M. H. Mondal, **M. Mukherjee**, B. P. Doyle and S. Nannarone, *Macromolecules* **42**, 7889 (2009).

Study of thickness dependent density in ultrathin water soluble polymer films, M. H. Mondal, **M. Mukherjee**, K. Kawashima, K. Nishida and T. Kanaya, *Macromolecules* **42**, 732 (2009).

Effect of Annealing Induced Polymer Substrate Attachment on Swelling Dynamics of Ultrathin Polymer Films, M. H. Mondal and **M. Mukherjee**, *Macromolecules* **41**, 8753 (2008).

Interaction of Chromium with Resistant Strain Aspergillus versicolor: Investigation with Atomic Force Microscopy and Other Physical Studies, S. K. Das, **M. Mukherjee** and A. K. Guha, *Langmuir* **24**, 8643 (2008).

Characterization of Langmuir-Blodgett Film Using Differential Charging in X-ray Photoelectron Spectroscopy**,** A. K. M. Maidul Islam and **M. Mukherjee**, *J. Phys. Chem. B;* **112**, 8523 (2008).

Neutralization kinetics of charged polymer surface**,** S. Mukherjee and **M. Mukherjee**, *J. Electron Spectrosc. Relat. Phenom.* **163**, 51 (2008).

X-ray photoelectron spectroscopy studies on core-shell structured nanocomposites**, M. Mukherjee**, S. Basu, B. Ghosh and D. Chakravorty, *Appl. Surf. Sci.* **253**, 8463 (2007).

Effect of Solvent-Polymer Interaction in Swelling Dynamics of Ultrathin Polyacrylamide Films: A Neutron and X-ray ReflectivityStudy, **M. Mukherjee**, Amarjeet Singh, J. Daillant, Alain Menelle, and F. Cousin, *Macromolecules***, 40**, 1073 (2007).

Controlled Surface Neutralization: A quantitative approach to study surface charging in photoemission, S. Mukherjee and **M. Mukherjee**, J. Electron Spectrosc. Rel. Phenom. **154**, 90 (2007).

Nitrogen-mediated interaction in polyacrylamide silver nanocomposites, S. Mukherjee and **M. Mukherjee**, J. Phys.: Condens. Matter **18**, 11233 (2006)

Effect of Polymer-Particle Interaction in Swelling Dynamics of Ultrathin Nanocomposite Films, Amarjeet Singh and **M. Mukherjee**, Macromolecules **38** 8795 (2005)

X-ray photoelectron spectroscopy studies of MgB_2 for valance state of Mg; A. Talapatra, S.K. Bandyopadhyay, Pintu Sen, P.Barat, S. Mukherjee, **M. Mukherjee** , Physica C **419** 141 (2005)

Transition from two-dimensional to three-dimensional melting in Langmuir-Blodgett films: M.K. Mukhopadhyay, M.K. Sanyal, A. Datta, **M. Mukherjee**, Th. Geue, J. Grenzer, and U.Pietsch , Phys.Rev.B **70** 245408 (2004)

Discrete film thickness in ployacrylamide-CdS nanocomposite ultrathin films: Amarjeet Singh and **M. Mukherjee**, Phys.Rev.E **70** 051608 (2004)

Swelling Dynamics of Ultrathin Polymer Films, Amarjeet Singh and **M. Mukherjee**, Macromolecules **36** 8728 (2003)

X-ray reflectivity and AFM studies of polystyrene-CdS nanocomposite thin films, **M. Mukherjee**, Neelima Deshmukh, S. K. Kulkarni, Appl. Surf. Sci. **218** 323 (2003).

Energy dispersive x-ray reflectivity technique to study thermal properties of polymer films, M. Bhattacharya, **M. Mukherjee**, M. K. Sanyal, Th. Geue, J. Grenzer, and U. Pietsch, J. Appl. Phys. **94**, 2882 (2003).

Reversible Negative Thermal Expansion in Polymer Films, **M.Mukherjee**, M.Bhattacharya, M.K.Sanyal, Th.Geue, J.Grenzer and U.Pietsch, Phys.Rev.E **66** , 061801 (2002).

1. Name - SRINANDA KUNDU

2. Photograph –scanned and attached

3. Educational background – M.Sc., PhD

2. Academic profile including earlier appointments – Joined SINP, Calcutta as Lecturer in 1993

3. Essential strength of research/development output –

Extensive studies are made on sputter deposited thin films and their studies are published in different journals.

A. Growth dynamics study of 2D ultrathin films and multilayers, their charaterisation by x-ray scattering, scanning probe microscopy, scanning and transmission electron microscopy and squid magneto meter.

Some important observations are made –

i) We showed by x-ray scattering, scanning probe microscopy that in case of Au, Ag, growth takes place via layer with mounds (~ nm size -i.e. SK-type) and in the initial stages they are highly porous
ii) It was also demonstrated that mounds aggregate laterally and then vertically with time (thickness) with different exponents.
iii) At nascent state ultrathin Ag or Au films can be modified to 1 D nano lines by hard AFM tip
iv) The Fe films are so porous that in case of multilayer growth the film grown on it (e.g. V), can easily penetrate Fe film with the kinetic energy associated with sputtered V.

B. Comparative studies are made on the modifications of surface and interfaces are made on post treated as grown films, such as ion beam irradiation and high vacuum annealing

C. Magnetic Multilayers are fabricated and characterized with XRR, AFM and SQUID- Two M.Tech. project- thesis are done –

i) Sputter deposited $(co/pt)_9$ are studied with SQUID and showed ferromagnetism at 5^0k and 10 ^{0}k

ii) structural and magnetic property study of sputter deposited $(Fe/V)_{14}$ where antiferomagnetic transition is observed at 45^0k (2009 -2010)

D. Dilute Magnetic Semiconductor - Transition metal doped oxides have attracted considerable interest as promising diluted magnetic semiconductors owing to the possibility of inducing room temperature ferromagnetism for advanced spintronics applications. Thin films grown by sputtering ZnO and Co simultaneously and also sequentially are characterized with x-ray reflectivity, SEM-EDAX, XRD and transport measurements are made with 4-probe method. Dependence Co's percentage is very much evident.

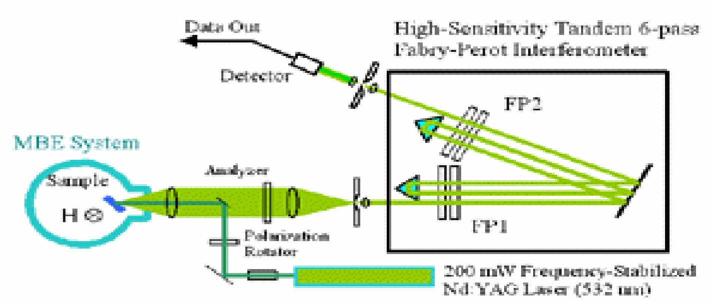
i) M.Tech. project thesis is done. Zinc Cobalt Oxide doped with Co and Al traces. (2007-2008)

E. Ion transport in electrolyte solution is of immense significance particularly for biophysical systems. Ionic Transport studies in alkali halide solutions are made using Radio Tracer technique and theoretically the velocity correlation coefficients are calculated for ternary electrolyte solutions. H. Chakrabarti collaborated with me.

F. Acoustic Study of Electrolytic Solutions – Aqueous NaCl solution is an integral part of all living bodies and ultrasonic is an important tool for studying their cluster formation under different solute concentration (ongoing). S Kundu and B Pal.

4. Future research/development plan:

In the context of Eleventh Five Year Plan (2007-2012), in our division "**Center for Nanoscience and Surface Physics" (CENSUP)** project is approved. Under **CENSUP,** I have a project titled **'**UHV multi-deposition system for depositing thin films and their insitu characterization by Brillouin light scattering' (BLS). The UHV unit comprises a few Knudsen cells, e- beam source and other accessories for growing well controlled thin films. In BLS, inelastic scattering of light occurs by thermally excited phonons waves in any material or by magnetic spin waves present in magnetic structures. From the shift of light frequency one can have an insight into elastic constants in general and of magnetic fluctuations of buried magnetic layers, especially of nanostructures and their confinement effects. Advent of high quality laser and modern day multipass interferometer made it possible to study especially magnetic nanostructures.



5. A few recent important publications:

1. Effect of Ionic Environment on the Transport of Cesium ion in alkali chloride solutions from Radio Tracer Studies, H Chakrabarti and S Kundu, accepted for publications in Applied Radiation and Isotopes, Online publication complete: 17-JUN-2010, Reference: ARI5072,DOI information: 10.1016/j.apradiso.2010.05.015

2. A Novel attempt to calculate the velocity correlation coefficients in ternary electrolyte solution", H Chakrabarti and S Kundu, accepted for publication in Journal of Solution Chemistry.#JOSL1144R2, April 7, 2010, 10:31 PM

3. Mass dependent surface interface modification of Ag/Co films under controlled ion beam irradiation, S. Kundu, Nucl. Instrum. Meth. **B 242**, 542 (2006)

4. Surface modification of mica due to titanium sputtering as studied by positron annihilation, B. Ganguly, N. Djourelov, T. Suzuki and S. Kundu, Appl. Rad. Isotopes **64**, 651 (2006).

5. Growth kinetic study of sputter deposition: Ag on Si/SiO2- S. Banerjee and S. Kundu, Surf. Sc. **537**, 153 (2003)

6. Structural and magnetic property of ultra thin [Fe (15 Å)/V (15 Å)]$_{14}$ multilayer – S.Maity,S.Kundu, B. Ghosh and S. Banerjee

1. Name: **Satyaban Bhunia**

2. Educational Background:
- Secondary Exam: 1986 with 1st div.
- Higher Secondary: 1988, Science stream, 1st div.
- 5 years integrated M.Sc. in Physics (spl. Solid State Phys), 1993 from Indian Institute of Technology, Kharagpur. CGPA 8.18/10
- Ph.D. from Indian Institute of Technology, Kharagpur in 1999, Thesis title "Crystal growth, characterization and device applications of ZnTe"

3. Academic profile including earlier appointments, awards etc.
- Scientist in Indian Defence Research and Development Organization (1998 – 1999)
- Researcher, 1999 – 2002, The University of Electro-Communications (UEC), Tokyo, Japan
- Post-Doctoral fellow 2002 – 2003 NTT Basic Research Laboratories, NTT Corporation, Atsugi, Japan
- Assistant professor, Indian Institute of Technology, Bombay (IIT Bombay) (2003 – 2004)
- Reader 'D', Saha Institute of Nuclear Physics, Kolkata, India (2004 – 2007)
- Assoc. Prof. 'E', Saha Institute of Nuclear Physics, Kolkata, India (2007 – present)

Investigator – Sponsored Projects:
1. Main investigator of the project *"Nanoscience Unit at SINP"* under "Nanomaterials Science and Technology Initiative (NSTI) of Department of Science and Technology (DST)".
2. Co-Principal Investigator of the national project "Indian Beamline at Photon Factory, KEK, Japan" sponsored by DST, Govt. of India
3. "SINP Beamline (BL13)" at INDUS 2 synchrotron facility, RRCAT, Indore
4. Principal Investigator of India-Japan (DST-JSPS) joint project entitled "Novel Semiconductor and Magnetic Properties in Nano-Structured Materials" under India-Japan Science Cooperative Programme.

3. Essential strength of research/development output
- The core of my research plan and strength is on semiconductor materials and devices, especially in the area of III-V and II-VI compounds. Particularly, I am interested in epitaxial growth of such compounds and different low dimensional nanostructures using Metalorganic Vapor Phase Epitaxy (MOVPE) system and chemical vapor deposition (CVD) methods, and characterization of these materials using optical and electrical methods. A MOVPE system, aimed at growing Ga-In-Al-As-P system is at its last phase of installation to pursue this research interest. We have also built a CVD system for growing ZnO thin films, nanowires and other type of self organized hierarchical nanostructures. Vertically aligned as well as randomly oriented nanowires of ZnO have been successfully grown after systematic variation of the controlling parameters in the CVD process.
- Synchrotron x-ray based nanomaterials characterization has been another area of my research interest. In this respect, I am involved as co-principal investigator of a national project entitled "Indian Beamline at Photon Factory, KEK, Japan". The experimental station has been developed at this synchrotron facility in Japan to carry out powder diffraction at low temperature and high pressure, grazing incidence x-ray diffraction, single crystal x-ray diffraction and x-ray reflectivity. I have also taken a major role in the national synchrotron project of INDUS 2 at RRCAT, Indore. Here, the "SINP Beamline" has been successfully assembled to carry out grazing incidence x-ray scattering studies of surfaces and interfaces in solids and liquids, reflectivity, diffuse scattering, two-dimensional diffraction, small angle scattering in reflection geometry, high resolution diffraction studies as a function of temperature, structural & morphological characterization of nanomaterials etc.
- Successfully completed the modular Photoluminescence (PL) set up in my laboratory at SINP for measuring optical properties of semiconductor materials and nanostructures at 300 K – 4 K.

4. Future research/development plan
- The initial focus of our MOVPE related activity is to grow III-V compound nanowires. Though the growth technique has advanced a lot to obtain such structures, still many issues remain regarding site specific growth, multiheterostructure growth and coupled quantum structures for integrated optoelectronic physics and application. After growth, I am particularly interested in electrical transport and optical emission properties of individual nanowires and heterostructures. We would also like to start major activity towards growth of GaInP/GaAs based heterostructure bipolar transistor as part of high speed device applications. I

plan to establish a major semiconductor processing facility at SINP in the coming plan period which should enable us to do basic device fabrication using photolithography, metallization, ion etching, and testing under clean room environment.

5. List of important publications starting with recent publications

1. Book Chapter: "TEM-Cathodoluminescence study of Semiconductor quantum dots and quantumwires", N. Yamamoto, K. Ishikawa, K. Akiba, S. Bhunia, K. Tateno, and Y. Watanabe, Book: Beam Injection Based Nanocharacterization of Advanced Materials: Ed. G. Salviati, T. Sekiguchi, S. Heun, A. Gustafsson, Chapter 2, pp 37-59, Research Signpost, 2008

Papers already published (Sorted according to the time of publication)

2. "Vapor condensation growth and evolution mechanism of ZnO nanorod flower structures" S. R. Haldar, A. Nayak, T. K. Chini, S. K. Ray, N. Yamamoto, and S. Bhunia, Physica Status Solidi A, 207 (2) (2010) pp. 364-369
3. "Temperature and wavelength dependence of transient photoconductivity in ZnTe" S. Johnston, R.K. Ahrenkiel, S. Bhunia, and D.N. Bose, Ind. J. Phys. 80 (2006) pp. 703 – 706
4. "Polarized cathodoluminescence study of InP nanowires by transmission electron microscopy" N. Yamamoto, S. Bhunia, and Y. Watanabe, Appl. Phys. Lett. 88 (2006) 153106 – 153108
5. "High resolution x-ray diffraction analysis of epitaxially grown indium phosphide nanowires", T. Kawamura, S. Bhunia, Y. Watanabe, S. Fujikawa, J. Matsui, Y. Kagoshima, and Y. Tsusaka, J. Appl. Phys. 97 (2005) 084318
6. "Real-time observation of fractional-order x-ray reflection profiles of InP(001) during step-flow growth" Seiji Fujikawa, Tomoaki Kawamura, Satyaban Bhunia, Yoshio Watanabe, Kenshi Tokushima, Yoshiyuki Tsusaka, Yasushi Kagoshima, and Junji Matsui, Jap. J. Appl. Phys. 44 (2005) pp. L144 – L146
7. "Vapor-liquid-solid growth of vertically aligned InP nanowires by metalorganic vapor phase epitaxy", S. Bhunia, T. Kawamura, S. Fujikawa, H. Nakashima, K. Furukawa, K. Torimitsu, and Y. Watanabe, Thin Solid Films 464-465 (2004) pp. 244-247
8. "Heteroepitaxial metalorganic vapor phase epitaxial growth of InP nanowires on GaP(111)B", Y. Watanabe, S. Bhunia, S. Fujikawa, T. Kawamura, H. Nakashima, K. Furukawa, and K. Torimitsu, Thin Solid Films 464-465 (2004) pp. 248-250
9. "Systematic investigation of growth of InP nanowires by metalorganic vapor-phase epitaxy", S. Bhunia, T. Kawamura, S. Fujikawa, and Y. Watanabe, Physica E 24 (2004) pp. 138-142
10. "Metal organic vapor phase epitaxial growth and properties of isolated and vertically aligned InP nanowires" S. Bhunia, T. Kawamura, Y. Watanabe, S. Fujikawa and K. Tokushima, Appl. Phys. Lett. 83 (2003) pp. 3371 – 3373
11. "Free-standing and vertically aligned InP nanowires grown by metal organic vapor phase epitaxy", S. Bhunia, T. Kawamura, S. Fujikawa, K. Tokushima, and Y. Watanabe Physica E 21 (2004) 583 - 587
12. "Real-time measurement of rocking curves during the MOVPE growth of GaInP/GaAs" S. Bhunia, T. Kawamura, S. Fujikawa, Y. Watanabe, K.Uchida, N. Sugiyama, M. Furiya, S. Nozaki, H. Morisaki, J. Matsui, Y. Kagoshima, Y. Tsusaka, Applied Surface Science 216 (2003) 382-387
13. "In-situ observation of step-terrace structures on MOVPE grown InP (001) by using grazing x-ray scattering", T. Kawamura, S. Bhunia, Y. Watanabe, S. Fujikawa, J. Matsui, Y. Kagoshima, Y. Tsusaka, Applied Surface Science 216 (2003) 361-364
14. "MOVPE growth of heavily carbon doped GaAs by using a new dopant source of CCl3Br and quantitative analysis of compensation mechanism in the epilayers", S. Bhunia, K. Uchida, S. Nozaki, N. Sugiyama, M. Furiya, and H. Morisaki, J. Appl. Phys. 39 (2003) 1613-1619
15. "Heavy carbon doping of GaAs by MOVPE using a new dopant source CBrCl3 and characterization of the epilayers" K. Uchida, S. Bhunia, N. Sugiyama, M. Furiya, M. Katoh, S. Katoh, S. Nozaki and H. Morisaki, J. Cryst. Growth 248 (2003) 124-129
16. "Real time observation of surface morphology of indium phosphide MOVPE growth with using x-ray reflectivity technique", T. Kawamura, Y. Watanabe, S. Fujikawa, S. Bhunia, K. Uchida, J. Matsui, Y. Kagoshima and Y. Tsusaka, J. Cryst. Growth 237-239 (2002) pp 398 – 402
17. "Determination of well widths in a MOVPE-grown InGaAs/InP multi-quantum well structure using SIMS and photoluminescence", D. N. Bose, P. Banerji, S. Bhunia, Y. Aparna, M. B. Chhetri and B. R. Chakraborty, Applied Surface Science, Vol 158 (2000), pp16-20
18. "Steady state and time resolved photoconductivity measurements of minority carrier lifetime in ZnTe", D.N. Bose, R.K. Ahrenkiel and S. Bhunia, J. Appl. Phys. Vol 86 (1999) pp. 6599-6601
19. "Microwave synthesis, single crystal growth and characterization of ZnTe", S. Bhunia and D.N. Bose, J. Cryst. Growth Vol. 186 (1998) pp.535-542

Name: Dr. Krishnakumar S. R. Menon
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Address: Surface Physics Division,
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1/AF Bidhannagar, Kolkata – 700 064
INDIA
e-mail: krishna.menon@saha.ac.in
Age and Date of birth: 39 Years; May 30, 1971
Sex: Male
Nationality: Indian

Education: Doctor of Philosophy (Ph.D), 1999; Indian Institute of Science (IISc), Bangalore, INDIA. Thesis Title: "*Electronic structure and metal-insulator transitions in transition metal sulphides and oxides*".

Master of Science (M.Sc.) in Physics, 1993; Indian Institute of Technology (IIT), Madras (Chennai), INDIA.

Bachelor of Science (B.Sc.) in Physics, 1991; University of Calicut, Kerala, INDIA

Professional Experience:

- Associate Professor-F at Saha Institute of Nuclear Physics, Jan. 2010 – Present.
- Associate Professor-E at Saha Institute of Nuclear Physics, Feb. 2007 – Jan. 2010.
- Reader-D at Saha Institute of Nuclear Physics, Oct. 2004 – Feb. 2007.
- Guest Scientist at Freie University, Berlin, Jan. 2004 – Sep. 2004.
- TRIL Research Fellowship at International Centre for Theoretical Physics (ICTP) and ELETTRA Sincrotrone Trieste, Italy, Jan. 2002 – Dec. 2003.
- Post-Doctoral Research Associate at Indian Institute of Science, Bangalore, Jan. 2001 – Dec. 2001.
- NSF Post-Doctoral Research Fellow at University of Connecticut and National Synchrotron Light Source (NSLS), Brookhaven National Laboratory, USA, Jan. – Dec., 2000.

Recent research/development output in brief:

My research interest is in the ***structure-property correlations*** at surfaces and ultrathin films of simple oxide materials, metal/semiconductor overlayers and low-dimensional materials. The surface structural properties of interest includes surface strain, dislocations, defect structures besides the surface relaxations and reconstructions. Along with Low-energy Electron Diffraction (LEED), we use Low energy Electron Microscopy (LEEM) and surface EXAFS (in TEY mode) for the surface structural studies. The surface electronic structure is investigated using X-ray Photoemission Spectroscopy (XPS) and Angle-resolved Photoemission Spectroscopy (ARPES) while surface magnetism is probed with synchrotron based spectroscopic and spectromicroscopic techniques such as X-ray Magnetic Circular Dichroism (XMCD), X-ray Magnetic Linear Dichroism (XMLD) and Photo-emission Electron Microscopy (PEEM).

For the study of surface electronic structure of crystalline materials, recently we have setup an ARPES laboratory at SINP. This state-of-the-art facility provides high energy and angular resolutions for modern day ARPES measurements of band-structure/Fermi-surface mapping besides X-ray Photoelectron Spectroscopy and Photoelectron Diffraction measurements. Initial results and characterization of this ARPES system has been published recently [1]. New ARPES results on some low-dimensional materials are being analysed and further investigated by synchrotron measurements.

The preperation chamber of ARPES facility is used for the epitaxial growth of metal/oxide films in a controlled way and characterized by the LEED prior to the spectroscopic measurements. At SINP, we are developing mini e-beam evaporators so that we can use them for depositing the materials in the UHV. These are developed at a fractional cost of the commercial ones and will be custamized for our use. Initial test results are quite satisfactory and have been the subject of an M-Tech thesis project.

In order to study the structure-property correlations of Nickel Oxide (NiO) system, we have been performing synchrotron experiments primarily at beamlines of ELETTRA synchrotron at Trieste, Italy. We have been quite successful in studying the surface antiferromagnetic domain structure of NiO single crystals using XMLD-PEEM spectromicroscopies. Moreover, we have developed a new method of surface antiferromagnetic domain imaging using unpolarized electrons, termed as Antiferromagnetic Low-energy Electron Microscopy (AFM-LEEM). This is essentaially a Dark-Field (DF) imaging method using the antiferromagnetic (half-order) reflections in the LEED and is expected to be published soon. We have also performed extensive experiments using EXAFS, X-ray Absorption Spectroscopy and Powder X-ray Diffraction measurements on the polycrystalline/nano-particles of NiO system. Many publications from the study of the NiO system is in progress and two articles have appeared recently [2,3].

I have been a part of the x-ray scattering beamline construction activities of SINP at INDUS-II, RRCAT as well as at Photon Factory, Japan. At RRCAT, the beamline construction is nearly completed and awaiting commissioning. Indian Beamline at Photon Factory has started functioning and initial scattering and diffraction experiments have been performed. At present, I am designing a UHV system for performing on-line growth studies and structural characterization of metal/oxide thin films which will be mounted on a heavy-duty 8-circle diffractometer at the beamline.

Under the Centre for Advanced Research & Education (CARE-II) project, I have started devleoping an experimental system for measuring variable temperature (300 – 4.2 K) transport and Magneto-Optical Kerr Effect (MOKE) properties. This will enable the users of the institute to perform resistivity and MOKE measurements down to 4.2 K under a magnetic field of 0.5 Tesla. Currently, the procurement of cryostat and other components are in progress.

Future research/development plan in brief (For next 6 years):

At present we are able to grow epitaxial oxide films in the preparation chamber of the ARPES system using molecular oxygen source only. Due to this, we are limited to growing only a few oxide systems such as NiO, MgO etc. In order to grow other interesting simple oxide films, we propose to procure an atomic oxigen source. This will also enable us to gain more control on the stoichiometry and reproducibility of the individual phases. In order to study the kinetics of the growth process as well as to monitor the quality of the films, a RHEED system will be attached with the growth chamber. The preparation chamber is already designed with all these future developments in mind. We plan to undertake this activity in the 5th year (2010-2011) of the current XIth plan period.

Using ARPES, we are able to probe the electronic band dispersions in the occupied part of the valence band. It would be very interesting and appropriate also to study the dispersions in the un-occupied density of states (conduction band) which will provide the complete electronic structure information. Thus, we plan to develop an Angle-resolved Inverse Photoemission Spectroscopy (ARIPS) setup for the study of the un-occupied band dispersions, integrated onto the existing ARPES setup. This will be developed in-house and I have the direct experience of developing an instrument at the Indian Institute of Science during my Ph.D period. The existing ARPES setup is designed so that an ARIPS can be easily integrated into it. We propose to excecute this project during the XIIth plan period (2012-2017).

In order to study the surface structure and morphology of the ultra-thin films and single crystal surfaces with a spatial resolution better than 10 nm, we propose having a Low-energy Electron Microscope (LEEM) facility at SINP during the XIIth plan period. Over last 3 years, we have gained immence experience in using this microscope (along with Photoemission Electron Microsope (PEEM)) at the Elettra synchrotron centre. We have even developed a novel way to image the surface antiferromagnetic domains (AFM-LEEM) and we would like to continue to delevop this field and to study the magnetic domain structure of antiferromagnetic thin films and surfaces at SINP. Micro-LEED can be used to study the micro-structural aspects of the surfaces while the surface morphologies and dislocation networks can be studied by LEEM. This instrument will enhance the quality of our research substantially as now we will have a clear understanding of the microscopic surface structure and even study real-time dynamic processes at surfaces. Such phenomena include tomography, phase transitions, adsorption, reaction, segregation, thin film growth, etching, strain relief, sublimation, and magnetic microstructure. Currently, there is no LEEM microscope available in India and we can bridge this gap with the proposed LEEM facility at SINP.

List of Important Publications (Since 2004):

1. S. K. Mahatha and **Krishnakumar S. R. Menon**, Current Science **98**, (2010).
2. S. Mandal, S. Banerjee, and **Krishnakumar S. R. Menon**, Phys. Rev. B **80**, 214420 (2009).
3. S. Mandal, **Krishnakumar S. R. Menon**, F. Maccherozzi and R. Belkhou, Phys. Rev. B **80**, 184408 (2009).
4. J. Honolka, T. Y. Lee, K. Kuhnke, D. Repetto, V. Sessi, P. Wahl, A. Buchsbaum, P. Varga, S. Gardonio, C. Carbone, **S. R. Krishnakumar**, P. Gambardella, M. Komelj, R. Singer, M. Fähnle, K. Fauth, G. Schütz, A. Enders and K. Kern, Phys. Rev. B **79**, 104430 (2009).
5. Sugata Ray, Priya Mahadevan, **S. R. Krishnakumar**, S. Mandal, Carlos Seiti Kuroda, T. Sasaki, Tomoyasu Taniyama, and Mitsuru Itoh, Phys. Rev. B **77**, 104416 (2008).
6. J. Honolka, K. Kuhnke, L. Vitali, A. Enders, K. Kern, S. Gardonio, C. Carbone, **S. R. Krishnakumar**, P. Bencok, S. Stepanow, and P. Gambardella, Phys. Rev. B **76**, 144412 (2007).
7. S. Banerjee, P. Sujatha Devi, D. Topwal, S. Mandal, and **Krishnakumar Menon**, Adv. Funct. Mater. **17**, 2847 (2007).
8. **S. R. Krishnakumar**, M. Liberati, C. Grazioli, M. Veronese, S. Turchini, P. Luches, S. Valeri and C. Carbone, J. Magn. Magn. Mater. **310**, 8 (2007).
9. C. Grazioli, Dario Alfè, **S. R. Krishnakumar**, Subhra Sen Gupta, M. Veronese, S. Turchini, Nicola Bonini, Andrea Dal Corso, D. D. Sarma, Stefano Baroni, and C. Carbone, Phys. Rev. Lett. **95**, 117201 (2005).
10. P. Gambardella, H. Brune, S. S. Dhesi, P. Bencok, **S. R. Krishnakumar**, S. Gardonio, M. Veronese, C. Grazioli and C. Carbone, Phys. Rev. B **72**, 045337 (2005).
11. D. D. Sarma, Dinesh Topwal, Manju U., **S. R. Krishnakumar**, S. La Rosa, G. Cautero, T. Y. Koo, P. A. Sharma, S-W. Cheong, and A. Fujimori, Phys. Rev. Lett. **93**, 097202 (2004).

Theoretical Condensed Matter Physics Division

Permanent Members :

Faculty members	**Technical staff**	**Auxiliary/Admins. staff**
B. K. Chakrabarti (Head, Sr. Prof.) A. N. Das (Sr. Prof.) A. K. Sen (Prof.) S. Yarlagadda (Prof.) S. N. Karmakar (Prof.) P. K. Mohanty (Prof.) A. Basu (Prof.)	K. Das (Sci. Asst.)	A. K. Nayak (Officer) P. S. Bhattacharya (Supr.) J. Mallick (Helper) A. Ram (Helper)

PhD students (since 2007): D. Samanta, S. Datta, A. Ghosh, D. Bagchi, M. Basu, R. Chatterjee, U. Basu, S. Biswas, S. Reja, M. Dey, P. Dutta, S. Saha, N. Sarkar

Postdocs (since 2007): A. Chandra, A. Kundu, M. Chakrabarti, K. Hajra

Major equipments and resources:
IBM-Power 5 Server, IBM Blade Server with 14 blades, Individual desktops.

RESEARCH ACTIVITY:

The activity of theoretical condensed matter physics (TCMP) division can be broadly classified under the categories (a) Physics of Strongly Correlated Systems and (b) Statistical Physics. The division has seven faculty members at present and each of them leads their respective group of students and post-doctoral fellows. The divisional activity also includes a centre for interdisciplinary research, namely the Centre for Applied Mathematics and Computational Sciences (CAMCS).

For a brief introduction to the present activities of the TCMP division and of the CAMCS, we give below a summary of the investigations carried out by the TCMP faculty essentially in the ongoing plan period (last few years). In the Appendix a list of publications from 2007 onwards is given.

Physics of Strongly Correlated Systems
(A. N. Das, S. Yarlagadda, S. N. Karmakar)

Atindra Nath Das's group studied Bose-Einstein condensation in an optical lattice to obtain interaction-induced depletion of bose condensate. At strong interaction, the condensation temperature decreases with filling for $n \geq 0.5$, where n is the number of bosons per site, and it becomes zero at $n = 1$ [PRB **72**, 094301 (2005)]. They studied the condensation of bosons in optical lattices under harmonic and quartic traps in different dimensions [EPJD **42**, 309 (2007); ibid **47**, 203 (2008)], as well as for anisotropic harmonic traps. Next, study of polaronic properties showed that site-diagonal disorder reduces the kinetic energy, Drude weight and spatial extent of the polarons. Increasing temperature also reduces the preceding quantities for weak and intermediate coupling. For strong coupling the effect of temperature is small but opposite [JPCM **20**, 345222 (2008)].

Sachin Karmakar's group, in the recent past, have focused attention on nanoscience. They have studied the effects of electron-electron interaction and disorder on persistent current in mesoscopic normal rings. They have shown that the long-standing anomaly between theory and experiment regarding the amplitudes of persistent currents in the mesoscopic rings can be resolved by including second-nearest-neighbor hopping integrals in the usual nearest-neighbor tight-binding Hamiltonian [J. Phys.: Condens. Matter, **18**, 5349 (2006)]. Their exact numerical calculations revealed that electron-electron interactions produce anomalous Aharonov-Bohm oscillations in the persistent currents which corroborate the experimental findings [Phys. Lett. A, **332**, 497 (2004)]. Karmakar *et al.*, to understand the behavior of magnetic multilayers, obtained the ground state phase diagram and magnetoconductance of such superlattices using Hubbard model [Phys. Rev. B, **75**, 235117 (2007)]. In a recent work they have proposed a magnetic quantum device which acts as a spin filter [Phys. Lett. A, **374**, 1522 (2010)].

Sudhakar Yarlagadda *et al.* solved (using novel approaches) the long-standing problem of analytically obtaining the Peierls instability condition in the Holstein model [PRB, **75** 035124 (2007) and PRB, **71**, 235118 (2005)] by considering *quantum phonons* and predicted the phase diagram away from half-filling. They were the first to show, using the Peierls instability framework, that the ground state orbital ordering of $LaMnO_3$ can be explained using even weak electron-phonon coupling [PRB **80**, 235123 (2009)]. Next, a new model was proposed to understand cooperative Jahn-Teller effect for quantum phonons. The model involves an *enhanced* next-nearest-neighbor (NNN) hopping and nearest-neighbor (NN) repulsion and predicts a dramatic first-order transition at a critical repulsion. Sudhakar's group also derived an effective d-dimensional Hamiltonian for a system of hard-core-bosons coupled to optical phonons in a lattice (arXiv:0907.3543). They demonstrated that the presence of NNN hopping and NN repulsion leads to supersolidity.

Statistical Physics
(B. K. Chakrabarti, A. K. Sen, A. Basu, P. K. Mohanty)

Bikas K. Chakrabarti completed some major work and reviewed thoroughly their contributions in Quantum Annealing (with a student) and Failure Dynamics in Fiber Bundles (with a student and a collaborator) in two papers in Rev. Mod. Phys. (in 2008 and 2010). Two more reviews in Rev. Mod. Phys. have recently been commissioned; one on Quantum Critical Phenomena in Transverse Ising and XY models (with students and collaborators) and the other one is on Statistical Physics of Fracture, Friction and Earthquakes (with a student and collaborators). His group introduced the Kinetic Exchange Models of Markets; published a textbook on Econophysics (2010, Wiley-VCH) and he has been invited for a Monograph on Econophysics from Cambridge Univ. Press, Cambridge.

In Asok K. Sen's group, studies on their semi-classical RRTN (Random Resistor cum Tunneling-bond Network, proposed in 1993-94) model continued [EPL **71**, 797 (2005)]. These studies include (i) nonlinear response, (ii) breakdown, (iii) two early power-law dynamics (e.g., in many natural phenomena like earthquakes, some protein-folding dynamics); and (iv) very strong memory (associated hysteresis), useful for cryptography and natural computation (CFS, IEEE Comp Soc, Los Alamitos, CA 2008). An extensive pedagogical review on the RRTN, with many open problems, has recently been written in Quantum and Semi-classical Percolation and Breakdown in Disordered Solids, Lect. Notes in Phys., Vol-762 (Springer, Berlin, 2009), edited by A. K. Sen *et al.*

Abhik Basu's group, inspired by the physics of magnetohydrodynamics (MHD), proposed a simplified coupled Burgers-like model in one dimension (1d) to describe 1dMHD. In addition to MHD, this model serves as a 1d reduced model for driven binary fluid mixtures. In particular, they determine the scaling exponents and the amplitude-ratios of the relevant correlation functions. [J. Stat. Mech. (2009) P08013]. At present, Abhik Basu and co-workers (students and collaborators) are investigating the statistical properties of homogeneous and isotropic three-dimensional binary fluid turbulence and the role of topological defects in determining the statistical properties of two-dimensional nonequilibrium systems. They are also looking at the macroscopic effects of coupling driven directed motion (simple nonequilibrium dynamics) with diffusive motion in a 1d model proposed by them. In another work, beginning with biophysical motivations, they proposed two-dimensional coarse-grained equations for active gel systems as generic models for cytoplasmic dynamics in cells.

Pradeep K. Mohanty's group developed a method [J. Stat. Phys. Lett. 2009] to solve a class of non-equilibrium lattice models. The method has been used successfully in Extended Katz Lebowitz Spoon model, Restricted Asymmetric Exclusion Process [PRE, 2008], exclusion process with internal degrees of freedom [arXiv:2010], Tonks gas and DNA denaturation transition (working) to reveal novel spatial correlations. The group is trying to understand absorbing state phase transitions which do not belong to the generic Directed Percolation universality class. In another recent work they showed that random walk in a bounded domain can produce regular patterns, and the non-trivial distribution of returning walkers on the repeated pattern is caused by hidden non-linearity [EPL 2009]. Recently Mohanty and co-workers have studied [OJB, 2009] the micro RNA (miRNA) co-target network and claim that miRNAs deregulate gene expression group-wise (contrary to the current view, *i.e.*, individual regulation). This would help biologists to predict miRNAs those are possibly involved in any specific phenotype. The group is planning to set up a miRNA cluster data base at SINP.

APPENDIX

List of publications of TCMP members (2010-2007):

2010

1. Inequality reversal: Effects of savings propensity and correlated returns, A. S. Chakrabarti and B. K. Chakrabarti, Physica A **389**, 3572 (2010).
2. Failure processes in elastic fiber bundles, S. Pradhan, A. Hansen, and B. K. Chakrabarti, Rev. Mod. Phys. **82**, 499 (2010).
3. Scaling theory of quantum breakdown in solids, B. K. Chakrabarti and D. Samanta, Phys. Rev. B **81**, 052301 (2010).
4. Quantum phase transition in a disordered long-range transverse Ising antiferromagnet, A. K. Chandra, J.-I. Inoue and B. K. Chakrabarti, Phys. Rev. E **81**, 021101 (2010).
5. A zero-temperature quantum Monte Carlo algorithm and quantum spin glasses , A. Das, A. K. Chandra and B. K. Chakrabarti, Comp. Sc. Eng., IEEE **12**, 64 (2010).
6. New possibilities for obtaining a steep nonlinear current-voltage characteristics in some semiconductor structures, D. I. Sheka, O. V.Tretyak, A. M. Korol, A. K. Sen and A. Mookerjee, International Journal of Modern Physics B, to be published (2010);
7. Moumita Dey, Santanu K. Maiti, and S. N. Karmakar, Magnetic quantum wire as a spin filter: An exact study, Phys. Lett. A, **374**, 1522 (2010).
8. Paramita Dutta, Santanu K. Maiti, and S. N. Karmakar, Quantum transport in an array of mesoscopic rings: Effect of interface geometry, Solid State Communications, **150**, 1056 (2010).
9. Paramita Dutta, Santanu K. Maiti, and S. N. Karmakar, Multi-terminal electron transport through single phenalenyl molecule: A theoretical study, Organic Electronics, **11**, 1120 (2010).
10. Moumita Dey, Santanu K. Maiti, and S. N. Karmakar, Topological effect on spin transport in a magnetic quantum wire: Green's function approach, Journal of Computational and Theoretical Nanoscience, (in press), [arXiv:1002.2345].
11. Jayeeta Chowdhury, Shreekantha Sil, S. N. Karmakar, and Bibhas Bhattacharyya, Quasi-one dimensional graphite ribbon structures in presence of magnetic field and on-site Coulomb correlation at half-filling, Eur. Phys. J. B, (in press), [arXiv:0811.1468].
12. Particle Ordering in Zero Range Process : Exact spatial correlations of the corresponding exclusion models, U. Basu and P. K. Mohanty, J. Stat. Mech. L03006 (2010).
13. Two-dimensional random walk in a bounded domain, M Basu and P. K. Mohanty, Europhys. Lett.**90**, 50005 (2010)

2009

14. Microeconomics of the ideal gas like market model, A. S. Chakrabarti and B. K. Chakrabarti, Physica A **388** 4151 (2009).
15. The Kolkata Paise Restaurant Problem and resource utilization, A. S. Chakrabarti, B. K. Chakrabarti, A. Chatterjee and M. Mitra, Physica A. **388**, 2420 (2009).

16. A. N. Das and M. Mitra, Effect of disorder and isotope on the properties of a two orbital double exchange system, Physica B **404**, 2481 (2009).

17. Orbital ordering in undoped manganites via a generalized Peierls instability, S. Yarlagadda, P. B. Littlewood, M. Mitra, R. K. Monu, Phys. Rev. B **80**, 235123 (2009).

18. Santanu K. Maiti and S. N. Karmakar, Quantum transport through heterocyclic molecules, Int. J. Mod. Phys. B, **23**, 177 (2009).

19. Jayeeta Chowdhury, S. N. Karmakar, and Bibhas Bhattacharyya, Effect of external electric field on the charge density waves in one-dimensional Hubbard superlattices, J. Phys.: Condens. Matter, **21**, 015302 (2009).

20. Dynamics of path aggregation in the presence of turnover, Debasish Chaudhuri, Peter Borowski, P K Mohanty, Martin Zapotocky, Europhys. Lett. **87**, 20003 (2009)

21. Active Absorbing State Phase Transition Beyond Directed Percolation : A Class of Exactly Solvable Models, U. Basu and P. K. Mohanty, Phys. Rev. E **79**, 041143 (2009)

22. Phase diagram of the ABC model on an interval, A. Ayyer, E. A. Carlen, J. L. Lebowitz, P. K. Mohanty, D. Mukamel, E. Speer, J. Stat. Phys **137**, 1166 (2009)

23. A. Basu and E. Frey, Scaling and universality in coupled driven diffusive models, J. Stat. Mech., P08013 (2009).

2008

24. Reaching the ground state of a quantum spin glass using a zero-temperature quantum Monte Carlo method, A. Das and B. K. Chakrabarti, Phys. Rev. E **78**, 061121 (2008).

25. Quantum annealing and analog quantum computations, A. Das and B. K. Chakrabarti, Rev. Mod. Phys. **80**, 1061 (2008).

26. Two-fractal overlap time series: Earthquakes and market crashes, B. K. Chakrabarti, A. Chatterjee and P. Bhattacharyya, Pramana - J. Phys. **71**, 203 (2008).

27. The mean distance to the n-th neighbour in a uniform distribution of random points: an application of probability theory, P. Bhattacharyya and B.K. Chakrabarti, Eur. J. Phys. **29**, 639 (2008).

28. Neural network modeling, B. K. Chakrabarti and A. Basu, Models of brain and mind: Physical, Computational and Psychological approaches Prog. in Brain Research, **168**, 155 (2008).

29. A. N. Das and S. Sil, Thermodynamic properties of Holstein polarons and the effects of disorder, J. Phys.: Condens. Matter **20**, 345222 (2008).

30. R. Ramakumar and A. N. Das, Lattice Bosons in quartic confinement, Eur. Phys. J. D **47**, 203 (2008).

31. Analytical results for stochastically growing networks: connection to the zero range process, P. K. Mohanty and S. Jalan, Phys. Rev. **E 77**, 045102 (2008)

32. Modeling wealth distribution in growing markets, U. Basu and P. K. Mohanty, Eur. Phys. J. **B 65**, 585 (2008).

33. A. Basu, J. F. Joanny, F. Juelicher and J. Prost, Thermal and non-thermal fluctuations in active polar gels, Eur. Phys. J. E **27**, 149 (2008).

2007

34. Kinetic exchange models for income and wealth distributions, A. Chatterjee and B.K. Chakrabarti, Eur. Phys. J. B **60**, 135 (2007).

35. Kolmogorov dispersion for turbulence in porous media: A conjecture, B. K. Chakrabarti, Physica A **384**, 25 (2007).

36. Economic inequality: Is it natural ?, A. Chatterjee, S. Sinha and B. K. Chakrabarti, Current Science **92**, 1383 (2007).

37. Ideal-gas like market models with savings: quenched and annealed cases, A. Chatterjee and B. K. Chakrabarti, Physica A **382**, 36 (2007).

38. A common origin of the power law distributions in models of market and earthquake, P. Bhattacharyya, A. Chatterjee and B. K. Chakrabarti, Physica A **381** 377 (2007).

39. R. Ramakumar, A. N. Das and S. Sil, Studies of Bosons in optical lattices in a harmonic potential, Eur. Phys. J. D **42**, 309 (2007).

40. Phase transition and phase diagram at a general filling in the spinless one-dimensional Holstein Model, Sanjoy Datta and Sudhakar Yarlagadda, Phys. Rev. B **75**, 035124 (2007).

41. Jayeeta Chowdhury, S. N. Karmakar, and Bibhas Bhattacharyya, Ground state phase diagram and magnetoconductance of a one dimensional Hubbard superlattice at half-filling, Phys. Rev. B, **75**, 235117 (2007).

42. Energy diffusion in hard-point systems, L. Delfini, S. Denisov, S. Lepri, R. Livi, P. K. Mohanty and A. Politi, Eur. Phys. J. Special Topics **146**, 21 (2007)

43. Driven diffusive systems of active filament bundles, P. K. Mohanty and K. Kruse, J. Stat. Phys **128**, 95 (2007)

44. Why only few are so successful ?, P. K. Mohanty, Physica **A 384**, 75 (2007)

45. Critical Behavior of Sandpile Models with Sticky Grains, P. K. Mohanty and D. Dhar, Physica **A 384**, 34 (2007)

46. A. Basu and S. Ramaswamy, Perspectives on the mode-coupling approximation for the dynamics of interacting Brownian particles, J. Stat. Mech, P11003 (2007).

47. B. K. Chakrabarti and A. Basu, Neural network modeling in Models of Brain and Mind - Physical, Computational and Psychological Approaches, Eds: R. Banerjee and B. K. Chakrabarti, Progress in Brain Research, **168**, Pages 155-168, 270 (2007).

NAME: Bikas K. Chakrabarti (DOB: 14.12.'52)

EDUCATIONAL BACKGROUND:
B. Sc. (1971), M. Sc. (1973; degree in 1975 due to Political disturbances),
Ph. D. (1979): all from Calcutta University; Post-Doc at Oxford University (1979-'80)
and Cologne University (1980-'81)

Academic profile including earlier appointments, awards etc

ACADEMIC PROFILE INCLUDING EARLIER APPOINTMENTS:
Chakrabarti joined the faculty of the Saha Institute of Nuclear Physics in 1983, where he presently is a Senior Professor. He is also a Visiting Professor of Economics in Indian Statistical Institute. He also visited many esteemed Universities and Laboratories as Invited Visiting Scientist; also as Professeur Invité in University of Paris, UP13, Lab-PMTM, CNRS (1988) and in École Centrale Paris (2010).

AWARDS etc:
- Young Scientist Award of Indian National Science Academy, New Delhi (1984)
- Shanti Swarup Bhatnagar Award of the Council of Scientific and Industrial Research, India (1997)
- Fellow, Indian Academy of Sciences, Bangalore (Elected, 1997)
- Fellow, Indian National Science Academy, New Delhi (Elected, 2003)
- Outstanding Referee (Lifetime) Award of the American Physical Society (2010)

Essential strength of research/development output

RESEARCH/DEVELOPMENT:
The research activity of Chakrabarti is mainly focused on statistical physics, condensed matter physics, computational physics, and their application to social sciences. He is specifically interested in
- Fracture, Breakdown and Earthquake,
- Statistics of Polymers in Random Media,
- Dynamic Hysteresis and Transitions under Periodic and Stochastic Fields,
- Quantum Phase Transition, Quantum annealing & Computation in Spin Glass Models
- Physical and Computational Models of Mind and Brain
- Econophysics and Sociophysics

He has published many papers, reviews (and three books) in Physics, Economics and interdisciplinary journals, including three reviews in Reviews of Modern Physics (Am. Phys. Soc.). He is an author of about 160 scientific papers in leading international scientific journals. According to Web of Science, his papers have received more than 1700 citations and his Hirsch index is 23.

Future research/development plan

Apart from developing further the studies on Fracture/Breakdown properties of disordered solids and on Quantum Glasses/Computation, Chakrabarti intends to develop (along with others in the country) a strong group in Eonophysics research in India. Econophysics resarches of the SINP group, in particular, is quite well appreciated internationally & some of the recent citations include (mention of "Kolkata School" here might be noted!):
- Editorial of Topical Issue on Physics in Society, The European Physical Journal B, Vol 57 (2007) pp 121-125, incorporating 2 of SINP group, in an Editorial Choice-list of 21 "exemplifying pioneering" publications (earliest in 1872) in "Economy & Political Economy";
- Discussions on "pioneering" papers from "Chakrabarti's research group" (p 187; pp 185-206) in Applied Partial Differential Equations (by Peter A. Markowich, DAMTP, Cambridge) Springer-verlag, Berlin (2007);
- Entry by economist J. Barkley Rosser, Jr. on “Econophysics” in The New Palgrave Dictionary of Economics, 2nd Ed., Vol 2, Macmillan Publishers, NY (2008), pp 729-732, beginning with "According to Bikas Chakrabarti (...), the term 'econophysics' was neologized in 1995 at the second Statphys-Kolkata conference in Kolkata (formerly Calcutta), India ...",

- Discussions by Victor Yakovenko on "influential" (p. 2803) papers from "Kolkata School" (p. 2808) in Encyclopedia of Complexity and Systems Science, Vol. 3, Springer-verlag, New York (2009) pp. 2800-2826 (see also pp. 2792-2800);
- Discussions by Victor Yakovenko and J. Barkley Rosser, Jr. on "influential" (p. 1705) & "elegant" (p. 1711) papers from "Kolkata School" (p. 1711) in Reviews of Modern Physics, Vol. 81 (2009) pp. 1703-1725.

List of important publications starting with recent publications

BOOKS:

- *Econophysics: An Introduction* (with S. Sinha, A. Chatterjee & A. Chakraborti), Wiley-VCH, Berlin (2010; in Press)
- *Statistical Physics of Fracture & Breakdown in Disordered Systems* (with L. G. Benguigui), Oxford Univ. Press, Oxford (1997)
- *Quantum Ising Phases & Transitions in Transverse Ising Models* (with A. Dutta & P. Sen), Springer-Verlag, Heidelberg (1996) [Second Edition, on request from the Publisher Springer, with new set of coauthors, J-I. Inoue & S. Suzuki; Contract signed last year].

REVIEWS:

- *Failure Processes in Elastic Fiber Bundles* (with S. Pradhan & A. Hansen), Rev. Mod. Phys. 82 (2010) 499-555
- *Quantum Annealing and Analog Quantum Computations* (with A. Das), Rev. Mod. Phys. 80 (2008) 1061-1081
- *Kinetic Exchange Models for Income and Wealth Distributions* (with A. Chatterjee), Eur. Phys. J. B 60 (2007) 135-149
- *Dynamic Transitions and Hysteresis* (with M. Acharyya), Rev. Mod. Phys. 71 (1999) 847-863

LAST FIFTEEN (JOURNAL) PUBLICATIONS:

Scaling theory of quantum breakdown in solids, B. K. Chakrabarti and D. Samanta, Phys. Rev. B 81 (2010) 052301 • *Quantum phase transition in a disordered long-range transverse Ising antiferromagnet*, A. K. Chandra, J.-I. Inoue and B. K. Chakrabarti, Phys. Rev. E 81 (2010) 021101. • *A zero-temperature quantum Monte Carlo algorithm and quantum spin glasses*, A. Das, A. K. Chandra and B. K. Chakrabarti, Comp. Sc. Eng., IEEE 12 (2010) 64-72. • *Statistical theories of income and wealth distribution*, A. S. Chakrabarti and B. K. Chakrabarti, Economics E-Journal (open access) 4 (2010) 2010-4 (www.economics-ejournal.org/economics/journalarticles/2010-4). • *Microeconomics of the ideal gas like market model*, A. S. Chakrabarti and B. K. Chakrabarti, Physica A 388 (2009) 4151-4158. • *Fractal models of earthquake dynamics*, P. Bhattacharya, B. K. Chakrabarti, Kamal, and D. Samanta, Rev. Nonlin. Dyn. & Complexity (Wiley-VCH), 2 (2009) 107-158. • *The Kolkata Paise Restaurant Problem and resource utilization*, A. S. Chakrabarti, B. K. Chakrabarti, A. Chatterjee and M. Mitra, Physica A. 388 (2009) 2420-2426. • *A novel quantum transition in a fully frustrated transverse Ising antiferromagnet* , A. K. Chandra, J.-I. Inoue and B.K. Chakrabarti, J. Phys.: Conf. Ser. 143 (2009) 012013. • *Reaching the ground state of a quantum spin glass using a zero-temperature quantum Monte Carlo method*, A. Das and B. K. Chakrabarti, Phys. Rev. E 78 (2008) 061121. • *Two-fractal overlap time series: Earthquakes and market crashes*, B. K. Chakrabarti, A. Chatterjee and P. Bhattacharyya, Pramana - J. Phys. 71 (2008) 203-210. • *The mean distance to the n-th neighbour in a uniform distribution of random points: an application of probability theory*, P. Bhattacharyya and B.K. Chakrabarti, Eur. J. Phys. 29 (2008) 639-645. • *Kolmogorov dispersion for turbulence in porous media: A conjecture*, B. K. Chakrabarti, Physica A 384 (2007) 25-27. • *Kinetic market models with single commodity having price fluctuations*, A. Chatterjee and B. K. Chakrabarti, Eur. Phys. J. B 54 (2006) 399-404. • *Infinite-range Ising ferromagnet in time-dependent transverse field: dynamics near quantum critical point*, A. Das, K. Sengupta, D. Sen and B. K. Chakrabarti, Phys. Rev. B 74 (2006) 144423. • *Analysis of a long-range random field quantum antiferromagnetic Ising model*, B. K. Chakrabarti, A. Das, J-I. Inoue, Eur. Phys. J. B 51 (2006) 321-329.

1. Name : Atindra Nath Das

Educational qualifications: M.Sc. (1974), Post M.Sc. (SINP, 1975-76), Ph.D.(Phys.) (Calcutta University, 1982).

2. Academic profile:

Research Fellow	SINP	1976-77
Lecturer	Kandi Raj College, Kandi	1978-1985
Faculty member	SINP	1985 to date
Visiting Scientist	Universite Paris Nord, France	1990-91

3. Essential strength of research/development output:

In the field of structural phase transitions explained (i) the anomalous thermal expansion below the transition temperature (T_c), (ii) the change in the frequency and linewidth of an internal mode in some Fluotitanates near T_c, (iii) the pressure dependence of the thermal hysteresis as observed for many first order transitions.

The superconducting phase diagram and other relevant properties in the context of high-T_c systems were studied using Hubbard and Holstein-Hubbard models. An improved pair tunneling model was developed. Phonon-based pairing using extended van-Hove singularity was also studied.

In the field of polarons a cross-over from small-to-large polaron crossover is shown in context to high-T_c systems. A perturbation method based on modified Lang-Firsov phonon basis was developed for Holstein model to achieve very good convergence in almost entire region of coupling. Possibilty of a ferromagnetic insulating phase between ferromagnetic metallic and AF insulating phase is shown theoretically for manganites. The effect of dispersive phonons on the polaron crossover, the coherent and incoherent motion of polarons and the effect of disorder on polaronic properties were studied.

Bose condensation and specific heat were studied for Bosons in optical lattices under harmonic and quartic potentials for different dimensions. The effect of anisotropic trap has been found to be very interesting for optical lattices.

4. **Future research/development plan:**

(i) Anisotropic harmonic trap yields a very interesting density of states. We have planned to study various properties of fermions and mixture of fermions and bosons under such trap in presence of different interactions.

(ii) Planeed for detailed exact studies of Holstein polarons including the effect of extended interaction, off-diagonal coupling, second nearest-neighbor hopping on size, effective mass, band dispersion, coherent and incoherent part of the kinetic energy, etc. of polarons.

5. List of important publications starting with recent publications:

Published Seventy eight (78) papers in reputed International Journals with the 'sum of the times Cited'= 678 and 'h-index'= 15. A list of some of the important papers is given below:

1. A. N. Das and S. Sil, Thermodynamic properties of Holstein polarons and the effects of disorder, J. Phys.: Condens. Matter **20**, 345222 (2008).
2. R. Ramakumar and A. N. Das, Bose-Einstein condensation in tight-binding bands, Phys. Rev. B **72**, 094301 (2005).
3. Marco Zoli and A. N. Das, Polaron crossover in molecular solids, J. Phys.: Condens. Matter **16**, 3597 (2004).
4. J. Chatterjee, M. Mitra and A. N. Das, Magnetic transition and polaron crossover in a two-site single polaron model including double exchange interaction, Euro. Phys. Jour. B **18**, 573 (2000).
5. J. Chatterjee and A. N. Das, Comparison of perturbative expansions using different phonon bases for the two-site Holstein model, Phys. Rev. B**61**, 4592 (2000).
6. A. N. Das and P. Choudhury: Stability and nature of polarons in a two-site two-electron model, Phys. Rev. B **49**, 13219 (1994).
7. Sujit Sarkar and A. N. Das: Isotope-shift exponent, pressure coefficient of T_c and the superconducting-gap ratio within the van Hove scenario, Phys. Rev. B **49**, 13070 (1994).
8. A. N. Das and S. Sil : A study of the polaronic band width and the small-to-large polaron transition in a many-polaron system, J. Phys.: Condens. Matter **5**, 8265 (1993).
9. A. N. Das, J. Konior, D. K. Ray and A. M. Oles: Superconductivity in a strongly correlated anisotropic 3-dimensional system, Phys. Rev. B **44**, 7680 (1991).
10. A. N. Das, J. Konior and D. K. Ray: Hole-phonon interaction in a strongly correlated Hubbard system, Physica C **170**, 215 (1990).
11. A. N. Das, B. Ghosh and P. Choudhury: Superconductivity, antiferromagnetism, Hall coefficient and the thermoelectric power for a single-band Hubbard model, Physica C **158**, 311 (1989).
12. A. N. Das and B. Ghosh : Effect of pressure on the thermal hysteresis of a first order transition, J. Phys. C: Solid State Phys. **16**, 1799 (1983).

Asok K Sen

Education

- 1975 M.Sc. (Applied Mathematics) Jadavpur University, Kolkata, India
- 1982 M.S. (Physics) Ohio State University, Columbus, OH, USA
- 1985 Ph.D. (Physics) Ohio State University, Columbus, OH, USA

Career Profile:

- 1985 - 1986 Visiting Scientist, Cornell University, Ithaca, NY, USA
- 1986 - 1988 Post-doctoral fellow, N.C. State Univ., Raleigh, NC, USA
- 1988 - 1989 Post-doctoral fellow, Univ. of Houston, TX, USA
- 1989 - 1993 Reader, SINP, Kolkata, India
- 1993 - 1998 Assoc. Professor, SINP, Kolkata, India
- 1998 - 2007 Professor 'F', SINP, Kolkata, India
- 2007 - to date Professor 'G', SINP, Kolkata, India

Awards/Distinctions:

- Elected SENIOR ASSOCIATE of the Abdus Salam International Centre for Theoretical Physics (AS-ICTP), Trieste, Italy (1998 - 2004)

- Awarded a 3-years' Indo-Ukrainian Research Project (DST) on "Electronic Transport in Low-dimensional Meso/Nano-sized Quantum Systems" as PrincipalInvestigator with co-investigator, Prof. Abhijit Mookerjee of SNBNCBS (2001).

Research Interests:

Statistical/ Condensed Matter Physics (Theory), Electronic Structure and Transport, Non-Hermitean hamiltonians, Quantum Coherence/ Decoherence, Q. Phase Transitions, Critical Phenomena, Wetting Transitions, Disordered/ Interacting Low-dimensional Systems, Wetting Transitions, Soft-condensed Matter, Nonlinear Response, Breakdown, Non-Debye (Power-law) Relaxation, Hysteresis, 1/f-noise etc. in Complex Systems, Numerical Methods.

Selected publications:

1.New possibilities for obtaining a steep nonlinear current-voltage characteristics in some semiconductor structures
Sheka DI, Tretyak OV, Korol AM, Sen AK, Mookerjee A
INTERNATIONAL JOURNAL OF MODERN PHYSICS B, to be published (2010);
available as arXiv:0905.2142v1 [cond-mat.mes-hall]

2. Two early-stage inverse power law dynamics in nonlinear complex systems far from equilibrium
Bhattacharya S, Sen AK
EUROPHYSICS LETTERS Volume: 71, 797 (2005)

3. Frequency-dependent conduction in disordered composites: A percolative study
Sen AK, Gupta AK
PHYSICAL REVIEW B Volume: 59, 9167 (1999)

4. The effect of non-linearity on one-dimensional periodic and disordered lattices
Senouci K, Zekri N, Bahlouli H, et al.
JOURNAL OF PHYSICS-CONDENSED MATTER Volume: 11, 1823 (1999)

5. Amplification or reduction of backscattering in a coherently amplifying or absorbing disordered chain
Sen AK
PHYSICA A-STATISTICAL MECHANICS AND ITS APPLICATIONS 261, 340 (1998)

6. Amplification and disorder effects in a Kronig-Penney chain of active potentials
Zekri N, Bahlouli H, Sen AK
JOURNAL OF PHYSICS-CONDENSED MATTER 10, 2405 (1998)

7. Aspects of dielectric breakdown in a model for disordered non-linear composites
Gupta AK, Sen AK
PHYSICA A247, 30 (1997)

8. Phase distribution in a disordered chain and the emergence of a two-parameter scaling in the quasiballistic to the mildly localized regime
Sen AK
MODERN PHYSICS LETTERS B11, 555 (1997)

9. Backscattering and the decay of transmittance in a coherently absorbing or amplifying ordered chain
Sen AK
MODERN PHYSICS LETTERS B10, 125 (1996)

10. Conductance and its fluctuations in disordered systems: Scaling behavior from ballistic to localized limit, Ganguli MN, Sen AK,
PHYSICAL REVIEW B52, 17342 (1995)

1. **Name: SACHINDRA NATH KARMAKAR**

2. Division: Theoretical Condensed Matter Physics Division
3. Present position and grade: Professor `G'
4. Academic qualifications: Ph.D. (Sc.), University of Calcutta, 1989
5. Postdoctoral positions: Research Associate at SINP from 11.12.1989 to 05.12.1990
6. Employments: Permanent faculty of SINP since December 6, 1990
7. Academic recognitions: Enrolled as referee for the following journals
    - Physical Review Letters
    - Physical Review B
    - Journal of Physics: Condensed Matter
    - Journal of Physics A: Math & Gen
    - Journal of Optics: Pure & Applied Optics
    - New Journal of Physics
    - Physica B
    - Indian Journal of Pure & Applied Physics
8. Research output:
    - Articles in referred journals: 35
    - Book publications: \Physics of Zero and One Dimensional Nanoscopic Systems", Springer Series in Solid
    - State Sciences, Vol.-156, Springer, Germany, 2007
    - Total citation: 367
    - Average citation: 10.49
    - H-index: 10
9. Ph.D. students:
    - Completed: 3
    - Ongoing: 3
10. Other academic records:
    - Teaching regularly in the Post-M.Sc. Physics Course of SINP, and, the M.Sc. Physics course of Tripura University, Agartala and Bengal Engineering & Science University, Kolkata
    - Invited speaker in several conferences
    - Paper-setter and examiner for the M.Sc. examinations of Jadavpur University, Burdwan University, Tripura University and Bengal Engineering & Science University
    - Moderator in physics for the M.Sc. Physics Examination of Tripura University
    - Examiner of the Ph.D. thesis of seven students
    - Member, Selection Committee for Reader, Department of Physics, Tripura University, Agartala
    - Member, Ph.D. Committee in Physics, Tripura University, Agartala
    - Convener, International Workshop on the Physics of Zero and One Dimensional Nanoscopic Systems" held at SINP, Kolkata-700 064, India (February 1-9, 2006)
11. Research interests: Physics of Mesoscopic & Nanoscopic Systems, Quasiperiodic Systems, Disordered Solids, Itinerant Magnets and Linear Polymers.

12. Highlights of research:

    Proposed a magnetic quantum device which acts as a spin filter.Exact numerical calculations revealed that in the mesoscopic normal metal rings electron-electron interaction produces anomalous Aharonov-Bohm oscillations in the persistent currents and these findings corroborate the experimental observations.Shown that the anomaly between theory and experiment regarding the amplitudes of the persistent currents in the mesoscopic normal metal rings can be resolved by including second-nearest-neighbor hopping integrals in the usual nearest-neighbor tight-binding Hamiltonian. Obtained the ground state phase diagram and magnetoconductance of a one-dimensional Hubbard super-lattice at half-filling.Shown analytically that contrary to the common notion, the aperiodic Thue-Morse lattice supports only extended electronic eigenstates due to the presence of a new type of correlated disorder. Hierarchies of extended states appear in the quasiperiodic copper-mean and period-doubling lattices due to the existence of dimer-type correlation among the atoms. Introduced an exact renormalization group technique for finding the dynamic structure factor of the quasiperiodic lattices Developed an exact decimation scheme for evaluating the eigenvalues and eigenfunctions of the quasiperiodic systems.

13. Future research plan:
Recently we have focused our interests on nanoscience, a rapidly emerging field that will most likely have a significant impact on the future of science and technology. We will study the conduction behavior of quantum dots, quantum wires, and molecular bridge systems. We will also work on spintronics and address spin transport problem in the presence of both Coulomb and spin-orbit interactions. The physics of graphene is very fascinating and we have an intention to study the behavior of massless Dirac fermions of graphene taking into account electron-electron interaction. We will also address the fundamental questions about metal-insulator transition in the presence of electron-electron interaction in disordered two-dimensional systems, quantum Hall conductance in heterostructures, and Kondo conductance in quantum dots. We will investigate the behavior of persistent current in quantum networks where interplay between disorder, electron-electron interaction and quantum coherence becomes very important.

14. List of important publications:

- Moumita Dey, Santanu K. Maiti & S. N. Karmakar, Magnetic quantum wire as a spin filter: An exact study, Phys. Lett. A 374, 1522 (2010)
- Paramita Dutta, Santanu K. Maiti & S. N. Karmakar, Multi-terminal electron transport through a phenalenyl molecule: A theoretical study, Organic Electronics, 11, 1120 (2010)
- Jayeeta Chowdhury, S. N. Karmakar & Bibhas Bhattacharyya, Ground state phase diagram and magneto-conductance of a one dimensional Hubbard superlattice at half-filling, Phys. Rev. B, 75, 235117 (2007)
- Santanu K. Maiti, J. Chowdhury & S. N. Karmakar, Strange behavior of persistent currents in small Hubbard rings, Phys. Lett. A, 332, 497 (2004)
- Anathnath Ghosh & S. N. Karmakar, Trace map of a general aperiodic Thue-Morse chain: Electronic properties, Phys. Rev. B, 58, 2586 (1998)
- Anathnath Ghosh & S. N. Karmakar, Periodic features in the dynamic structure factor of the quasiperiodic period-doubling lattice, Phys. Rev. B, 57, 2834 (1998)
- Arunava Chakrabarti, S. N. Karmakar & R. K. Moitra, Role of a new type of correlated disorder in extended electronic states in the Thue-Morse lattice, Phys. Rev. Lett., 74, 1403 (1995)
- Arunava Chakrabarti, S. N. Karmakar & R. K. Moitra, Renormalization group analysis of extended elec-tronic states in one-dimensional quasiperiodic lattices, Phys. Rev. B, 50, 13276 (1994)
- S. Sil, S. N. Karmakar, R. K. Moitra & Arunava Chakrabarti, Extended states in one-dimensional lattices: Application to the quasiperiodic copper-mean chain, Phys. Rev. B (Rapid Communication), 48, 4192 (1993)
- Arunava Chakrabarti & S. N. Karmakar, Renormalization group method for exact Green's functions of self-similar lattices: Application to generalized Fibonacci chains, Phys. Rev. B (Rapid Communication), 44, 896 (1991)

Name : Sudhakar Yarlagadda (Prof. G, Theor. Cond. Mat. Phys. Div.)

Educational Background:

1) Bachelors: IIT Kanpur (9.3/10.0 CPI)
2) MS & Phd (1989) in Cond. Mat. Phys. (5.96/6.0 GPA, Purdue Univ., USA)
3) Postdoc at MPI (Stuttgart) and NTT Basic Research Labs

Academic Profile (earlier appointments, awards, etc.):

1) Asst. Prof. at IIT Delhi; 1995–1996
2) Visiting faculty at Univ. of Houston for about 2 years (starting Jan. 2000)
3) Visiting Fellow at Univ. of Cambridge for 1 year (starting April 2007)
4) Visitor at KITP, Santa Barbara for 2 months (Oct. to Dec., '07) and for 6 weeks (May-June, '09)
5) Center for Applied Mathematics and Computational Science (CAMCS) was a result of my proposal being selected by the DAE-collective-vision-development-for-future meeting held at BARC.
6) David Ross Fellowship at Purdue Univ.; Certificates of Merit at IIT Kanpur; State Special Merit Scholarship, 1973-1980; and National Science Talent Scholarship in Mathematics.
7) One of the editors of proceedings of the International Conference on Strongly Correlated Electron Systems [IJMPB **15** Nos. 19&20 (2001)] and proceedings of the International Workshop on Econophysics of Wealth Distributions (Springer 2005).
8) Referee for PRL, PRB, etc; Chaired sessions in intl. confs. (at IISc, TIFR, IMSc, SN Bose, IITK)
9) Gave more than 10 talks at international conferences and 10 talks at national confs.
10) Taught advanced courses in many-body physics, condensed matter physics, magnetism, etc.

Essential strength of research output:

We derived a quasiparticle pseudo Hamiltonian of an infinitesimally polarized electron gas which fully takes into account the many-body effects of both charge and spin density fluctuations. We calculated self-consistently Fermi liquid parameters like the effective mass, the effective g-factor, spin susceptibility in 2D systems and found fair agreement with experiments. My works on electron gas [see especially PRB **38** 10966 (1988); PRB **40** 5432, (1990); PRB **49** 7887 (1994); PRB **49** 14188 (1994); PRB **61** 12556 (2000)] are well recognized and many distinguished scientists (including Nobel prize winners) cite them. In fact, in the book "Quantum Theory of the Electron Liquid" (Cambridge 2005) by G. F. Giuliani and G. Vignale, my works form a major theme of Chapter 8.

I had predicted a novel magnetization instability in the quantum Hall effect regime [PRB **44** 13101 (1991)] and the proposed experiment (measuring diagonal resistivity) was carried out by K. von Klitzing *et al.* [PRB **47** 4048 (1993)] and the instability was explicitly demonstrated. The prediction was also verified by Mike Pepper *et al.* [PRL **79**, 4449, (1997)] through activation transport studies. Several Nobel prize winners (such as H. L. Stormer, D. C. Tsui, K. v. Klitzing, and H. Kroemer) and Buckley prize winners (such as J. K. Jain, A. H. MacDonald, and S. M. Girvin) cite this work.

We develop a framework to analyze the distribution of wealth in societies [Physica A, **353** 529 (2005)] by using Boltzmann transport theory. We derive the distribution of wealth analytically by proposing a new trading model for the wealthy and obtain power-law (Pareto-like) behavior.

My paper on colossal magnetoresistance [PRB, **62** 14828 (2000)] contains some interesting ideas.

Recently, (using novel approaches) we solved the long-standing problem of analytically obtaining the Peierls instability condition in the Holstein model [PRB, **75** 035124 (2007) and PRB, **71**, 235118 (2005)] and predicted the phase diagram away from half-filling. We corrected serious errors in the effective polaronic Hamiltonian derived by Hirsch and Fradkin [PRB **27**, 4302 (1983)]. We showed that the ground state orbital ordering of $LaMnO_3$ can be explained using even weak electron-phonon coupling [PRB **80**, 235123 (2009)]. We determined the orbital ordering by extending to the $LaMnO_3$ Jahn-Teller system our recently developed Peierls instability framework for the Holstein model.

I proposed a new model (arXiv:0712.0366) to understand cooperative Jahn-Teller effect. The model involves a next-nearest-neighbor (NNN) hopping and nearest-neighbor (NN) repulsion. The model predicts a dramatic first-order transition at a critical interaction strength.

We derived an effective d-dimensional Hamiltonian for a system of hard-core-bosons coupled to optical phonons in a lattice (arXiv:0907.3543). We demonstrated that the presence of NNN hopping and NN repulsion leads to supersolidity (i.e., homogeneous coexistence of CDW and a superfluid).

Future research plan:

1) Study the Hubbard-Holstein model so as to take into account both electron-electron interactions and electron-phonon interactions. Many strongly correlated systems have both interactions.
2) Study coexistence of diagonal long range order (CDW or SDW) and off diagonal long range order (superconductivity/superfluidity). Possible real system examples are dichalcogenides, helium-4, bismuthates, iron based superconductors, etc.
3) Study cooperative Jahn-Teller interaction in manganites. To understand orbital ordering along with other orderings (i.e., charge and spin) one needs to model cooperative electron-phonon interaction taking into account quantum phonons.
4) Study of entanglement around phase transitions. Entanglement may yield additional information beyond usual correlation functions and order parameters. Understanding entanglement is useful in non-equilibrium processes as well.
5) Econophysics of wealth distribution of nations and many-body correlations.

List of important publications:

1) "Supersolidity in a Bose-Holstein model", S. Datta and S. Yarlagadda, arXiv:0907.3543.
2) "Orbital ordering in undoped manganites via a generalized Peierls instability", S. Yarlagadda, P. B. Littlewood, M. Mitra, and R. K. Monu, Phys. Rev. B **80**, 235123 (2009).
3) "Cooperative electron-phonon interaction in molecular chains", Sudhakar Yarlagadda, arXiv:0712.0366.
4) "Phase transition and phase diagram at a general filling in the spinless one-dimensional Holstein Model", S. Datta and S. Yarlagadda, Phys. Rev. B, **75** 035124 (2007).
5) "Many-Polaron Effects in the Holstein Model", Sanjoy Datta, Arnab Das, and Sudhakar Yarlagadda, Phys. Rev. B, **71** 235118 (2005).
6) "An analytic treatment of the Gibbs-Pareto behavior in wealth distribution", Arnab Das and Sudhakar Yarlagadda, Physica A, **353** 529 (2005).
7) "Jahn-Teller polarons and their superconductivity in a molecular conductor", R. Ramakumar and S. Yarlagadda, Phys. Rev. B., **69** 104519 (2004).
8) "Holstein polarons, Frohlich coupling and superconductivity in a molecular conductor", R. Ramakumar and Sudhakar Yarlagadda, Phys. Rev. B, **67** 214502 (2003).
9) "Analytic treatment of a trading market model", A. Das and S. Yarlagadda, Physica Scripta T**106**, 39 (2003).
10) "Screened interaction and self-energy in an infinitesimally polarized electron gas via Kukkonen-Overhauser method", S. Yarlagadda and G. F. Giuliani, Phys. Rev. B, **61** 12556 (2000).
11) "Mixed charge-spin response functions of an arbitrarily polarized electron gas", S. Yarlagadda, Solid State Commun., **116** 167 (2000).
12) "Colossal magnetoresistance using the small polaron picture with finite band width effects", S. Yarlagadda, Phys. Rev. B, **62** 14828 (2000).
13) "Many-body local fields and Fermi liquid parameters in a quasi-two-dimensional electron liquid", S. Yarlagadda and G. F. Giuliani, Phys. Rev. B. **49**, 14188 (1994).
14) "Landau theory of the Fermi liquids and the integration-over-the-coupling-constant algorithm", S. Yarlagadda and G. F. Giuliani, Phys. Rev. B. **49**, 14172 (1994).
15) "Quasiparticle pseudo hamiltonian of an infinitesimally polarized Fermi liquid", S. Yarlagadda and G. F. Giuliani, Phys. Rev. B. **49**, 7887 (1994).
16) "Fermi liquid theory in the low density two-dimensional Hubbard model", S. Yarlagadda and S. Kurihara, Phys. Rev. B. **48**, 10567 (1993).
17) "Negative thermodynamic density of states and charge density wave instability in the lowest Landau level", S. Yarlagadda, Phys. Rev. B **48**, 4707 (1993).
18) "Magnetization instabilities at tilted magnetic fields in the quantum Hall regime", S. Yarlagadda, Phys. Rev. B **44**, 13101 (1991).
19) "Spin susceptibility in a two-dimensional electron gas", S. Yarlagadda and G. F. Giuliani, Phys. Rev. B **40**, 5432 (1989).
20) "Many-body effective mass and anomalous g factor in inversion layers", S. Yarlagadda and G. F. Giuliani, Phys. Rev. B **38**, 10966 (1988).

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I. CAREER PROFILE

•**Ph.D.** in August 2000 from Harischandra Research Institute,Allahabad, India •**Postdoctoral Fellow**, Tata Institute of Fundamental Research, Mumbai, India (Aug'00- Sept'02) •**Feinberg Fellow**, Weizmann Institute of Science, Israel (Sept'02- Sept'04) •**Visiting Scientist**, MaxPlank Institute(PKS), Dresden, Germany (Sept'04-Oct'05) •**Associate Professor**, Saha Institute of Nuclear Physics (Nov'05- Aug'08) • **Professor**, Saha Institute of Nuclear Physics (Aug'08-)

II. RESEARCH INTERESTS

I am a theoretical physicist working in the general area of non-equilibrium statistical physics and its application to some interdisciplinary science, like econo-physics and bio-physics. Summary of some of my selected research works follows. I would like to pursue future research in three important directions : **i)** Novel-correlations in non-equilibrium steady states, **ii)** Absorbing state phase transitions beyond directed percolation (DP), and **iii)** micoRNA co-target network and its implications.

Exact Solutions : Classical non-equilibrium systems do not ensure existence of the state functions like Hamiltonian and entropy as these systems are known to have non-zero current in the configutaion space. Thus the steady states of these systems posses interesting and non-trivial correlations which are usually absent in equilibrium. One of my main research interest is to unfold these novel correlations. Recently we propose a method[14] which can provide an exact steady state and spatial correlations in a class of non-equilibrium models. The method has been used successfully in Extended Katz Lebowitz Spoon (EKLS) model, Restricted Assymetric Exclusion Process (RASEP)[11], Exclusion process with internal degrees of freedom[17], Tonks gas, DNA denaturation transition etc..

Explosive Percolation : In general, the nonequilibrium systems are modeled by the stochastic dynamics, which dictates the transition from one configuration to the other. Sometimes one encounters configurations which are absorbing: once in such a configuration the system never escapes. A transition from an inactive state to an active phase is usually termed as an active absorbing phase transition (AAPT), which generically belongs to the Directed Percolation (DP) universality class. Many other non-equilibrium phase transitions, like synchronization, roughening are known to be in the DP class. Recently a generic Langevin equation is proposed [Muñoz *et. al.*, PRL 2003] to capture these seemingly different phenomena under one umbrella. These theories predict that such transitions are either continuous, belonging to the DP or Karder Parisi Zhang universality class, or it is discontinuous. Discontinuous transitions have been seen in the context of surface growth. In 2004, we demonstrated[20] the first order synchronization transition and recently we have been able to show that such first order transitions can appear as a bond percolation[18] in any dimension (including 1-d).

Sand pile models and DP : Sand-pile models (SPM) are prototype examples of self organized critilacity. If sand grains are dropped at the at the top of the conical sand-pile, grains flow down wards. The propagation of activity on the surface of a sand pile is similar to that of the percolation of infection in DP, however the universality classes of SPM are known to be different from DP. We claim that the SPM are unstable against certain specific kinds of perturbations called "stickiness" and generically flow to the robust DP fixed point.

AAPT beyond DP : It is important to note the following. Even though, the generic AAPT belongs to DP class, the queen of non-equilibrium phase transitions, there are several other AAPT which are different from DP. Departure from DP is a less understood area and I am trying to understand these sytems by studying some simple tractable models. Recently we introduce a model, namely RASEP[11], where hard core particles on a ring can move to one of the neighbouring vacant sites when the other neighbour is occupied. This model shows AAPT different from DP at density $\rho = 1/2$. The spatial correlations and the exact critical exponents are obtained analytically. The orderparameter of the model satisfies the requirements of DP-conjecture and we are trying to reason why this class of models shows non-DP behaviour.

Econo-physics : A year old law in economics, namely Pareto law, states that the wealth of rich people in any socity follows a power-law distribution, which is modelled recently [Chatterjee *et. al.*, Physica **A** 2004]. We could solve these models exactly[1] and show why one gets a power law distribution of wealth, even when agents interact through a conserving dynamics. In a later work, we emphasize that conservation of wealth is not an important criterion[8] in modelling Pareto distribution and show an explicit example of growing market which results in same phenomenon.

Bio-physics : In the application front we have modeled some of the biological systems. In a recent article we show how (1200 different kinds of) axons from the nasal epithelium of mamals grow[10] in the post natal stage and organize into fascicules in the absence of chemical guiding cues. In a different study we have modelled[4] the contactile ring that is formed by actines at the center of the cell during cell divison and explained what makes the contractile ring to shrink.

miRNA co-target network : One of the main research activity which I am going to pursue in future is the microRNA co-target networks in Biology. microRNAs (miRNA) are small (about 23 base long) RNAs transcribed from the DNA. These miRNAs usually downregulate gene-expression by binding themselves to the UTRs of the mRNAs which translates into proteins. The diversity of miRNA targets offer enormous level of combinatorial possibilities by forming complex regulatory networks; constructed from the pairwise co-targets of miRNAs. It turns out that these relevant set of miRNAs form several small *clusters*. We claim that the miRNA clusters are building blocks of biological functions as many of these clusters are expressed maximally in specific tissues[13]. Those miRNAs which are known to deregulate the genes involved in genetic diseases are also found to be cluster specific. Our recent study of 20 other animals also indicate that the clustering of miRNAs is a universal feature. Thus, we propose that the genes are better regulated by co-targeting of clusters of miRNAs, compared to individual regulation. We are planning some experiments here (SINP) to verify this.

We sincerely believe that these studies will help biologists in their search for miRNAs that target the genes involved in any specicific phenotypes. Recently we started collaborating with U. Kolthur in TIFR, Mumbai on glucose metabolism. We are also trying to study (with A. Erzan and E. Gungor ITU, Istanbul) the the relevant set of miRNAs involved in Mediterian Fever.

In all these studies the weighted network of miRNA pairs is created from the number of common targets (genes) they have. One can construct similar networks from the common disease or the common Transcription factors and obtain miRNA clusters. It is important to compare these clusters obtained from different scenarios. We are planning to built a database of miRNA clusters at SINP.

[•] **Publications :**

———————————**2006**———————————

[1] *Generic features of the wealth distribution in ideal-gas-like markets*, P. K. Mohanty, Phys. Rev. **E 74**, 011117 (2006)

[2] *A new approach to partial synchronization in globally coupled rotators* P. K. Mohanty and A. Politi, J. Phys. **A 39**, L415 (2006)

———————————**2007**———————————-

[3] *Energy diffusion in hard-point systems*, L. Delfini, S. Denisov, S. Lepri, R. Livi, P. K. Mohanty and A. Politi, Eur. Phys. J. Special Topics **146**, 21 (2007)

[4] *Driven diffusive systems of active filament bundles*, P. K. Mohanty and K. Kruse, J. Stat. Phys **128**, 95 (2007)

[5] *Why only few are so successful ?*, P. K. Mohanty, Physica **A 384**, 75 (2007)

[6] *Critical Behavior of Sandpile Models with Sticky Grains,* P. K. Mohanty and D. Dhar, Physica **A 384**, 34 (2007)

———————————**2008**———————————

[7] *Analytical results for stochastically growing networks: connection to the zero range process*, P. K. Mohanty and S. Jalan, Phys. Rev. **E 77**, 045102 (2008)

[8] *Modeling wealth distribution in growing markets*, U. Basu and P. K. Mohanty , Eur. Phys. J. **B 65**, 585 (2008).

[9] Stochastic Modeling of Single Molecule Michaelis Menten Kinetics M. Basu and P. K. Mohanty (arXiv:0901.2844)

———————————**2009**———————————

[10] *Dynamics of path aggregation in the presence of turnover*, Debasish Chaudhuri, Peter Borowski, PKM, Martin Zapotocky, Europhys. **Lett. 87**, 20003 (2009)

[11] *Active Absorbing State Phase Transition Beyond Directed Percolation : A Class of Exactly Solvable Models*, U. Basu and P. K. Mohanty, Phys. Rev. E **79**, 041143 (2009)

[12] *Phase diagram of the ABC model on an interval*, A. Ayyer, E. A. Carlen, J. L. Lebowitz, P. K. Mohanty, D. Mukamel, E. Speer, J. Stat. Phys **137**, 1166 (2009)

[13] *Micro RNA Interaction Network in Human*, S. Mookherjee, M. Sinha, S. Mukhopadhyay, N P Bhattacharyya and P. K. Mohanty, Online Jnl. of Bio-informatics **10**, 280, 2009

———————————**2010**———————————

[14] *Particle Ordering in Zero Range Process : Exact spatial correlations of the corresponding exclusion models*, U Basu and P. K. Mohanty, J. Stat. Mech. L03006 (2010).

[15] *Two-dimensional random walk in a bounded domain*, M Basu and P. K. Mohanty, Europhys. Lett. **90**, 50005(2010)

[16] *Asymmetric Simple Exclusion Process on a Cayley Tree*, M. Basu and P. K. Mohanty (arXiv:0910.5885)

[17] *TASEP on a ring with internal degrees of freedom*, U. Basu and P. K. Mohanty (*communicated*)

[18] *Explosive Bond Percolation in one and higher dimensions*, M. Basu, U. Basu, A. Kundu and P. K. Mohanty (*in preparation*).

—————**Older works**(*selected*)—————

[19] *Generic Sandpile Models Have Directed Percolation Exponents*, P. K. Mohanty and D. Dhar, Phys. Rev. **Lett. 89**, 104303 (2002).

[20] *First-order Synchronization Transition in Locally Coupled Maps*, P. K. Mohanty, Phys. Rev. E 70, 045202(R) (2004).

[21] *Modelling one-dimensional driven diffusive systems by the Zero-Range Process*, M. R. Evans, E. Levine, P. K. Mohanty, D. Mukamel Euro. Phys. J. **B 41**, 223 (2004)

• Name: **Abhik Basu**

• Education qualification:

– B. Sc in Physics in Presidency College, University of Calcutta, Calcutta, India(1992).

– M. S. in Physics at Indian Institute of Science, Bangalore, India (1996).

– Ph.D at Indian Institute of Science, Bangalore, India (2000).

• Professional experience (a) Professor F, Saha Institute of Nuclear Physics, Calcutta, India (February 2009 - present).

(a)Associate Professor E, Saha Institute of Nuclear Physics, Calcutta, India (August 2006 - February 2009).

(b)Distinguished PKS postdoctoral Fellow, Max-Planck-Institut f¨ur Physik Komplexer Systeme, Dresden, Germany (January 2005 - August 2006).

(c)Guest Scientist, Max-Planck-Institut f¨ur Physik Komplexer Systeme, Dresden, Germany (September 2004 - December 2004).

(d)Alexander von Humboldt Fellow

(e)Fellow, Poornaprajna Institute of Scientific Research, Bangalore (September 2002 - September 2005).

(f)Guest Scientist at the Hahn-Meitner Institute, Berlin, Germany, from July 1 to September 30, 2001, and from March 28 to May 22, 2002.

(g)Poornaprajna Research Scientist, working as a post-doctoral fellow at the Department of Physics, IISc, Bangalore, India (1999- August 2002).

• Research Strength

Our research strength has been the broad areas of physics of systems driven out of equilibrium. All natural systems are nonequilibrium systems (typically) due to external energy supplies. We have studied such systems from the perspectives of nonequilibrium statistical mechanics. In particular, we have been involved in problems of statistical mechanics of driven, dissipative system such as fluid and magnetohydrodynamic (MHD) turbulence, and surface growth models. We have investigated scaling properties of different time independent and time dependent correlation functions of the relevant dynamical variables in the models. More recently, we have been interested in theoretical studies of driven soft-matter and biological systems, e.g., dynamics of semiflexible polymers under various kinds of fluid flows, mode-coupling theories of self-diffusing colloids interacting via a pairwise potential and the dynamics of visco-elastic active gels.

• Future Research Plan

In the near future we intend to focus on the nonequilibrium dynamics and phase transitions of two-dimensional (2d) systems. Equilibrium systems in 2d do not undergo usual order-disorder phase transitions, which can be explained within the framework of the Mermin-Wagner theorem. In contrast to more conventional phase transitions in 3d, phase transitions in 2d are induced and controlled by topological defects. Classical 2d XY is a simple model exhibiting such topological phase transitions. Compared to the extensive studies of 2d phase transitions, such studies for nonequilibrium are still in their infancies. Biological and soft-matter systems provide natural examples where nonequilibrium analogues of equilibrium topological phase transitions are expected to be of importance. Specific examples include dynamics of cortical actins in eukaryotic cells, fluctuation properties of biomembranes, dynamics of shear induced melting of laser induced freezing etc. Our preliminary studies in the context of simple model systems already yield qualitatively new results in the form of continuously varying universality classes. We believe studies of realistic 2d systems of biological or soft-matter origin, should shed further light on the physics of collective phenomena in such systems and will yield results all of which may be tested in controlled experiments.

• Head, Max-Planck Partner Group at the Saha Institute of Nuclear Physics, Calcutta, India, supported by the Department of Science and Technology (India) and Max-Planck-Society (Germany) for a period 2009-2011.

• List of important publications

– A. Basu and E. Frey, Scaling and universality in coupled driven diffusive models, J. Stat. Mech., P08013 (2009).
– A. Basu, J. F. Joanny, F. J¨ulicher and J. Prost, Thermal and non-thermal fluctuations in active polar gels, accepted and to appear in Eur. Phys. J. E (2008).
– A. Basu and S. Ramaswamy, Perspectives on the mode-coupling approximation for the dynamics of interacting Brownian particles, J. Stat. Mech, P11003 (2007).
– A. Basu, Symmetries and novel universal properties of turbulent hydrodynamics in a binary fluid mixture., J. Stat. Mech - Th. Expt. (Letter), L09001 (2005).
– A. Basu Statistical properties of driven Magnetohydrodynamic turbulence in three dimensions: Novel universality, Europhys. Lett., 65, 505 (2004).
– D. Das,A. Basu, M. Barma and S. Ramaswamy,Weak and strong dynamic scaling in a one-dimensional driven coupled-field model: Effects of kinematic waves, Phys. Rev. E 64, 021402 (2001).
– A. Basu Phase transitions and noise crosscorrelations in a model of directed polymers in a disordered medium, Phys. Rev. E 62, 4675 (2000).
– A. Basu, A. Sain, S. Dhar, and R. Pandit, Multiscaling in Models of Magnetohydrodynamic Turbulence- Phys. Rev. Lett.81, 2687 (1998).
– A. Basu, The Screw Dynamo and the Generation of Magnetic Fields- Phys. Rev. E 56, 2869 (1997).

Applied Materials Science Division

Permanent Employees

Scientific	Technical	Administrative/ Auxiliary
Alokmay Datta Professor & Head	**Avedananda Bhattacharya** Scientific Assistant	**Suvashis Sanyal** Superintendent
Abhijit Sanyal Scientist	**Shyamaprasad Mullick** Technician	**Provash Haldar** Helper
Madhusudan Roy Associate Professor		
Supratic Chakraborty Associate Professor		

PhD Students: **Smita Mukherjee, Nupur Biswas**

Major Equipments and Resources:

1. Thermogravimetry Analyzer
2. Differential Scanning Calorimeter
3. Semiconductor Parameter Analyzer and Probe station
4. Fourier Transform Infrared Spectrometer (Mid and Far Infrared)
5. Near Field Scanning Optical Microscope-Confocal Microscope-Atomic Force Microscope
6. Spinning Drop Tensiometer
7. RFand DC Magnetron Sputter Deposition Unit

Research Activities:

This division has been created in May 2010 from the erstwhile Microelectronics Division, inducting Prof. Datta from the Surface Physics Division, with the following research areas

1. **Micro-electronics and ultrasonic device research –** ***Madhusudan Roy and Supratic Chakraborty***
2. **Image processing and hardware development –** ***Abhijit Sanyal***
3. **Nanomaterials –** ***Alokmay Datta, Madhusudan Roy and Supratic Chakraborty***
4. **Soft materials and nano-bio interfaces –** ***Alokmay Datta***

Publications

2010

1. *Nanoparticle Surface as Activation Site*, Nupur Biswas, Ayesha Rahman, Alokmay Datta, Arunava Goswami, and Ratan Lal Bramhachary, *J. Nanosci. Nanotechnol.*(in press).

2. *Morphology and dielectric enhancement in bismuth titanate films*, Smita Mukherjee, Alokmay Datta, Prashanta Kumar Ghosh and Amitava Ghoshray, *IUP J. Nanotechnol.*(in press).

3. *A Novel Edge Detection Technique Using Modified Canny Edge Detector Employing Exponential Filter*, Abhijit Sanyal, Aindrik Dutta, Sankha Baran Dutta, Madhusudan Roy, *International Journal of Computer Science*, (in press).

4. *Microstructural and Magnetic Characterization of the Dusts from a Stone Crushing Industry in Birbhum, India* , A. Bhattacharjee, H. Mandal, M. Roy, J. Kusz, M. Zubko, P. Gütlich, *J. Magn. Magn. Mater.*, (in press).

5. *A Preliminary Study to Identify Magnetic Particulate Matters in Vehicle Fuel Wastes*, A Bhattacharjee, H Mandal, M. Roy, T. K. Chini, *Environ Monit Assess* (2010) DOI 10.1007/s10661-010-1598-x (in press).

6. *Effect of Cavity and Pillar Thickness of a Cavity Micromachined Ultrasound Transducer on the Membrane Displacement: A Simulation Study*, R Das, S Chakraborty and M Roy, *J. Pure Appl. Ultrason.*, (in press).

7. *Electrical conduction property of molecular magnet material – $\{N(n\text{-}C_4H_9[Fe(II)Fe(III)(C_2O_4)_3\}\infty$: Before and after thermal degradation*, A. Bhattacharjee, D. Bhakat, M. Roy and J. Kusz, *Physica B* **405** (2010) 1544-1550.

8. *Rod-like ferrites obtained through thermal degradation of a molecular ferrimagnet*, A. Bhattacharjee, D. Roy, M. Roy, S. Chakraborty, A. De, J. Kusz, W. Hofmeister, *J Alloys & Compounds*, **503** (2010) 449-453.

9. *A non-equilibrium quasistationary state in an ionic liquid caused by a focused laser*, Natsuki Iguchi, Alokmay Datta, Kenichi Yoshikawa, Yukihiro Yoshida, and Gunzi Saito, *Chem. Phys. Lett.* **485**, 110 (2010).

2009

10. *Anomalous ultrasonic attenuation of agarose hydrogel*, Madhusudan Roy and Supratic Chakraborty, *J. Pure Appl. Ultrason.* **31**, 61-66(2009).

11. *FPGA Implementationof Binary Threshold Decomposition using Multiprocessor Architecture*, Abhijit Sanyal , Sankha, Baran Dutta and Aindrik Dutta, International Journal Of Computers, Information Technology and Engineering, Vol. 3, No. 1, January-June 2009. pp 111-115.

12. *Design of dual universal asynchronous receivertransmitter on FPGA with special hamming correction*, Saptarshi Das, Abhijit Sanyal, Indian Journal of Instrumentation, September 2009 issue(Vol. 40.)

13. *Self-Assembly of a Two-Dimensional Au-Nanocluster Superlattice and Its Photoluminescence Spectra* Sudeshna Chattopadhyay, Rabibrata Mukherjee, Alokmay Datta, Abhijit Saha, Ashutosh Sharma, and Giridhar U. Kulkarni, *Journal of Nanoscience and Nanotechnology* **9**, 190 (2009).

14. *Chemistry at Air/Water Interface versus Reaction in a Flask: TuningMolecular Conformation in Thin Films*, Smita Mukherjee, Alokmay Datta, Angelo Giglia, Nicola Mahne, and Stefano Nannarone, *Langmuir* **25**, 3519 (2009).

15. *Interaction of Oxicam NSAIDs with lipid monolayer: Anomalous dependence on drug concentration*, Sarathi Kundu, Hirak Chakraborty, Munna Sarkar and Alokmay Datta, *Colloids & Surfaces B* **70**, 157 (2009).

16. *Laser-induced Microscopic Phase-Transition on an Ionic Liquid*, Natsuki Iguchi, Alokmay Datta, Kenichi Yoshikawa, and Yue Ma, *Journal of Physics: Conference Series* **148**, 012067 (2009).

17. *Morphology and Structural Evolution in Cobalt Stearate Langmuir-Blodgett Films*, Smita Mukherjee and Alokmay Datta, *J. Nanosci. Nanotechnol.* **9**, 5237 (2009).

18. *Nanoparticle–Virus Complex Shows Enhanced Immunological Effect Against Baculovirus*, Ayesha Rahman, Nupur Biswas, Christian Ulrichs, Carmen Büttner, Ratan Lal Bramhachary, Arunava Goswami, and Alokmay Datta, *J. Nanosci. Nanotechnol.* **9**, 5567 (2009).

19. *Dependence of mesoscopic growth on molecular configuration in Langmuir–Blodgett multilayers*, S. Mukherjee and A. Datta, *Appl. Surf. Sci.* **256**, 380 (2009).

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20. *Implementation of a hit reconstruction algorithm for the ALICE Dimuon High-level Trigger*, Bruce Becker, Sukalyan Chattopadhyay, Corrado Cicalo, Davide Marras, Abhijit Sanyal, Sabyasachi Siddhanta, Artur Szostak, & Gianluca Usai, ALICE-INT-2008-013 Version 1.0

21. *Relating structure with morphology: A comparative study of perfect Langmuir–Blodgett multilayers*, S. Mukherjee, **A. Datta**, A. Giglia, N. Mahne and S. Nannarone, *Chemical Physics Letters* **451**, 80 (2008).

22. *Relaxation of Bimolecular Layer Films on Water Surfaces,* S. Kundu, A. Datta and S. Hazra, *Langmuir* **24**, 9386 (2008).

23. *Manipulation of a Liquid Droplet by Laser*, N. Magome, A. Isomura, K. Agladze, M.I. Kohira K. Miura, A. Datta, and K. Yoshikawa, Journal of the Japan Society of Microgravity Application **25**,.791, (2008).

2007

24. *Effect of Polymer Confinement: Tuning Self-Assembled Growth of Monodisperse Au Nanoparticles on Polystyrene Films*, Sudeshna Chattopadhyay and Alokmay Datta, Macromolecules **40**, 3313 (2007).

25. *Intramolecular and Intermolecular Rearrangements in Nanoconfined Polystyrene*,S. Chattopadhyay, A. Datta, A. Giglia, N. Mahne, A. Das and S. Nannarone, *Macromolecules* **40**, 9190 (2007).

Science Review

Name: **Alokmay Datta**

Educational background

1978	B.Sc. (Physics Hons)	Calcutta University (St Xavier's College)
1980	M.Sc. (Physics)	Calcutta University
1982	Post M.Sc.	Saha Institute of Nuclear Physics
1989	Ph.D. (Physics)	Calcutta University

Academic profile

Official Positions

1981-82	Post M.Sc. Associate, Saha Institute of Nuclear Physics
1982-89	Research Fellow, Solid State and Molecular Physics Division, Saha Institute of Nuclear Physics
1990-94	Lecturer, Solid State and Molecular Physics Division, Saha Institute of Nuclear Physics
1994-2000	Reader, Solid State and Molecular Physics Division and Surface Physics Division, Saha Institute of Nuclear Physics
2000-04	Associate Professor, Surface Physics Division, Saha Institute of Nuclear Physics
2004-07	Professor F, Surface Physics Division, Saha Institute of Nuclear Physics
2007-10	Professor G, Surface Physics Division, Saha Institute of Nuclear Physics
Present	Professor G and Head, Applied Material Science Division, Saha Institute of Nuclear Physics

Awards

1998-2000	National Science Foundation Postdoctoral Fellow, Northwestern University, USA
2008-09	Japan Society for Promotion of Science Fellow and Visiting Professor, Kyoto University, Japan
2006-date	Fellow, West Bengal Academy of Science and Technology
2009	Eminent Materials Scientist of the Year, Institute of Engineers (India)

Essential strength of research/development output

1. Understanding the role of metal ions on two-dimensional nanoscale organization of organic molecules in monolayers and multilayers, with following major results:

(a) Self-assembly of two-dimensional lattices of metal ions at air-water interface (b) Spontaneous evolution of bi-molecular layer on water surface with membrane-like mechanical response and drastic reduction of surface tension(c) Near perfect growth of multilayer structures (d) Non-covalent, 'weak' bonding deciding structural evolution over polar or covalent bonding

2. Understanding the effect of confinement of simple and complex fluids to nanoscales, with following major results:

(a) Emergence of spontaneous one-dimensional order (b) Emergence of a short-range intermolecular repulsive potential in complex fluids (c) Change in molecular conformation in complex fluid due to confinement (d) Control of two-dimensional surface aggregation and thus nanoparticle growth through degree of fluid confinement

3. Observation of non-extensive dynamics in molecular systems

4. Observation of cell wall-nanoparticle interaction in viral envelopes, with specific biological functionalities

5. Development of Beamline BL-13 at the INDUS-2 Synchrotron at RRCAT, Indore (team member)

Future research/development plan

1. Understanding the role of Large Amplitude Motions in the dynamics of biological systems, nano-bio composites and non-extensive molecular systems

2. Understanding the competition between different short-range and long-range forces in complex fluids under confinement

3. Understanding the phase transitions in the two-dimensional lattices of metal ions self-assembled in presence of organic monolayers

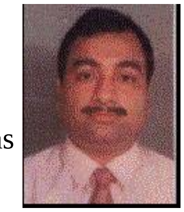
Development

1. ***Radiation-pumped Imaging Ellipsometry and Microscopy***
2. ***Surface Acoustic Wave Microscopy***
3. ***Imaging Ellipsometry at the BL-13 beamline***

List of 10 important publications (last 5 years)

1. Natsuki Iguchi, Alokmay Datta, Kenichi Yoshikawa, Yukihiro Yoshida, and Gunzi Saito, *Chem. Phys. Lett.* **485**, 110 (2010).
2. Ayesha Rahman, Nupur Biswas, Christian Ulrichs, Carmen Büttner, Ratan Lal Bramhachary, Arunava Goswami, and Alokmay Datta, *J. Nanosci. Nanotechnol.* **9**, 5567 (2009).
3. Smita Mukherjee, Alokmay Datta, Angelo Giglia, Nicola Mahne, and Stefano Nannarone, *Langmuir* **25**, 3519 (2009).
4. S. Kundu, A. Datta and S. Hazra, *Langmuir* **24**, 9386 (2008).
5. S. Mukherjee, **A. Datta**, A. Giglia, N. Mahne and S. Nannarone, *Chemical Physics Letters* **451**, 80 (2008).
6. S. Chattopadhyay, A. Datta, A. Giglia, N. Mahne, A. Das and S. Nannarone, *Macromolecules* **40**, 9190 (2007).
7. Sudeshna Chattopadhyay and Alokmay Datta, Macromolecules **40**, 3313 (2007).
8. S. Chattopadhyay and A. Datta, Physical Review B **72**, 099539 (2005).
9. S. Kundu, A. Datta and S. Hazra, Langmuir **21**, 5894 (2005).
10. A. Datta, S. Kundu, M.K. Sanyal, J. Daillant, D. Luzet, C. Blot and B. Struth; Physical Review E **71**, 041604 (2005).

1. **Name, Passport size photograph and educational background:**



   a. Name : Supratic Chakraborty
   b. Educational Qualifications : Ph. D. (Physics)
   c. Educational background : B.Sc. (Burdwan Univ.), M. Sc. (Banaras Hindu Univ.), Ph. D. (Kalyani Univ.)

2. **Academic profiles including earlier appointments and awards etc. :**

   a. Working as an Associate Professor – E in the Saha Institute of Nuclear Physics since Aug. 1, 2007.
   b. Invited by the Department of Electrical and Electronic Engineering, the University of Hong Kong, Hong Kong for three months in the year 2006.
   c. Appointed and worked as a Reader – D in the Microelectronics Division of the Saha Institute of Nuclear Physics from Feb. 2004 to July, 2007.
   d. Employed as a Research Fellow in the Microelectronics Division of the School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore.
   e. Employed as a Research Assistant – I in the Department of Electrical and Electronic Engineering, Hong Kong University, Hong Kong.
   f. Employed as a Research Assistant – II in the Department of Electrical and Electronic Engineering, Hong Kong University, Hong Kong.
   g. Earlier worked as a Research Assistant – II in the Department of Electrical and Electronic Engineering, Hong Kong University, Hong Kong.
   h. Visited as a Research Student to the Department of Electrical Engineering. Tokyo Denki University, Tokyo, Japan for six months.

3. **Essential Strength of Research and development output:**

The account on strength of research and development output, after the appointment in the grade Reader – D in the Microelectronics Division of the Saha Institute of Nuclear Physics, has been described in brief in the following. The strength and justifications of submitting such a proposal during XI-th five year plan period is also mentioned below.

After joining the Institute, it is observed that a project on medical imaging and related image processing techniques, already approved by the Department of Atomic Energy, was being carried out by the Divisional members in the X-th plan period. One direction of the project was dealt with the improvement of quality of ultrasound images, grabbed through conventional ultrasound scanner, through various algorithms. Another dimension of the project was development of ultrasound probe. Considering the expertise in the field of VLSI design and fabrication, the direction in developing the ultrasound probe was preferred. Accordingly, in Vision 2004, a concept of development of Micro Electro Mechanical System (MEMS)-based ultrasound transducer and sensor were proposed. Considering the then on-going projects, personal skill and profession and objectives of the National Science and Technology Policy and its expectation from the Indian Scientific Community working with the academic and R&D Institutions in India, stated below, the job of MEMS-based transducer design and fabrication of ultrasound transducer was decided to be taken up. The National Science and Technology Policy, adopted in 2003, mentioning role of all academic and R&D Institution, states –

> "To provide necessary autonomy and freedom of functioning for all academic and R&D institutions so that an ambience for truly creative work is encouraged, while

ensuring at the same time that the science and technology enterprise in the country is fully committed to its social responsibilities and commitments."

Setting a target for the betterment of mankind and self reliance for indigenous technological development, such a challenging job was taken up. The objective of the project was to deliver a small linear array-based capacitive transducer, replacing conventional piezo-electric-based transducer with many technical and operational advantages. Apart from this job, the temperature dependent ultrasound attenuation properties of agarose, a material widely used for preparing tissue mimicking phantoms, was studied in detail.

The approved project on development of ultrasound probe was taken up in the XI-th five year Plan period. The design of the transducer was completed. Semiconductor grade device fabrication facilities are being established comprising of different instruments and a clean room. The process of creating the facilities will be completed by July 2010. The fabrication process will start with a month or so after installation of the essential instruments.

4. Future Research/Development plan:

An appraisal on SiC-based particle counter has already been accepted by the Specialist Group during the mid-term appraisal presentation. Since, most of the instruments are common to both the projects, such a project on development of SiC-based particle counter may be submitted in the XII-th plan period.

5. List of important publications starting with recent publications:

i. Rod-like ferrites obtained through thermal degradation of a molecular ferrimagnet
A. Bhattacharjee, D. Roy, M. Roy, S. Chakraborty, A. De, J. Kusz, W. Hofmeister
J Alloys & Compounds (*in press*).

ii. Density profiles and electrical properties of thermally grown oxide nanofilms on p-type 6H-SiC(0001)
S. Hazra, Supratic Chakraborty and P. T. Lai
Applied Physics Letters, **85**, 5580 (2004)

iii. Interface properties of N_2O-annealed SiC MOS devices
Supratic Chakraborty, P. T. Lai, J. P. Xu, C. L. Chan and Y. C. Cheng
Solid State Electronics, **45**, 471-474 (2001)

iv. Effects of nitridation and annealing on interface properties of thermally oxidized SiO_2/SiC MOS system
P. T. Lai, Supratic Chakraborty, C. L. Chan and Y. C. Cheng
Applied Physics Letters, **76**, 3744-3746 (2000).

v. New micro humidity field effect transistor sensor in ppm_v level
Supratic Chakraborty, Kazuhiro Hara and P.T.Lai
Review of Scientific Instruments, **70**, 1565 (1999)

vi. Moisture sensitive field effect transistors using $SiO_2/Si_3N_4/Al_2O_3$ gate structure
S. Chakraborty, K. Nemoto, K. Hara and P. T. Lai
Smart Materials and Structures, **8**, 274 (1999)

1. Name: **Madhusudan Roy**

Educational background: Passed undergraduate examination with honours in Physics from the Calcutta University in 1980 and postgraduate examination with electronics as special paper from the North Bengal University in 1983. Worked in the field of Experimental Plasma Physics and Gas Discharge Electronics as a research scholar and awarded Ph.D. from the North Bengal University in 1989.

2. Academic profile including earlier appointments, awards etc.

Joined the Indian Association for the Cultivation of Science (IACS) as Research Associate in 1988 and carried out research works in the field of Laser Raman Phonon Spectroscopy study of Photoreaction Dynamics in Organic Crystals. After a brief stay at IACS I took an appointment as a Lecturer in 1989 in a central university, North-Eastern Hill University. I was promoted to Senior Lecturer in 1994 and Reader in 1999. I spent some time as Visiting Scientist in Indian Statistical Institute and as Visiting Fellow in Mizoram University. Imparted teaching to the postgraduate students of Vidyasagar University as a guest faculty. In the year 2002 I joined the Microelectronics Division, Saha Institute of Nuclear Physics (SINP). By now I have completed more than twenty years in service.

3. Essential strength of research/development output

(a) In the first phase of implementation of the project entitled, "Development of Linear Ultrasonic Transducer Array for Medical Imaging and Related Image Processing Techniques(LINUT)", approved by Department of Atomic Energy during current XIth five year plan period, our objective i.e. setting up a Clean Room of Class 100 and Class 1000 surrounded by Class 10000 corridors for housing micro/nano fabrication facilities to carry out research and developmental activities is on the verge of completion. The total area of the clean room, considering the AC plant room, AHU room and utilities, is about 2100 sq ft.
The detailed configurations of the major instruments, namely, mask aligner, PECVD, ICP – RIE, sputtering, plasma asher, electron beam evaporation etc. to be housed under micro/nano facilities are made and purchased procedure by our end are completed. They are all in shipping/inspection/installation stage.

A Capacitive Micro-machined Ultrasound Transducer (CMUT) using finite element method (FEM)-based software, PZFlex has been designed. Since use of such transducer is for medical imaging, a damped output of the transducer necessary for pulse-echo mode is of our primary interest. The design also puts stress on its effective power output for better echo signal. It is observed that above properties of a transducer inherently depend on its membrane thickness, cavity thickness and pillar width supporting the membrane. Considering above objectives, the effect of membrane thickness, cavity thickness and pillar width on the transducer output has been studied and accordingly, physical dimension for MEMS based CMUT has been completed.

(b) Synthesis of nano-materials with molecular magnetic materials as precursor(under a collaboration project, entitled, INVESTIGATIONS INTO THE MULTIFUNCTIONALITY OF SOME MOLECULAR MATERIALS AND THEIR APPLICATION POTENTIAL and approved by the Department of Science and Technology, DST No. SR/S2/CMP-0036/2006):
In recent years the magnetic properties of nano-particles have attracted much interest due to their significance in both technological applications and fundamental research. Among different

synthetic routes for the preparation of metal oxide nano-particles thermal decomposition of metal complexes becomes increasingly important mainly due to the easy control of process conditions, particle size, particle crystal structure, and purity. We have carried out investigation on the thermal decomposition of an oxalate ligand based molecular ferrimagnet - {N(n-C4H9)4[FeIIFeIII(C2O4)3]}$\tilde{\infty}$ From the physical characterization (XRD, IR, SQUID) of the decomposed material it is found that the decomposed material is basically hematite along with a small fraction of magnetite. The iron oxides are composed of particles of mean crystallite size of 62 nm. This result is the first ever report of synthesis of nano-ferrites from a molecular magnet precursor. The result underlines a new route for synthesis of nano-materials with molecular magnetic materials as precursor.

(c) A systematic investigation has been initiated to identify the air pollutants and characterize their physical properties to understand how dangerous their effects could be on health and environment.

4. Future research/development plan

Amorphous silicon nitride (Si3N4) thin layers are the most widely applied dielectric layers in modern semiconductor devices. Excellent properties such as high chemical inertness, high thermal stability and corrosion resistance of silicon nitride make their extensive use in semiconductor industry. Moreover, Si_3N_4 also exhibits remarkable mechanical, optical and dielectric properties. Although there are several chemical vapor deposition (CVD) techniques, namely low pressure CVD (LPCVD), atmospheric pressure CVD (APCVD) and plasma enhanced CVD (PECVD) to grow the Si3N4 and SiO_2 films, the PECVD technique has become very popular for its advantages in growth of amorphous SiO_2 and Si_3N_4. Doping of p- and n-type dopants in silicon is also possible using the PECVD. The advantages of PECVD are: i) the growth may be carried out at lower temperatures (< 400^{o}C); ii) control of residual stress of the grown film during deposition; iii) control of composition of the grown film by controlling the ratios of gases. The ultimate aim is to grow oxide and nitride films of silicon of very low residual stress using pulsed PECVD technique. Electrical and optical properties of the films will also be investigated.

5. List of important publications starting with recent publications

- A Bhattacharjee, D Bhakat, **M Roy** and J Kusz, Physica B 405 (2010) 1544-1550.
- A Bhattacharjee, D Roy, **M Roy**, S. Chakraborty, A De, J Kusz, W Hofmeister, J Alloys & Compounds, 503 (2010) 449-453.
- A Bhattacharjee, H Mandal, **M Roy**, T K Chini, Environ Monit Asse (2010) DOI 10.1007/s10661-010-1598-x (in press)
- A. Bhattacharjee, H. Mandal, **M. Roy**, J. Kusz, M. Zubko, P. Gütlich, J. Magn. Magn. Mater,(2010),(accepted for publication)
- **M Roy** and S Chakraborty, Polymer 48, (2007) 5484-85
- **M Roy** and S Chakraborty, Polymer 46, (2005) 3535-37

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DATE OF BIRTH: 26th JULY, 1963
DIVISION : APPLIED MATERIAL SCIENCE
DESIGNATION: ENGINEER(G)
EDUCATIONAL QUALIFICATION AND EXPERIENCE: Btech in Electrical Engineering with more than 25 years experience in the area of Computer Engineering. More than 16 year experience in R&D work in Microelectronics, VLSI Design, Image processing, Programmable logic based system development etc.
INDUSTRIAL EXPERIENCE: Four years in Data General Corporation (U.S) subsidiary in India as Computer Engineer, Senior Computer Engineer and Computer Specialist, prior to joining SINP.

R&D ACTIVITIES IN SINP

DEVELOPMENT OF FRONT END COPROCESSOR ON FPGA FOR HIGH LEVEL TRIGGER(DHLT) PROJECT OF DIMUON ARM IN ALICE EXPERIMENT AT CERN

I have designed a Front end Coprocessor chip for the Dimuon High Level Trigger Project (DHLT) for the ALICE experiment at CERN. This design was based on Xilinx Field Programmable Gate Array(FPGA). This design has undergone extensive review and has been accepted by CERN.
DHLT project was started to improve the selectivity of the central trigger and consequently to decrease the amount of data to be stored.In the DHLT architecture the data from the Dimuon Arm Detector gets transferred via Optical fiber into a ReadOut Receiver card(RORC) of the DAQ system. These data streams are also replicated into the HLT-RORC. The HLT-RORC has an embedded Field Programmable Gate Array(FPGA) co-processor which does all data intensive task for local pattern recognition. Also embedded in the architecture of the HLT-RORC is an external memory to be used as a storage of look-up tables and these can be used to perform a variety of application.

IMPLEMENTATION OF IMAGE PROCESSING ALGORITHMS ON RECONFIGURABLE HARDWARE FOR MEDICAL IMAGE PROCESSING.

Design of adaptive filter for speckle suppression in ultrasound images

Speckle noise poses a hindrance in visual assessment of the ultrasound images required for diagnosis purposes. I have designed a filter which employs an adaptive post filtering technique to remove the speckle noise by identifying the speckle corrupted pixels. The filter provides an useful tool to improve the image quality along with feature retention of the ultrasound medical images.

Improved edge detection using Canny edge detector employing exponential filter

Canny edge detector is one of the widely used edge detection tool employing gaussian filter for smoothing of the input image. This results in a loss of information for images with high mean gray value which have slight variations. I have designed an exponential filter which is employed before the actual Canny edge detection process and it helps in information retention and better edge detection.

FPGA implementation of binary threshold decomposition using multiprocessor architecture

In an image, salt and pepper noise occurs due to randomly occurring white and black pixels which can be reduced using median filter. Direct median filtering of an image by sorting is very time consuming. I have implemented a filter using binary threshold decomposition technique which decomposes the pixel values into a set of binary sequences making the study of deterministic and statistical properties of median filters easier. I have also designed a hardware architecture of it for FPGA implementation.

Design of Dual Asynchronous Receiver Transmitter(DUART) on FPGA with special Hamming error correction

I have designed the above mentioned communication chip for system on Chip (SOC) application. This can help in flawless serial transmission of image data. This design will be incorporated as a part of embedded systems with real time set up, dedicated for medical image processing.

FUTURE R&D PLANS

- Development of an embedded platform for general image processing algorithm implementation.
- Real-time Operating System (RTOS) – embedded system integration for real-time Ultrasound image processing.
- Hardware implementation of developed medical image processing algorithms.
- Implementation of the developed algorithms on images, e.g.:ultrasound and Echo cardiograph images.

PUBLICATION

1. Saptarshi Das, **Abhijit Sanyal** " *SOC Implementation of Dual Universal Asynchronous Receiver Transmitter (DUART) with Advanced Error Correction Technique*", Proceedings of the International Conference on Aerospace Electronics, Communication & Instrumentation (ASECI-2010), Vijaywada, pp-144, 6^{th}-7^{th} January, 2010.
2. **Abhijit Sanyal**, Sankha, Baran Dutta and Aindrik Dutta "*FPGA Implementation of Binary Threshold Decomposition using Multiprocessor Architecture*", International Journal Of Computers, Information Technology and Engineering, Vol. 3, No. 1, January-June 2009. pp 111-115.
3. Saptarshi Das, **Abhijit Sanyal**. "*Design of dual universal asynchronous receiver transmitter on FPGA with special hamming correction*". Indian Journal of Instrumentation , appeared in Semptember 2009 issue.
4. **Abhijit Sanyal**, Aindrik Dutta, Sankha Baran Dutta, Madhusudan Roy "A *Novel Edge Detection Technique Using Modified Canny Edge Detector Employing Exponential Filte*r" International Journal Of Computer Science, accepted for publication.
5. **Abhijit Sanyal**, Aindrik Dutta, Sankha Baran Dutta, Madhusudan Roy. "I*mproved Edge Detection Using Modified Canny Edge detector Employing Exponential Filte*r". Proceedings of Indian Conference on Computer Vision Graphics Image & Video Processing (ICCVGIVP 2009), Nagpur, pp-37,March 13-14, 2009.
6. **Abhijit Sanyal**, Aindrik Dutta, Sankha Baran Dutta, Madhusudan Roy. "*Adaptive Filter for Speckle Suppression in Medical Ultrasound Images*". Proceedings , International Conference on Biomedical Instrumentation and Health Care Engineering (ICOBIAHC),pp-1, Chennai, August 6-8, 2009.