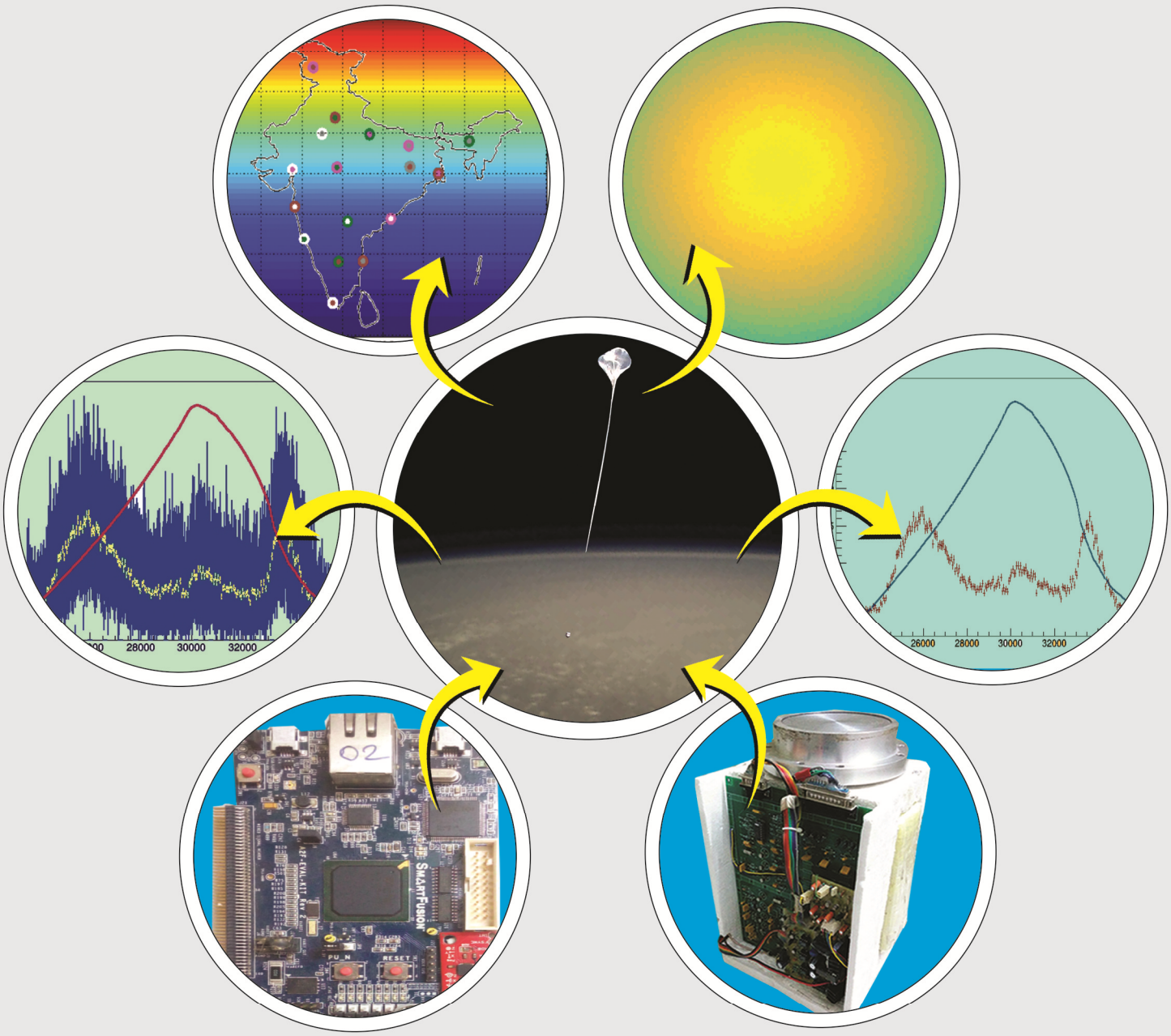
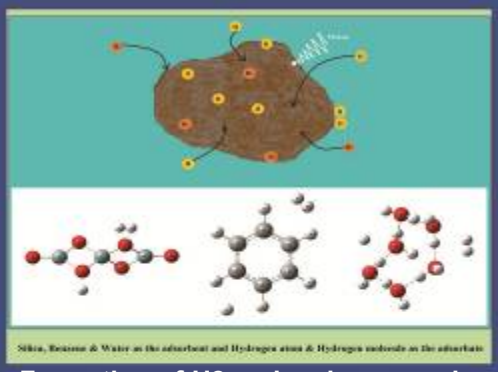
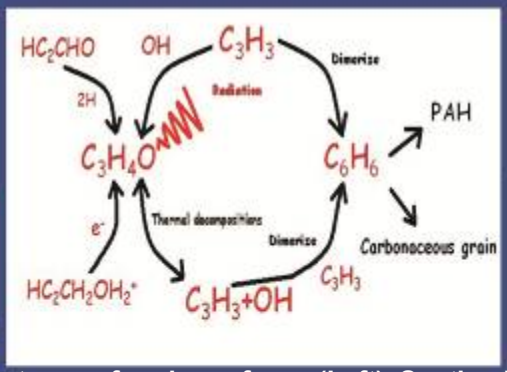
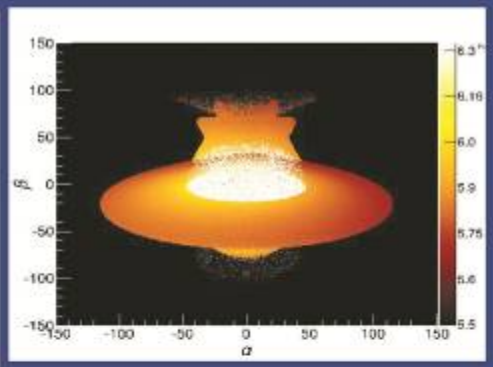
Annual Report
2016-2017



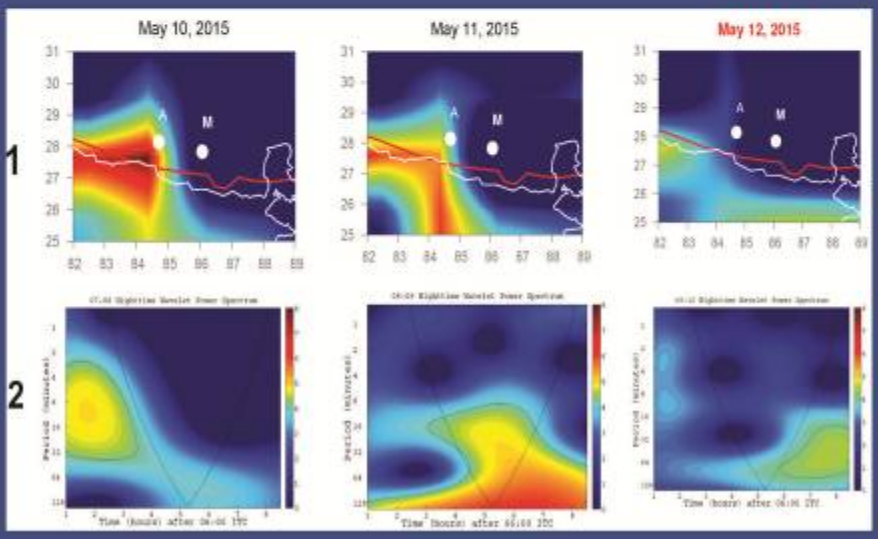
Indian Centre for Space Physics

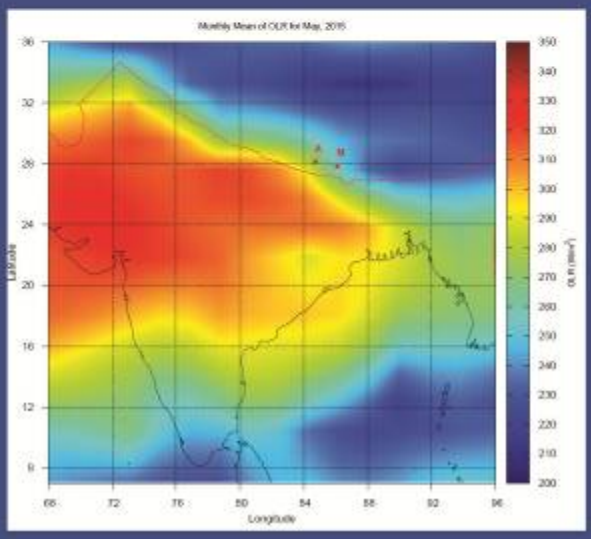




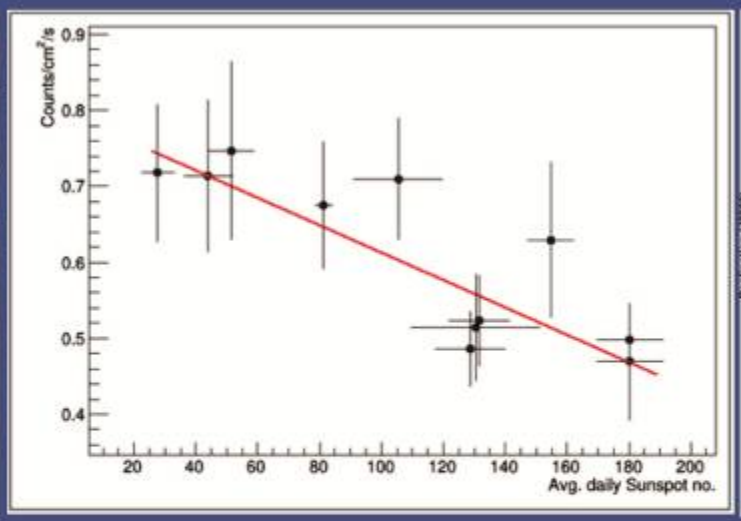


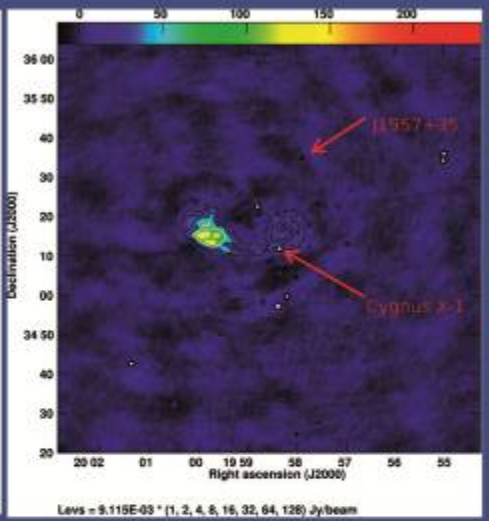
Formation of H2 molecules on various types of grain surfaces (Left). Synthesis of Propargyl Alcohol (important for the formation of PAH) in the ISM (Middle). Image of TCAF seen from an inclination angle of 70 degree in presence of outflows (Right).





Simulated results during the M7.3 Nepal earthquake on May 12, 2015. Left upper panel shows daily Eddy field around the earthquake epicenters for May 10 to May 12, 2015 as obtained from satellite data. Left lower panel shows wavelet power spectrum (WPS) of the VLF data for May 7 to May 10, 2015. Monthly mean of OLR over the Indian subcontinent for the month of May, 2015 (Right).





24`` telescope optical tube for Ionospheric and earthquake research centre (IERC) campus of ICSP at Sitapur, Paschim Medinipur (Left). Anti-correlation between the solar activity in terms of average daily sunspot number secondary cosmic-ray counts at Pfortzer maximum (Middle). 1490 MHz JVLA image of the field of a transient source J195754+353513 combining 9 days of observations. All observations used in this image were conducted in 1991 when antennas were in D configuration. Cygnus X-1 and J195754+353513 are indicated by arrows (Right).

INDIAN CENTRE FOR SPACE PHYSICS
ANNUAL REPORT
(2016-2017)

TABLE OF CONTENTS

Published by:
Indian Centre for Space Physics, Chalantika 43, Garia Station Road, Garia, Kolkata 700084

EPABX +91-33-2436-6003
Extension Numbers:
Department of Ionospheric Science: 21
Department of Astrochemistry/Astrobiology: 22
Accounts: 23
Seminar Room: 24
Computer room: 25
Department of High Energy Radiation: 26
X-ray Laboratory: 27
Fax: +91-33-2462-2153

E-mail:root@csp.res.in**Website**: http://csp.res.in

Front Cover: Balloon activities of ICSP. **Back Cover:**Various newspaper stories on ICSP activities.

Report of the Governing Body

This is the Eighteenth Annual report of Indian Centre for Space Physics (ICSP). The Centre had significant progress both in the academic and infrastructural front in 2016-2017. ICSP focused on its goal to work only in niche areas in Astronomy, Astrophysics and Space Physics.

In astrobiology/astrochemistry we worked on the evolution of proto-planetary disks and their chemical evolutions. Emission properties of several complex molecules, the stability of carbon-chain molecules in space were studied. Our ex-student Dr. L. Majumdar who was at University of Bordeaux, France has been offered to join Jet Propulsion Laboratory, California Institute of Technology of NASA. Dr. D. Sahu from this group received his PhD degree and went to PRL, Ahmedabad as a post-doctoral fellow. Eight papers were published this year from this group.

In high energy Astrophysics division, we crossed major milestones in studying how exactly matter accretes on a black hole. Limits on viscosity in advective and Keplerian flows have been found to agree with theoretical expectations from Two Component Advective Flow solution. Masses of several black hole candidates were found and X-ray spectra of outflows were determined. A student Mr. A. A. Molla has passed the pre-thesis examination. A SERB project was approved. A joint workshop with Astronomical Society of India was organized at Jaipur.Dr. Debnath visited Taiwan and a new Indo-Taiwanese collaborative work started. Five papers in International Journals were published.

The low-cost balloon programme ICSP also crossed several milestones. Several TIFR made polythene weather balloons were launched and valuable data from Crab, solar X-rays and Cosmic rays were obtained. Two papers in International Journal were accepted for publication. The group's proposal for landing a 4kilo payload on the lunar surface on board a lander was accepted by TEAM INDUS as they look for sponsors.. The structural stability of the payload while landing on the moon has been studied. The journey would be decided after having clarity on landing location and its ability to protect our payload in extreme thermal shock. A SERB proposal on phoswich payload launching was approved

The ionospheric and earthquake research centre (IERC) at Sitapur expanded and the sliding roof observatory construction to house both the 0.61m and 0.25m telescopes is in progress. Several college students participated in sky viewing in batches. The 0.61meter telescope has been ordered. VLF studies of OLR and AGW were made. Suman Chakraborty has successfully passed the pre-thesis examination. Ex-student Dr. S. Palit joined the group of Prof. F. Raulin at Sao Paolo, Brazil. Two major papers were published in this year from this group.

S.K. Maji and D. Sahu received PhD Degree. Asit K. Chaudhury of Malda Branch has submitted his Thesis. ICSP is grateful to International Centre for Theoretical Physics for supporting training of a student from Nepal towards PhD. The Government of West Bengal and the Central Government funding agencies, such as MoES, DST, ISRO and CSIR have been funding various projects and fellowships at ICSP. We thank ICSP office for timely compilation of the annual report and Audit reports.

Prof. S.K. Chakrabarti, Honorary General Secretary
Indian Centre for Space Physics Kolkata: September 14, 2017

Governing Body (GB) of the Centre

Prof. B.B. Bhattacharyya, President
Prof. Sandip K. Chakrabarti, Secretary
Prof. S. Midya, Treasurer
Prof. A. R. Rao, Member
Mr. Prabir Kumar Das, Member
Prof. Arun K. Tewari, Member
Mr. Gurusaran Das Gupta, Member
Dr. S. C. Chakravarty, Member
Dr. Sonali Chakrabarti, Member

Members of the Research Advisory Council (RAC)

Prof. A. K. Tewari, Ex. RKMR College (Chairman)
Prof. S. Midya, Calcutta University
Prof. A. R. Rao, Tata Institute of Fundamental Research, Mumbai
Prof. S. K. Chakrabarti, S.N. Bose Nat'l Centre for Basic Sciences, Kolkata & ICSP
Prof. D. J. Saikia, National Center for Radio Astronomy, Pune
Prof. N.M. Ashok, PRL, Member
Secretary, State Council of Higher Education (ex-officio)
Prof. Ranjan Gupta, IUCAA, Member

Academic Council Members

Prof. Sandip K. Chakrabarti (Chairman)
Dr. Dipak Debnath
Dr. Sujay Pal
Mr. Rajkumar Maiti (non-Member Secretary)
Dr. Ankan Das (Convenor)
Dr. Sabyasachi Pal
Mr. Debashis Bhowmick

In-Charge, Academic Affairs (Honorary)

Prof. Sandip K. Chakrabarti (Tel. : +91 33 24366003,
Email: sandip@csp.res.in / sandipchakrabarti9@gmail.com)

Dean (Academic) and Finance Officer (Acting)

Dr. Ankan Das (Tel. : +91 33 24366003 Extn: 22,
Email: ankan@csp.res.in / ankan.das@gmail.com)

Administrative Officer (Acting)

Dr. Dipak Debnath (Tel.: +91 33 24366003 Extn: 26,
Email: dipak@csp.res.in / dipakcsp@gmail.com)

Public Information Officer

Mr. Rajkumar Maiti (Tel.: +91 33 24366003 Extn: 23,
Email: rajkumar@csp.res.in / rajkumarmaiti24@gmail.com)

In Charge of the Departments

Dr. Ankan Das	Astrochemistry / Astrobiology
Dr. Dipak Debnath	High Energy Astrophysics
Dr. Sujay Pal (Till 20th March, 2017)	Ionospheric Science
Dr. Sudipta Sasmal (Since 21st March, 2017)	Ionospheric Science
Mr. Debashis Bhowmick	Instrumentation for Space Exploration

Regular Faculty Members

Dr. Ankan Das	Assistant Professor-II
Dr. Dipak Debnath	Assistant Professor-II
Dr. Ritabrata Sarkar	Assistant Professor
Dr. Sudipta Sasmal	Assistant Professor

Honorary Faculty Members

Dr. B. B. Bhattacharyya, Ex-ISM, Dhanbad	Emeritus Professor
Dr. S. K. Chakrabarti, SNBNCBS	In-Charge, Academic Affairs
Dr. S. Chakrabarti, M. M. Chandra College	Professor
Dr. S. C. Chakravarty, EX-ISRO	Senior Professor
Dr. A. K. Chatterjee, Malda College	Scientist
Dr. R. Chattopadhyay, Haripal Institution	Scientist
Dr. T. K. Das, Narasimha Dutta College	Assoc. Professor
Dr. P. K. Jana, Panipukur B.Ed. College	Scientist
Dr. M. M. Majumdar, DPI	Scientist
Dr. S. K. Midya, Calcutta University	Professor
Dr. G. Tarafdar, Barasat Govt. College	Scientist
Dr. B.G. Dutta, R.B.C. College	Scientist
Dr. S. K. Mondal, S-K-B University	Scientist
Dr. H. Ghosh, Heritage Institute of Tech.	Scientist
Dr. K. Giri, NITTTR, Kolkata	Scientist
Dr. S. Ray, G.H. College	Scientist

Project Scientists

Dr. Sabyasachi Pal (MoES) Dr. Sourav Palit (MoES) Dr. Sudipta Sasmal (MoES)
Dr. Partha Sarathi Pal (MoES) Dr. Tamal Basak (MoES)

Post Doctoral Fellow

Dr. Sujay Pal (MoES)

Senior Research Fellows

Mr. Arka Chatterjee (MoES) Mr. Dipen Sahu (MoES) Mr. Dusmanta Patra (MoES)

Md. Aslam Ali Molla (MoES) Mr. Suman Chakraborty (MoES)

Mr. Prasanta Gorai (DST) Mr. Arghajit Jana (ISRO)

Junior Research Fellows

Mr. Debjit Chatterjee (DST) Mr. Soujan Ghosh (MoES) Mr. Milan Sil (INSPIRE)

ICTP Junior Research Fellow

Mr. Shreeram Nagarkati (ICTP)

Visiting Research Fellows

Mr. Asit K. Choudhury	Mr. Washimul Bari	Mr. Amit Chowdhury
Mr. Surya K. Maji	Mr. Dipak Sanki	Mr. Bakul Das

Engineers / Laboratory Staff

Mr. Debashis Bhowmick	Engineer- A
Mr. Arnab Bhattacharya	Junior Engineer
Mr. Susanta Middya	Technical Assistant (MoES)
Mr. Samir Bhowmick	Technical Assistant (MoES)
Mr. Hriday Roy	Laboratory Assistant

Office Staff

Mr. Rajkumar Maiti	Office Assistant / Accountant
Mr. Jyotisman Moitra	Computer Assistant
Mr. Ram Chandra Das	Office Attendant
Mr. Uttam Sardar	Office Helper

Security Staff

Mr. Parimal Das
Mr. Barun Chakraborty

Research Facilities at the Head Quarter

Library: The library has well cataloged journals and conference proceedings in Astronomy, Astrophysics and Space sciences and an excellent collection of text books.

Internet: The Centre has dedicated lease-line internet with csp.res.in domain.

Computers: The Centre has modern high-speed computers and several servers which are connected through LAN/Wi-Fi and through the lease-line Internet.

Seminar room: The seminar room at ICSP is well equipped with modern amenities and wireless Internet.

Guest house: This facility is to provide lodging for residential scientists and visitors to stay overnight.

Laboratories: X-ray and VLF laboratories equipped with PCB making instrument, vacuum chamber, uninterrupted power supply and solar panels. Payloads for Balloon flights are fabricated and tested in this laboratory.

Facilities at other branches of the Centre:

IERC at Sitapur, West Medinipur: The Ionospheric and Earthquake Research Centre (IERC) for studying VLF, radio and optical astronomy was inaugurated at Sitapur, Paschim Medinipur, West Bengal in 2012. It has computing and internet facilities, VLF antennas and receivers, small Radio Dish antenna; 0.25m Meade Optical Telescope. A 0.61m class telescope is being installed soon. It has a guest house to accommodate 20 students for skywatching and optical observations. Solar power for electricity keeps this remote Centre running round the clock.

Balloon Facility at Bolpur, Birbhum: This Centre is used only during balloon flights twice per year for a period of about two months. It has all the facilities to launch balloons and retrieve payloads. Plan is being made to have a permanent facility.

ICSP branch at English Bazar, Malda: two office rooms at Atul Market and the terrace are regularly used by the members of the Malda branch. It has computing and internet facilities and a small library. It has VLF antennas to receive VLF signals from transmitters all over the world.

Antenna at Cooch Behar: This antenna is used to receive VLF data from transmitters around the globe.

ICSP new campus: Building of the new campus is planned in the land procured on lease on the Eastern Bypass.

Brief Profiles of the Scientists of the Centre

Dr. Achintya K. Chatterjee: He is the Associate Professor and Ex. Head, Physics Department, Malda College and an honorary scientist of ICSP. He is currently doing data analysis RXTE satellite and observing SID by VLF antenna. He is also the President of the Malda Branch of ICSP.

Dr. Ankan Das: He is an Assistant Professor-II and HoD, Astrochemistry/Astrobiology of ICSP. He is also the Dean (Academic) and Acting Finance officer of the centre. His main research interest is in the formation of bio-molecules in star forming regions.

Mr. Arghajit Jana: He is anISRO RESPOND project Senior Research Fellow and is working in X-ray Astronomy.

Mr. Arka Chatterjee: He is an MoES project Senior Research Fellow in Black Hole Astrophysics. He is working on Photon Bending near very compact objects.

Mr. Arnab Bhattacharya: He is a junior engineer at ICSP and is involved in ICSP activities for software developments for balloon experiments.

Mr. Asit Kumar Choudhury: He is an Asst. Teacher at the L.M.S.M. Institution, Malda and is an honorary Senior Research Fellow of ICSP. He is working on data analysis of RXTE satellite and also observing SID using VLF. He is also the Secretary of the Malda branch of ICSP.

Md. Aslam Ali Molla: He is a Senior Research Fellow working in an MoES sponsored project. He is working on observational studies on Black Hole properties in X-Ray energy band.

Mr. Bakul Das: He is an Asst. Teacher at Kalimpong Govt. High School and is a part time visiting research fellow. He works on VLF signal and Earthquake correlational studies.

Prof. Bimalendu B. Bhattacharyya: He is the President of the Governing Body and an Honorary Emeritus Professor. He is currently serving as the Chairman of the Science Advisory Council of NGRI, Hyderabad. He is an ex-Director of Indian School of Mines, Dhanbad. His field of specialization is the study of deep crustal structure on earth from magneto-telluric data.

Dr. Broja G. Dutta: He is an Assistant Professor at R.B.C. College, North 24 Parganas and has completed his Ph.D. as a “Teacher Fellow” at ICSP under “Faculty Improvement Programme” of UGC. He is working on the time-lag properties of X-ray emission from accretion disks around black holes. He is an honorary Scientist of ICSP.

Mr. Debashis Bhowmick: He is an engineer at ICSP and is the laboratory in Charge which oversees the activities related to VLF antennas, X-ray detector fabrication, test and evaluation and balloon experiments.

Mr. Debjit Chatterjee: He is a DST First track Project Research Scholar and is working on theoretical studies in High energy astrophysics as a Junior Research Fellow.

Dr. Dipak Debnath: He is an Assistant Professor and HOD of High Energy Astrophysics, ICSP. He is also Acting Administrative officer of the Centre. His main research interest is observational and theoretical studies of the properties of stellar massive black hole candidates during their X-ray active periods.

Mr. Dipen Sahu: He is an MoES project Senior Research Fellow in Astrochemistry/ Astrobiology. He is working on deuterated species formation in star forming regions.

Mr. Dusmanta Patra: He is an MoES project Senior Research Fellow in Radio Astronomy and is working on Spectral ageing analysis of Giant radio galaxies using Very Large Array and Giant Meterwave Radio Telescope. He studies multi-wavelength properties of Galactic micro-quasars.

Dr. G. Tarafdar: He is an honorary scientist of the Centre. He is a faculty at Barasat Govt. College.

Dr. H. Ghosh: He is an Assistant Professor at Heritage Institute of Technology. He works on Monte Carlo simulation of Radiative transfer around black holes.

Dr. K. Giri: He is an Assistant Professor at NITTTR, Kolkata. He works on numerical simulations of accretion flow around black holes.

Dr. M. M. Majumdar: He is an honorary scientist of ICSP. He is working on similarities of accretion flows around black holes and fluid dynamics in a converging-diverging duct.

Dr. P. K. Jana: He is teaching at the Panipukur B. Ed. College and is an honorary scientist of ICSP. He works on trends of Ozone depletion over India. He is an honorary Scientist of ICSP.

Mr. Prasanta Gorai: He is a DST project Senior Research Scholar in Astrochemistry/ Astrobiology and is working on the formation of various complex molecules in star forming regions.

Dr. R. Chattopadhyay: He is an Asst. Teacher at Haripal G. D. Institution. His research work includes Airglow and Ozone depletion. He is an honorary scientist of ICSP.

Mr. R. Khan: He is an Asst. Teacher of Bidhan Nagar Govt. High School and is involved in activities of ICSP observatories. He is in charge of the training with IERC Optical Telescopes.

Dr. Ritabrata Sarkar: He is an Assistant Professor at ICSP. He is analyzing the data of balloon borne experiments which include corrections due to atmosphere and instrumental effects.

Prof. S. K. Midya: He is a Professor and Co-ordinator of the Dept. of Atmospheric Science of Calcutta University and an honorary Professor of ICSP. He works on Airglow experiments, Ozone depletion problem and Earthquakes.

Dr. Sabyasachi Pal: He is a Project Scientist at ICSP. He is working on search for transient radio sources and multi-wavelength study of known transient events. He is doing a galactic plane survey, main goal of which is to search for new supernova remnants.

Prof. Sandip K. Chakrabarti: He is a Senior Professor and HoD, Astrophysics & Cosmology of S.N. Bose National Centre for Basic Sciences and In-Charge of Academic activities and the General Secretary of ICSP. His research interests range from physics of black hole accretion and outflows; high energy astrophysics; instrumentation for X- ray/gamma-ray observations and low cost balloon borne studies; ionospheric perturbations due to terrestrial and extra-terrestrial phenomena and their effects on VLF radio waves and Chemical Evolution of star forming regions.

Dr. Sonali Chakrabarti: She is an Associate Professor at the Maharaja Manindra Chandra College and an honorary Professor of the ICSP. Her research interest lies in the formation of bio-molecules in space, VLF research and study of the possibility to produce high resolution millimeter and microwave grating instruments.

Mr. Soujan Ghosh: He is anMoES Junior Research Scholar working at IERC/Sitapur. He works on VLF radio data and its analysis.

Dr. Sourav Palit: He is an MoES Project Scientist at ICSP. He is involved in GEANT-4 simulations of solar-terrestrial interactions and interpretation of VLF data.

Mr. Sreeram Nagarkoti: He is an ICTP supported Junior Research Fellow. He is working on computation of effects of viscosity on outflow rates from accretion disks around black holes.

Dr. Sudipta Sasmal: He is an MoES Project Scientist working at ICSP. He is working on the study of earthquake precursors using VLF data. He visited Antarcticatwice for data acquisition.

Dr. Sujay Pal: He is an MoES Post Doctoral Fellow at ICSP. He is involved in theoretical studies of various ionospheric disturbances through propagation of LF/VLF/ELF signal within the Earth-ionosphere wave-guide and its connection to Space-Weather phenomena and Earthquakes.

Mr. Suman Chakraborty: He is a Senior Research Fellow working under MoES project. He is working on LEP events, generation of AGW during Solar eclipse and CTIP Model.

Dr. Suman Ray: He is working as an honorary scientist. He is in the VLF group and is working on the earthquake related anomalies of VLF signals. He is a Teacher at G.H. College.

Mr. Surya Maji: He is an Asst. Teaching in a School in W. Medinipur. He has submitted his Ph.D. thesis. He works on the effects of eclipse on VLF signals.

Dr. Sushanta K. Mondal: He is an honorary scientist of ICSP. He is an Assistant Professor at S.K.B.M. University, Purulia.

Dr. Tilak B. Katoch: He is an honorary Senior Research Fellow (SRF) and is working on the observation of solar flares by RT-2 satellite and X-rays sources by LAXPC instruments. He is a Scientist in X-ray Astronomy group of TIFR.

Dr. T. K. Das: He is an honorary Associate Professor of ICSP. His work is on the solar physics, especially on sunspots and classification of radio bursts. He also works on the geo-spot model of earthquakes, relationships between earthquakes and VLF etc.

Mr. Washimul Bari: He is an Asst. Teacher in Malda and is an honorary Senior Research Fellow at ICSP, Malda branch. He works on VLF studies of ionosphere and also data analysis of NASA/ISRO satellites.

Research Work Published/Accepted for Publication

Bhattacharjee A., Banerjee, I., Banerjee, A., Debnath, D., and Chakrabarti, S. K "The 2004 Outburst of BHC H1743-322: analysis of spectral and timing properties using the TCAF solution." MNRAS, 2017, 466, 1372.

Bhattacharjee, A., Debnath, D., Chakrabarti, S.K., Banerjee, I., Banerjee, A. "2004 outburst of BHC H1743322: Analysis of spectral and timing properties using the TCAF Solution" 2016, cosp, 41E, 190.

Chatterjee, A., Chakrabarti, S. K., Ghosh, H., "Images and spectral properties of two-component advective flows around black holes: effects of photon bending", MNRAS, 2017, 465, 3902.

Chatterjee, D., Debnath, D., Chakrabarti, S.K., Mondal, S., Jana, A., Molla, A.A., "Evolution of spectral and temporal properties during early phase of 2011 outburst of MAXI J1543-564 with TCAF Solution" 2016, cosp, 41E, 326.

Chatterjee, D., Debnath, D., Chakrabarti, S. K., Mondal, S., Jana, A., "Accretion Flow Properties of MAXI J1543-564 during 2011 Outburst from the TCAF Solution", ApJ, 2016, 827, 88.

Das, P., Midya S.K. , Das D.K.,Rao G.S. and Raj U**(2017)** Characterizing Indian Meteorological Moisture Anomaly Condition Using Long-term (1901-2013) Gridded Data - A Multivariate Moisture Anomaly Index (MMAI) Approach, Int.J. Climatology. DOI:10.1002/joc.

Das, A., Chakrabarti, S. K., Majumdar, L., Sahu, D., "Deuterium enrichment of Interstellar dusts", 2016, cosp, 42E, 401.

Das, G.K., Debnath, G.C., Pradhan, D., Midya S.K.(2016) Diagnostic Study of Deep depression over Northwest Bay of Bengal in June 2011 : A case Study. *Vayu Mondal* 42(1),43-55 (*ISSN 0970-1397)*

Deb, A., Giri, K., Chakrabarti, S. K., "Numerical simulation of vertical oscillations in an axisymmetric thick accretion flow around a black hole", MNRAS, 2017, 462, 3502.

Debnath, D., Chakrabarti, S. K., Jana, A., Chatterjee, D., Molla, A. A. Mondal, S., "Accretion Flow Properties of three MAXI Black Hole Candidates: Analysis with the TCAF Solution, Proceeding of 7 years of MAXI: monitoring X-ray transients,2017,81,Eds. M. Serino, M. Shidatshu, W. Iwakiri, T. Mihara.

Debnath, D., Pal, P.S., Chakrabarti, S. K., Mondal, S., Jana, Chatterjee, A. D., Molla, A. A. "TCAF model in XSPEC : An efficient tool to understand accretion flow dynamics around black holes", 2016, cosp, 41E, 421.

Debnath, D., Pal, P.S., Chakrabarti, S.K., Mondal, S., Jana, A., Chatterjee, D., Molla, A.A., "Spectral fits with TCAF model : A global understanding of both temporal and spectral properties of black hole sources" 2016, cosp, 41E, 422

Dutta, B. G., Chakrabarti, S. K., "Temporal Variability from the Two-Component Advective Flow Solution and Its Observational Evidence", ApJ, 2016, 828,101.

Etim, E. E., Chakrabarti, S. K., Das, A., Gorai, P., Arunan, E., "Interstellar Carbon Chains: Is Thermodynamics the Key?" 2016, cosp.,41E, 558.

Etim, E. E., Chakrabarti, S. K., Das, A., Gorai, P, Arunan, E., "Search for the isomers of C2H3NO and C2H3NS in the Interstellar Medium", 2016, cosp...41E, 557.

Etim, E. E., Chakrabarti, S. K., Das, A., Gorai, P., Arunan, E., "Interstellar Aldehydes and their corresponding Reduced Alcohols: Interstellar Propanol?" 2016, cosp...41E, 556.

Etim, E., E., Gorai, P, Das, A., Chakrabarti, S. K.,Arunan, E., "Systematic Theoretical Study on the Interstellar Carbon Chain Molecules" , ApJ, 2016, 832,144.

Etim, E.E, Gorai, P., Das, A., Arunan, E., "C_5H_9N Isomers: Pointers to Possible Branched Chain Interstellar Molecules", EPJD, 2017, 71, 86.

Etim, E.E., Gorai P., Das, A., Arunan, E., "Interstellar Protonated Molecular Species", ASR, 2017, 60, 709.

Ghosh, A., Chakrabarti, S. K., "Smearing of mass accretion rate variation by viscous processes in accretion disks in compact binary systems", Ap&SS, 2016, 361, 310.

Ghosh, S., Sasmal, S., Midya S.K. Chakrabarti, S.K., (2017) Unusual Change in Critical Frequency of F 2 Layer during and Prior to Earthquakes Open journal of earthquake Research 6,191-203.

Gorai, P., Das, A., Das, A., Sivaraman, B., Etim, E.E., Chakrabarti, S.K., "A Search for Interstellar monohydric Thiols", ApJ, 2017, 836, 70.

Gorai, P., Das, A, Majumdar, L., Chakrabarti, S.K., Sivaraman, B., Herbst, E., "The Possibility of Forming Propargyl Alcohol in the Interstellar Medium", 7, MAP, 2017, 6, 36.

Gorai, P., Chakrabarti, S. K., Das, A., Majumdar, L., Sahu, D., Sivaraman, B., "Search for Deuterated methyl acetate in the ISM", 2016, cosp...41E, 731.

Goswami, S., Midya S.K.(2016) Variation of Rate of Change of Tropospheric Ozone with Rainfall during different seasons over Gangetic West Bengal,India *Contemporary Research In India* 6(2),1-6 (*ISSN 2231-2137)*

Goswami, S., Midya S. K. **(2016)** Seasonal Variation of daily total column ozone (TCO), it's depletion and formation on Surface Ozone over Chennai,India *J Ind Geo. Union.* 20, 101-111 (**Impact factor-0.313 ,**ISSN No.-0257-7968)

Jana, A., Debnath, D., Chakrabarti, S. K., Chatterjee, D., Molla A. A., Mondal, S., "Inflow-Outflow Properties of Accretion Disk around MAXI J1836-194 with TCAF Solution during its 2011 Outburst", Proceeding of 7 years of MAXI : monitoring X-ray transients,2017, 87, Eds. M. Serino, M. Shidatshu, W. Iwakiri, T. Mihara.

Jana, A., Debnath, D., Chakrabarti, S.K., Mondal, S., Chatterjee, D., Molla, A.A. "Hard state of SWIFT J1753.5-0127 during 2005 outburst", 2016, cosp, 41E, 890.

Jana, A., Debnath, D., Chakrabarti, S.K., Mondal, S., Chatterjee, D., Molla, A.A., "Spectral and timing properties of MAXI J1836-194 during its 2011 outburst and estimation of mass with TCAF solution", 2016, cosp, 41E, 891.

Molla, A. A., Chakrabarti, S. K., Debnath, D., Mondal, S., "Estimation of Mass of Compact Object in H 1743-322 from 2010 and 2011 Outbursts using TCAF Solution and Spectral Index-QPO Frequency Correlation", ApJ, 2017, 834, 88.

Molla, A. A., Debnath, D., Chakrabarti, S.K., Mondal, S., Jana, A., D Chatterjee, "Evolution of spectral and temporal behaviour of MAXI J1659-152 during its 2010 outburst with TCAF Solution", 2016, cosp, 41E, 1322.

Molla, A. A., Debnath, D., Chakrabarti, S.K., Mondal, S., Jana, A., Chatterjee, D., "Estimation of mass of black hole candidate H1743-322 using spectral and timing analysis of 2010 and 2011 outbursts with TCAF and POS models" , 2016, cosp, 41E, 1324.

Molla, A. A., Debnath, D., Chakrabarti, S. K., Mondal, S., Jana, A., "Estimation of the mass of the black hole candidate MAXI J1659-152 using TCAF and POS models", MNRAS, 2016, 460, 3163.

Mondal, S., Chakrabarti, S. K.,Debnath, D., "Spectral study of GX 339-4 with TCAF using Swift and NuSTAR observation", Ap&SS, 2016, 361, 309.

Mondal, S., Debnath, D., Chakrabarti, S.K., Jana, A., Chatterjee, D., "Signature of Iron line on the spectra of GX 339-4 with TCAF using NuSTAR observation", 2016, cosp, 41E, 1328.

Mondal, S., Debnath, D., Chakrabarti, S.K., Jana, A., Chatterjee, D., "Viscosity profile and Quasi Periodic Oscillation frequency of few transient black hole candidates", 2016, cosp, 41E, 1329.

Mondal, S., Debnath, D., Chakrabarti, S.K., Jana, A., Chatterjee, D., "Deconvolved spectra of Two Component Advective Flow including jet", 2016, cosp, 41E, 1330.

Nagarkoti, S., Chakrabarti, S. K., "Viscosity parameter in dissipative accretion flows with mass outflow around black holes", MNRAS, 2016, 462, 850.

Nagarkoti, S., Debnath, D., Chakrabarti, S.K., Mondal, S., A. Chatterjee, "Characterization of H 1743-322 during its 2003 outburst with TCAF Solution", 2016, cosp, 41E, 1383.

Nwankwo, V. U. J., Chakrabarti, S. K., Ogunmodimu, O., JASTP, 2016, 145, 154.

Palit, S., Ray, S., Chakrabarti, S. K., "Inverse problem in ionospheric science: prediction of solar soft-X-ray spectrum from very low frequency radiosonde results", Ap&SS, 2016, 361,151.

Pal, P., Sasmal, S., Chakrabarti, S. K., "Studies of Seismo-ionospheric Correlations using Anomalies in Phase of Very Low Frequency Signal, GNHR, 2017, 10.1080.

Pal, P.S., Debnath, D., Chakrabarti, S.K., "Spectral variation during one quasi-periodic oscillation cycle in the black hole candidate H1743-322", 2016, cosp, 41E, 1499.

Saha U, Singh, D., Midya S.K., Singh R.P.,Singh A.K.and Kumar S (2017) Spacio-temporal variability of lightning andconvective activity over South/South-East Asia with an emphasis during El Nino and La Nina J.Atmos.Res.***https://doi.org*** /10.1016 /j.atmosres.2017.07.005

Sahu, D., Chakrabarti, S. K., Das, A.,"Study the Formation of H2, HD and D2 under Various Interstellar Conditions", 2016, cosp, 41E,1684.

Sarkar D,Das P,Jana P.K.and **Midya S.K.(2017)** Variation in Tropospheric Ozone Concen-trations Over Different Stations in India,Zen.Inter.J.Multi.Res. 7

Sarkar, R., with 61 co-authors, "Geomagnetically trapped, albedo and solar energetic particles: Trajectory analysis and flux reconstruction with PAMELA", 2017, ASR, 60/4, 788-795.

Sil, M., Chakrabarti, S. K., Das, A., Majumdar, L., Gorai, P., Etim, E.E., Arunan, E., "Computation of Adsorption Energies of Some Interstellar Species", 2016, cosp, 41E, 1803.

Sil, M., Gorai, P., Das, A., Sahu, D., Chakrabarti, S. K., "Adsorption energies of H and H2: a quantum-chemical study", EPJD, 2017, 71, 45.

Sivaraman, B., Mason, N., Chakrabarti, S. K., Das, A., Gorai, P., Rajan, R., Pradeep, T., Sundararajan, P., Cheng, B. M., "Only Amorphous Ethanethiol Exists in the Interstellar Medium", 2016, cosp, 41E, 1823.

Sundrarajan, P., Rajan, R, Gorai, P., J-I Lo, Das, A., Pardeep, T., Cheng, B-M., Mason, N.J., Sivaraman, B., "Qualitative Observation of Reversible Phase Change in Astrochemical Ethanethiol Ices using Infrared Spectroscopy" **,**Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 2017, 178, 166.

Sundararajan., P., Sahu, D. Lo, J. I., Sekhar, B. N. R., Cheng, B. M, Das, A., Pirogov, L., Mason, N. J., Sivaraman, B., "SH Stretching Vibration of Propanethiol Ice - A Signature for its Identification in the Interstellar Icy Mantles", 2017, Ap&SS, 362, 126.

Impact Factor per Journal by ICSP scientists in 2016-2017:

Impact Factor in2016-2017				
Sl. No	Journal Name	Impact Factor (IF)	No. Of publications	Total IF
1	ApJ	5.533	5	27.665
2	MNRAS	4.961	5	24.805
3	SAA	2.536	1	2.536
4	MAP	1.67	1	1.67
5	AP&SS	1.622	3	4.866
6	ASR	1.401	3	4.203
7	EPJD	1.208	2	2.416
8	JASTP	1.39	1	1.39
9	GNHR	1.19	1	1.19
Total Impact Factor				70.741

Departmental Progress Reports (2016-2017)

Department of Astrochemistry/Astrobiology

Study the formation of stars is immensely important as this hold the clue to the origin of our presence in the Universe. Various evolutionary stages of the star formation could well be probed with the observation of various molecules. It is a long-standing aspiration to use chemical properties of interstellar species to understand the physical properties of the ISM. At ICSP, we are engaged in these studies to answer the evolutionary history of the complex bio-molecules in the Interstellar medium and circumstellar disks. At present, our department has one JRF (Mr. Milan Sil) and one SRF (Mr. Prasanta Gorai). This year, one of our students, Mr. Dipen Sahu had submitted his Ph.D. Thesis to the University of Calcutta and waiting for the degree. This year, we have published eight papers in some of the reputed international refereed journals. Dr. Ankan Das visited various National Institutes (IISC, PRL) for presenting departmental research activities.

Ankan Das

(Dr. Ankan Das)
HOD, Astrochemistry/Astrobiology

Department of High Energy Astrophysics

Study of various theoretical and observational aspects of black holes are being studied in this department. There are total seven regular (Prof. Sandip K. Chakrabarti, Dr. Dipak Debnath, Dr. Partha Sarathi Pal, Mr. Arka Chatterjee, Mr. Shreeram Nagarkoti, Md. Aslam Ali Molla, Mr. Arghajit Jana, and Mr. Debjit Chatterjee) and visiting members (Dr. Broja Gopal Dutta and Mr. Nirmal Saha) are working in this group. Regular research scholars are working on various important topics of theoretical and observational aspects of black holes under different national and international project grants. A total six scientific papers are published in high impact refereed international journals and another two papers in conference proceedings of international journals during current financial year.

During this period, we attend different scholarly places to attend scientific conferences or workshops. We went to National Cheng Kung University, Tainan, Taiwan to attend “2016 ASROC annual meeting” during 2016 May 13-16 (Debnath, D.,); IUCAA, Pune, India to attend “ASTROSAT A01 workshop” during 2016 July 13-14 (Chatterjee, D. & P. S. Pal); TIFR, Mumbai to attend International conference on “Wide Band Spectral and Timing Studies of Cosmic X-ray Source" during 2017 January 10-13 (Prof. S.K. Chakrabarti, Debnath, D., Nagarkoti, S., A. Chatterjee, Molla, A.A., Jana, A., D.Chatterjee); TIFR, Mumbai, India to attend workshop on “Data Analysis and LAXPC Science" during 2017 January 18-21 (Prof. S.K. Chakrabarti, Debnath, D., Nagarkoti, S., A. Chatterjee, Molla, A.A., Jana, A., Chatterjee, D.); Jaipur, India to attend “Astronomical Society of India (ASI)” during 2017 March 6-10 at B. M. Birla Auditorium (Prof. S.K. Chakrabarti, Debnath, D., A. Chatterjee, Jana, A., Chatterjee, D.). Dr. D. Debanth also visited Institute of Astronomy, National Tsing Hua University, 101, Sec 2, Kuang-Fu Road, Hsinchu, 30013, Taiwan to work with Prof. Hsiang-Kuang Chang from April 28, 2016 to July 22, 2016 as a Visiting Assistant Professor. Prof. Chakrabarti, S.K. and Dr. D. Debanth also organized one day workshop in ASI meeting on 6th March (2017) at B. M. Birla Auditorium, Jaipur, India on (Workshop4:) ``X-ray Observations and Data Analysis of Compact Objects" .

Dipak Debnath

(Dr. Dipak Debnath)
HOD, High Energy Astrophysics

Department of Instrumentation for Space Exploration

Several Instrumentation and data analysis aspects of Balloon born science are studied in this department. VLF Radio instrumentation and overall maintenance are also carried outby this departmental staff. Successful Development of different lab facilities like vacuum chamber, have been done for testing the detector etc. There are total Seven regular member (Prof. Sandip K. Chakrabarti, Mr. Debashis Bhowmick, Dr. Ritabrata Sarkar, Mr. Arnab Bhattacharya, Mr. Susanta Middya, Mr. Hriday Roy, Mr. Uttam Sardar) working in this group. There are eighteen successful balloon missions during this year.

Debashis Bhowmick

(Mr. Debashis Bhowmick)
HOD, Instrumentation for Space Exploration

Department of Ionospheric Sciences

We focus observational and theoretical understanding of impression of various terrestrial and extra-terrestrial sources on ionosphere and sub-ionospheric propagated Very Low Frequency (VLF) signals. Simultaneous real time monitoring of VLF radio wave are running in IERC, Sitapur, ICSP Malda branch and Koochbehar. Ten members have been worked in this department. Two papers were published in highly reputed international journals.Mr. Surya K. Maji successfully submitted his PhD thesis and Mr. Suman Chakraborty successfully defended his pre-PhD viva-voce in University of Calcutta. Dr. Sourav Palit joined in a University in Sao-Paulo, Brazil.Dr. Sasmal, Dr. Basak and Mr. Chakraborty participated in the 3rd URSI RCRS meeting in NARL, Tirupati. Mr. Chakraborty, Mr. Ghosh and Mr. Sanki participated in the Scostep/ISWI International School on Space Sciences, Sangli, Maharashtra. Prof. Chakrabarti attended the 7th VERSIM Symposia in Hermanus, South Africa. D. Sasmal was the MSO and Prof. Chakrabarti was the DO of the scientific session C0.3 of the 41st COSPAR meeting in Istanbul, Turkey. Dr. Sasmal guided one B.Sc. INSPIRE project student.

Sudipta Sasmal.

(Dr. Sudipta Sasmal)
HOD, Ionospheric Sciences

Members of Scientific Societies/Committees

Sandip K. Chakrabarti is a member of the following 1) Board of Studies, Dept. Of Atmospheric Science (Calcutta University), 2) Board of Research Studies, University of Gour Banga, 3) Member NAAC team for evaluation of TIFR and GMRT, 4) Consultative Administrative Committee of SNBNCBS Head of the Department, Astrophysics and Cosmology, 5) SCREC and APMP committees. He is the In Charge and Secretary of Governing Body, Indian Centre for Space Physics.

Dipak Debnath was the Convener of the ASI the Workshop4: ``X-ray Observations and Data Analysis of Compact Objects" at Jaipur, India on 6th March (2017).

Sudipta Sasmal was the External Examiner in M.Sc. Computational final semester at Sidho Kanho Birsha University, 2017. He is the Convener, Executive Committee, Ionospheric & Earthquake Research Centre (IERC/ICSP), Sitapur, Medinipur (W).and the Convener, Academic Council, Indian Centre for Space Physics, Kolkata.

Prasanta Gorai became a member of Royal Society of Chemistry.

Ph.D. Thesis Submitted

Surya Kanta Maji submitted Ph.D. thesis on "The effects of the solar eclipse on signal amplitude of very low frequency radio waves in Indian sub-continent**"**(University of Calcutta).

Dipen Sahu submitted Ph.D. thesis on **"**Astrophysical processes leading to deuterium enrichment of the interstellar medium" (University of Calcutta).

Asit K Choudhury submitted Ph.D. thesis on **"**Sources of High Energy Radiation and their effects on the Very Low Frequency (VLF) Radio Signals" (Maulana Abul Kalam Azad University of Technology).

Course of Lectures offered by ICSP members

Ankan Das, Ritabrata Sarkar, and Dipak Debnath gave about 30 lectures to the 4th semester Physics post-graduate students of R. K. Mission Residential College (Autonomous) on High Energy Astrophysics and Cosmology as part of the Astronomy and Astrophysics Course. This is offered on a regular basis every year.

Dipak Debnath Delivered lectures and guided post-M.Sc. students for Pre-Ph.D. course work according to the UGC guide-line and affiliated by University of Calcutta at Indian Centre for Space Physics (ICSP), Kolkata for the academic semester 2016-17. The subjects (each of full 50 marks) taught during the course are: PHY 001: Research Methodology, PHY 002: Review of Topical Research, PHY 003: Astrophysics and Space Science, and PHY 004: Project Work.

Participation in National / International Conferences & Symposia

Sandip K. Chakrabarti gave following oral presentations in **July, 2016**: Black Holes and the Universe at the Golden Jubilee celebration meeting of LLSM Institution, Malda. **Sept, 2016:** Food Habits of Black Holes, an Astronomy department seminar at the University of Durban, South Africa and at the University of Cape Town, South Africa, Chemical Evolution of the Universe since Big Bang and the Origin of Life, public lectures at the University of Durban and University of Cape Town. Accretion processes in Astrophysics: A six-hour seminar series at the Astronomy Department of the University of Cape Town."Earth as a gigantic detector: Using VLF signals to recreate spectrum of injected radiation on earth'" and "Observations of long term VLF propagation effects from Antarctic Stations at Maitri and Bharati of India" oral presentations at the VERSIM conference at Harmanus, South Africa. **January, 2017 :**"Mysterious Black Holes" a public lecture at Malda College Ground, "Excitements in Astronomy, Astrophysics and Space Research" at RKMR College (Auton.), Narendrapur. Inaugural talk on "Accretion processes on black holes becomes Science" at the 'Wide Band Spectral and Timing Studies of Cosmic

X-ray Sources' conference at TIFR. **March, 2017:**Inaugural talk on "X-ray Studies of Compact objects: theory and observational support" at the satellite workshop of Astronomical Society of India meeting, Jaipur.

Ankan Das visited Physical Research Laboratory, Ahmedabad, 8-10th September, 2016 and IISC Bangalore, 16-17th October, 2016.

Dipak Debnath Participated in the following **May, 2016**: ASROC Annual Meeting at National Cheng Kung University, Tainan, Taiwan during May 13-16, 2016.**June, 2016:** Delivered invited lecture at **Institute of Astronomy, National Tsing Hua University**, 101, Sec 2, Kuang-Fu Road, Hsinchu, 30013, Taiwan on 17th June 2016., **December, 2016:** Oral presentation at RIKEN symposium on "7 years of MAXI: monitoring X-ray transients" at RIKEN, Saitama, Japan on 5th Dec. 2016. **January, 2017:** He gave an oral presentation at International conference on "Wide Band Spectral and Timing Studies of Cosmic X-ray Source" during January 10-13, 2017 at TIFR, Mumbai, India. **March, 2017:** he gave an oral presentation at XXXVth Meeting of Astronomical Society of India (ASI) during 6-10 March 2017, at B. M. Birla Auditorium, Jaipur, India.

Ritabrata Sarkar visited SN Bose National Center for Basic Sciences, Kolkata, India, August 2016.attended and gave an oral presentation 35th Meeting of Astronomical Society of India, Jaipur, India on March 6 – 10, 2017.

Sudipta Susmal gaveoral presentations in the following: **December, 2016**:Indian Scientific Expedition to Antarctica, Gomokpota Gunodhor High School, Medinipur (W), 24th December, 2016.Indian Scientific Expedition to Antarctica: A Brief Overview, Sristi NGO, Medinipur (W), 28th December, 2016.Life and Science in Antarctica", Khukurdaha Science Fair, Medinipur (W), 29th December, 2016.**January, 2017**: Radio Science in Antarctica, Sidho Kanho Birsha University, Purulia, 25th January, 2017.**March, 2017**: Study of the Dependence of Sub-Ionospheric Very Low Frequency (VLF) Signal Propagation Characteristics on the Lower Ionospheric parameters During Nepal Earthquake on May, 2015, 3rd URSI Regional Conference on Radio Science, National Atmospheric Research Laboratory (NARL), Tirupati, India, 1-4 March, 2017. He also presented three posters in the same URSI meeting.

Arka Chatterjee presented a talk in **January, 2017 on**Spectrum, Image and Time Evolution of Photons from Two Component Advective Flow in presence of Comptonization, TIFR, Mumbai. He attended the following exhibition in **March, 2017:** Image and Time Lag properties of Photons emitted from a Two Component Advective Flows as obtained from the Monte-Carlo Simulations, ASI meeting Jaipur,

Dushmanta Patra visited NCRA/GMRT for observation of the projects 'Multi-frequency properties of a narrow angle tail radio galaxy J0037+18.' on October-November, 2016; gave the following poster presentation in **March, 2017:** Multi-frequency study of large radio galaxies and Galactic and extra-galactic transient radio sources, ASI, meeting, 6-10 March, 2017 at Jaipur, India.

Suman Chakraborty attended the SCOSTEP/ISWI International School on Space Science in Sangli, Maharashtra from November 7 – 17, 2016.He presented a poster at International Union of Radio Science URSI - RCRS 2017 organized by NARL, Tirupati, India from March 1 – 4, 2017.

Visits abroad from the Centre

Sandip K. Chakrabarti Visited University of Durban and University of Cape Town for several weeks (Sept. 2016)

Dipak Debnath Visited Institute of Astronomy, National Tsing Hua University, 101, Sec 2, Kuang-Fu Road, Hsinchu, 30013, Taiwan to work with Prof. Hsiang-Kuang Chang from April 28, 2016 to July 22, 2016.

Shreeram Nagarkoti attended the School of Cosmology, ICTP, Trieste, Italy, June, 2016.

Collaborative research & project work

*Modeling of Interstellar Gas-Grain Chemistry and study the spectral properties of some complex Interstellar molecules,*A. Das (ICSP), S.K. Chakrabarti (SNBNCBS and ICSP): Funded by Department of Science and Technology.

Abstract:Almost two hundred species were discovered in the interstellar medium (gas and ice) and thousands of chemical species were discovered in meteorites which are believed to be formed in proto-stellar phase. Surprisingly, reaction rate coefficients for the formation of several of these Interstellar gas phase as well as grain surface species, what to talk about amino acids seen in meteorites are, till date, unknown. Occasionally one takes approximate values of the reaction rates for modeling purposes, but these might yield misleading results. We perform Quantum Chemical simulation to study the spectral properties of several important Interstellar species to correlate different observational aspects. Armed with chemical abundances and spectral knowledge of complex molecules, we predict abundances of bio-molecules and their precursors.

Interstellar chemistry as a powerful tool to investigate physical conditions around the star forming regions and protoplanetary disks, A. Das (ICSP), S.K. Chakrabarti (SNBNCBS and ICSP): Funded by Department of Science and Technology.

Abstract:It is a long-standing aspiration to use chemical properties of various interstellar species for the measurement of physical properties of molecules clouds and star forming regions. In this project, we want to test outcomes of various models of interstellar chemistry and cross check them with known results. Molecules with two or more hydrogen atoms would be useful to trace the dynamic properties because of their ortho to para spin orientations. Temperature dependency of this ortho to para ratio (in the high temperature, ortho to para ratio is close to 3.0 but at low temperature, it drops significantly) would be an useful diagnostics tool for this purpose. During the star formation process, study of abundances of sulfur bearing species would be another option to use as a chemical clock. Circumstellar disk is a natural byproduct of a rotating cloud collapse. These disks are the birth sites of the planetary systems and are thus called the protoplanetary disks. Study of the chemical composition of these disks will provide some estimation of the initial chemical composition of future planets. Similarly, ambipolar diffusion is a phenomenon which controls the rate of star formation to some extent. Thus the measurement of ambipolar lengthscale would be essential. This is done by measuring differences in line widths of similar charged and neutral species. In this regard, we will use CASSIS interactive spectrum analyzer. Moreover, we will use CASSIS to model astronomical spectra of various species under different physical circumstances.

Study of the spectral properties of few transient black hole candidates with Two Component Advective Flow model [D. Debnath (ICSP), S. K. Chakrabarti (SNBNCBS and ICSP)] Funded By DST/FTYS

Abstract: The main goal of this project is to study the spectral properties of the black hole candidates (BHCs) with two-component advective flow (TCAF) model and from there we want to
get a clear picture about the mass accretion processes around a BHC. Chakrabarti and his collaborators have qualitatively argued that the TCAF model should fit well for various types (states) of black hole spectra, take from different spectral states of XTE J1550-564, H 1743-322, GX 339-4. In the present project, we are developing a software i.e., TCAF model fits file which will directly fit the observed data from NASA's archive as a local model in HeaSARC's spectral analysis software package XSPEC. From the spectral fit, one can also directly extract physical parameters related to the mass accretion flows around the BHCs: two-component (Keplerian and sub-Keplerian) flow rates, shock locations, shock strengths, possible mass of the BHCs and distance of the BHCs. Detailed accretion flow dynamics, classification of different spectral states, prediction of quasi-periodic oscillation (QPO) frequencies, unknown black hole mass, etc. will be explained in this project.

Study of timing properties of few outbursting black hole candidates, [D. Debnath (ICSP), S. K. Chakrabarti (SNBNCBS and ICSP)] Funded By ISRO/RESPOND

Abstract:Main scientific objectives of the project are to quantify precisely how the time variation of spectra is taking place during the entire outburst phase, for each of the transient black hole candidates, such as GX 339-4, GRO J1655-40, H 1743-322, XTE J1550-564, XTE J1859+226 etc. during their outburst phases. Also to predict the origin of quasi-periodic oscillations (QPOs)
by making detailed temporal and spectral studies of the properties of few transient X-ray binaries. If the QPOs are caused by oscillations of shocks, then, our goal would be to understand what causes the drifts of the shocks in order that the evolving frequencies may be explained. We also will work on prediction of the mass of unknown transient black hole candidates by the fitting results obtained from day-wise QPO frequency evolutions and constant normalization spectral fit with two-component advective flow (TCAF) model as a local model in HeaSARC's spectral analysis software package in XSPEC.

X-ray Properties of Accretion Flows and Estimation of Fundamental Parameters of Black Hole Binaries, [D. Debnath (ICSP)] Funded By DST/SERB.

Abstract: Study of a few black hole (BH) sources in X-rays to infer about spin, mass, distance, inclination angle, outflow rates, line properties, etc. will be done in the project using two-component advective flow (TCAF) solution. Recently Debanath his collaborators have successfully implemented most generalized black hole accretion flow solution TCAF (was introduced by Chakrabarti and his collaborators in mid-90s) as an additive table model in NASA's spectral analysis software package XSPEC. TCAF model fitted spectra provides us information about the physical flow parameters, such as two component accretion (Keplerian and sub-Keplerian) rates, shock (location and compression ratio) other than mass of the black hole (if kept free while fitting spectra). Most probable values of the masses of few BH sources have also been successfully estimated from our spectral analysis with the TCAF solution. In this project, we will study accretion flow properties of few more BH sources with TCAF paradigm. We also try to estimate their intrinsic physical parameters (for e.g., spin, mass, distance, inclination angle, etc.) from our spectral study.

M.Sc.project students guided by ICSP members

Dr. Sudipta Sasmal supervised Mr. Debayan Chatterjee (St. Xavier's College), on "Study of Very Low Frequency Signal Characteristics during Sunrise and Sunset by Using Solar Zenith Angle Profile" for J.C. BoseNat. Sc. Talent Search Scholarship (Reg. No. Sch/Per/A/15/25A).

Summary of Research Activities of the Scientists at the Centre

Astrobiology/Astrochemistry

Top: (L to R): A. Das, S. Chakrabarti and S.K. Chakrabarti
Bottom: (L to R): D. Sahu, P. Gorai and M.Sil

The chemical composition of interstellar grain mantle is mostly dependent on adsorption energies of the surface species. Since hydrogen is widespread either in atomic or in molecular form, we perform quantum chemical calculations to find out the variation of the adsorption energies of H and H2 depending on the nature of the adsorbents. Choice of absorbents was based on relative abundances of interstellar materials. We found that, for all types of adsorbents considered in our study, binding energies of H are always lower than those of H2 , whereas, some of the experimental values are just the other way around.

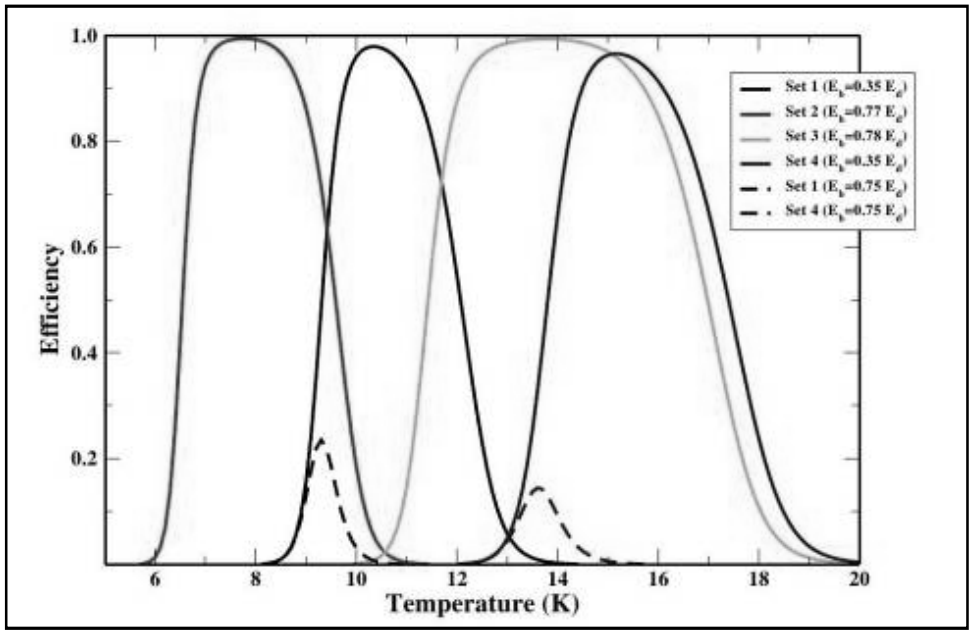


Figure 1: Efficiency window for the formation of H2 is shown by considering various sets of available binding energies.

Majority of the known interstellar cations are protonated species believed to be the natural precursors for their corresponding neutral analogues formed via the dissociative recombination process. The protonation of a neutral species can occur in more than one position on the molecular structure thus resulting in more than one proton binding energy value and different protonated species for the same neutral species. We found that protonated species resulting from a high proton binding energy prefers to remain protonated rather than transferring a proton and returning to its neutral form as compared to its analogue that gives rise to a lower proton binding energy (PBE) from the same neutral species. For two protonated species resulting from the same neutral molecule, the one that results in a higher PBE is more stable as compared to its counterpart that is responsible for the lower PBE for the same neutral species.

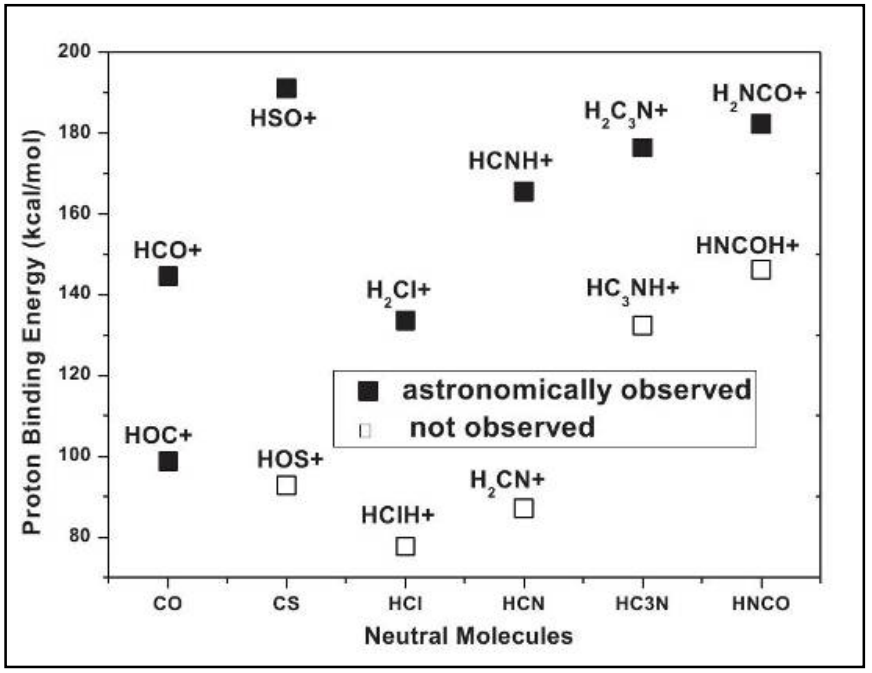


Figure 2: Relationship between PBE and astronomical observation of protonated species is highlighted.

Astronomical observation of isopropyl cyanide further stresses the link between the chemical composition of the interstellar medium (ISM) and molecular composition of the meteorites in which there is a dominance of branched chain amino acids as compared to the straight. However, observations of more branched chain molecules in ISM will firmly establish this link. In the light of this, we have considered C5H9N isomeric group in which the next higher member of the alkyl cyanide and other branched chain isomers belong. We found that the only isomer of the group that has been astronomically searched, n-butyl cyanide is not the most stable isomer and therefore, which might explain why its search would only yield upper limits of its column density without a successful detection. Rather, the two most stable isomers of the group are the branched chain isomers; tert-butylnitrile and isobutyl cyanide. Based on our results, we propose to tert-butylnitrile.

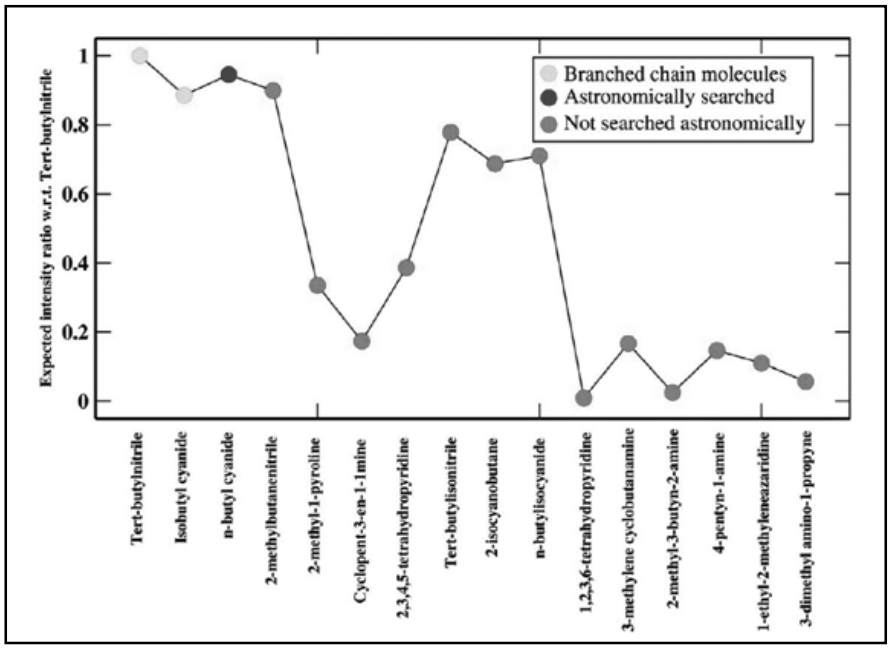


Figure 3: Expected intensity ratio by assuming the same column density and rotational temperature is shown.

In order to understand the synthesis of PAHs, either in interstellar or circumstellar regions, it is essential to understand the formation of the six-member aromatic species, benzene. It may be formed by the recombination of propargyl radicals. Propargyl alcohol (PA) would be the source of propargyl radical in the ISM which is yet to be detected. Based on our results, we propose to observe this species and its deuterated forms (OD-PA). Figures4 (a-c) refer to the warm-up portion of our simulation. Figure 4a represents the evolution of PA and OD-PA whereas Figure 4b represents the evolution of PA related species such as C3H3, HC2CHO and HC2CH2O and Figure 4c represents the evolution of the major icy species water, methane and methanol for the gas and ice phases.

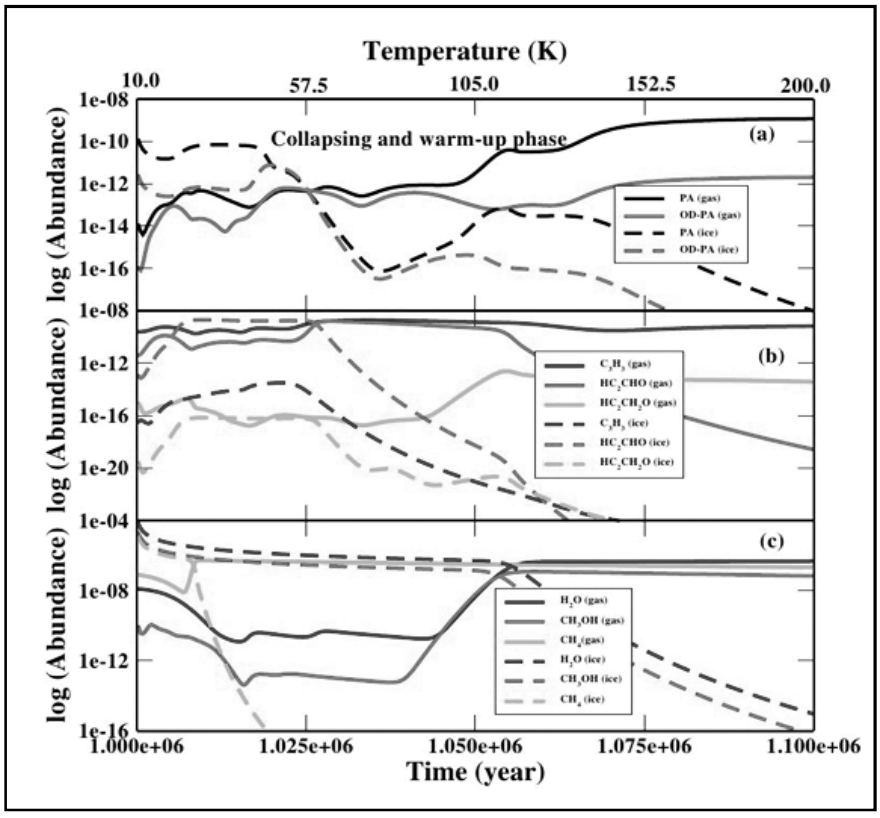


Figure 4: Synthesis of PAH during collapse of ISM in warm phase.

Sources of High Energy Radiations

(L to R): S. K. Chakrabarti, A. Chatterjee, S. Nagarkoti, D. Debnath

Black Hole Astrophysics

We carry out theoretical studies of how matter is accreted into black holes, how matter is ejected from accretion disks in the form of jets and outflows and how radiation is emitted from these disks and outflows. Our interest is to focus on the effects of viscosity on the topology of the flow and emitted radiation. We are interested to find how the strong gravity close to a black hole affects the flow geometry. We also study how black holes focus photons to our side by bending the photon trajectory and cause apparent deformation of the disk image through Doppler and gravitational redshifts and time-lags among various energy components.

i) Estimating viscosity parameter α from observational data: We calculate the viscosity parameter α in both sub-Keplerian and Keplerian components in accretion disks of various outbursting sources under TCAF paradigm. We find the parameter space which allows shock formation and calculate all possible values of Quasi-Periodic Oscillations (QPO) theoretically. Then, we tally them with observed QPOs to find the likely range of viscosity parameter in the sub-Keplerian component (α_{SK}). We then estimate the viscosity parameter in Keplerian component (α_K) for various outbursting sources. During 2010-11 outburst of GX 339-4, α_{SK} was below 0.13 and $\alpha_K$was ~ 0.34. Similarly during 2010 outburst of MAXI J1659-152 α_{SK} was below 0.1 and $\alpha_K$was ~0.22 and during 2011 outburst of MAXI J1836-194 α_{SK} was below 0.11 and α_K was ~0.18.

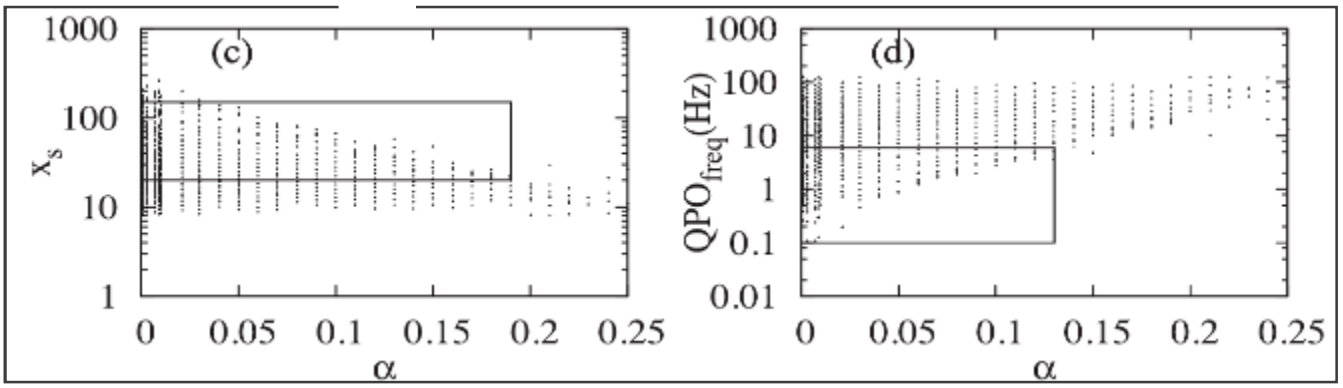


Figure 5: All possible values of shock locations and QPO frequencies are plotted with α. The values inside the rectangles are relevant for 2010-2011 outburst of GX 339-4.

ii) **Time Lag Properties of Photons Emitted from Two Component Advective Flow:** X-Ray photons observed by the satellites show an energy dependent time lag behavior. For different QPO frequencies, the magnitude of time lag changes. In general, for higher energies, the time lag of photons increases. Also, the

effect of inclination angle plays a major role on the lag magnitude and their signs. Dutta & Chakrabarti (2016) presented the possible contributors of the time lag. They are: Comptonization, disk reflection, photon bending and inclination angle of the black hole accretion disk with respect to the line of sight of the observer. In our earlier work, we have added Comptonization and photon bending together to produce image and spectra corresponding to an observer sitting at a particular inclination angle. We have added disk reflection and computed the time of arrival of photons on the plane of observer with respect to different energy bands and plotted for various inclination angles. For increasing shock locations, we have showed that the lag magnitude increases. Panel (a) shows time lags for 0°(square), 10°(triangle); Panel (b) shows time lags for 20° (square), 36° (triangle), 50° (star) and Panel (c) shows time lags for 60° (square), 70° (triangle), 80° (star). Our simulation matches with the current observational results.

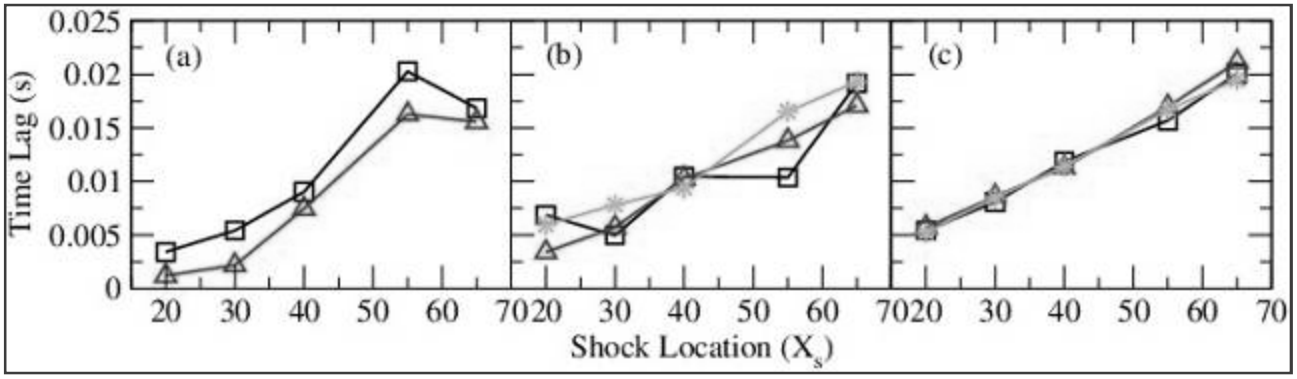


Figure 6: Time lag (in seconds) between hard band (5–100) keV and soft band (0.1–5) keV is plotted against shock location (X_s). (a) Square and triangle lines represent 0°and 10°, (b) Square, triangle and star lines represents 20°, 36°and 50°, respectively and (c) square, triangle and star lines represent 60°, 70°and 80°, respectively

X-ray Astronomy

(L to R): D. Debnath, A.A. Molla, A. Jana

(L to R): D. Chatterjee, A. K. Choudhury

The X-ray Astronomy group is involved in fitting observational results with various models. It also analyses results and interprets in terms of physical processes around black holes. Our major activity has been to implement TCAF solution into XSPEC and fit observational data with this solution. Our solutions give physical parameters of the flow directly and found most convincing explanations for evolution of parameters of accretion flows. We also estimate the black hole mass.

i)**Evolution of Timing and Spectral Properties of MAXI J1543-564 during its 2011 Outburst:** The source was first observed by MAXI/GSC on 2011 May 8. We studied early rising phase of the outburst using RXTE/PCA observations from 2011 May 10 to 15. The frequency of the Low Frequency Quasi-periodic oscillations (LFQPOs) are observed to evolve monotonically for first five observations. On sixth observation (2011 May 14), a decrease in QPO frequency is observed. To understand detailed accretion flow properties of the source during this phase of the outburst, we make spectral analysis using phenomenological disk blackbody plus power-law models and generalized physical flow model TCAF solution. The combined disk blackbody plus power-law model fit tells us a rough estimate of the flux contributions of the thermal and non-thermal components, where our TCAF model fits provide us the physical cause of such radiations. Depending upon nature of variations of TCAF model fitted two component (Keplerian disk and sub-Keplerian halo) accretion rates, accretion rate ratio (ARR), and observed QPOs, we classified the period of our analysis (early rising phase of the 2011 outburst of MAXI J1543-564) into two spectral states, namely, Hard-Intermediate (HIMS) and Soft-Intermediate (SIMS).

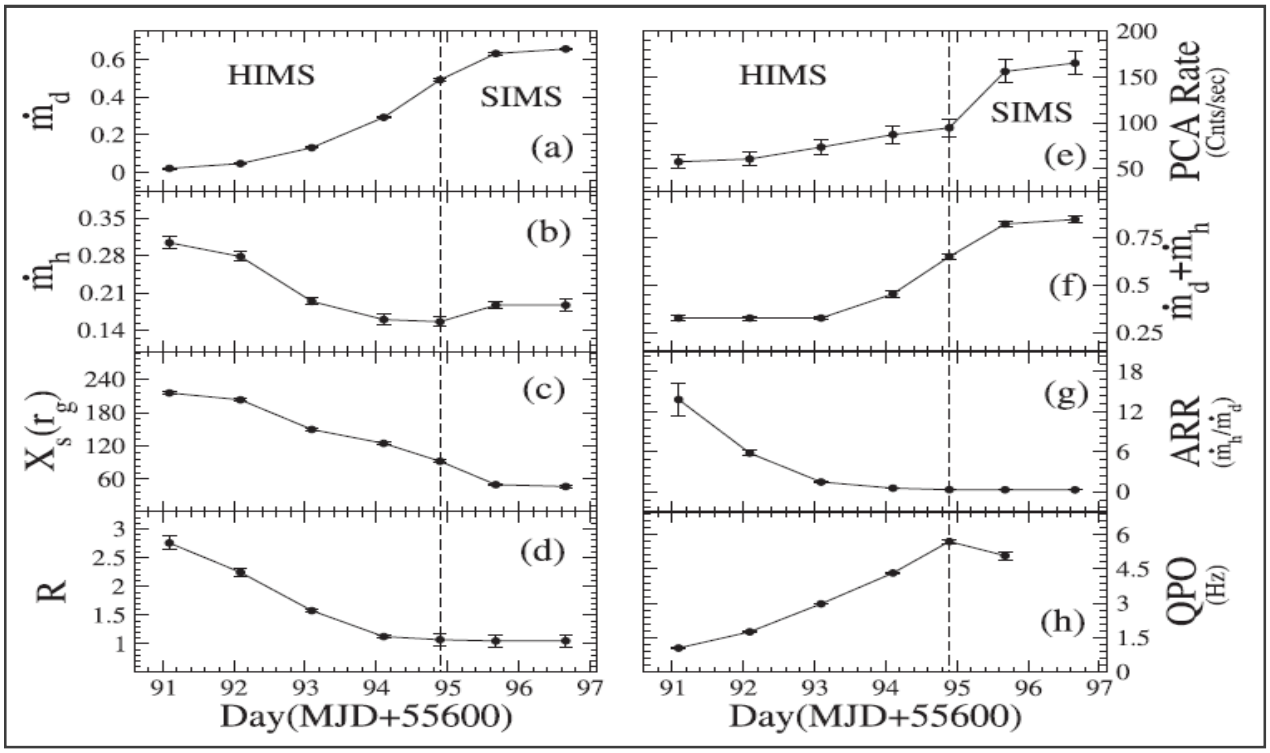


Figure 7: Variations of (a) disk rate (ṁd) in Eddington rate, (b) halo rate (ṁh) in Eddington rate, (c) shock location (X_s) in (r_g), (d) compression ratio (R), (e) PCU2 count rate, (f) total flow rate (ṁd + ṁh) (g) ARR, i.e., $\dot{m}_h/\dot{m}_d$, and (h) observed QPO frequency(Hz).

ii) **<u>Evolution of low frequency QPOs during 2011 outburst of MAXI J1543-564: Fitted with POS model:</u>**
Chakrabarti and his collaborators introduced shock oscillation model (SOM) in mid-90s to find origin of these QPOs. According to SOM, QPOs are mainly due to resonance oscillation of the shock wave, when cooling time scale (t_c) of the flow becomes comparable to the infall time scale (t_i). The observed QPOs are inversely proportional to the infall times from shock locations. We studied monotonic evolutions of the LFQPOs during initial rising phase of the outburst with the propagating oscillatory shock (POS) model (which is a time varying form of the SOM. Instantaneous location of the shock, compression ratio, velocity of the shock movement, etc. are calculated from POS model fit.

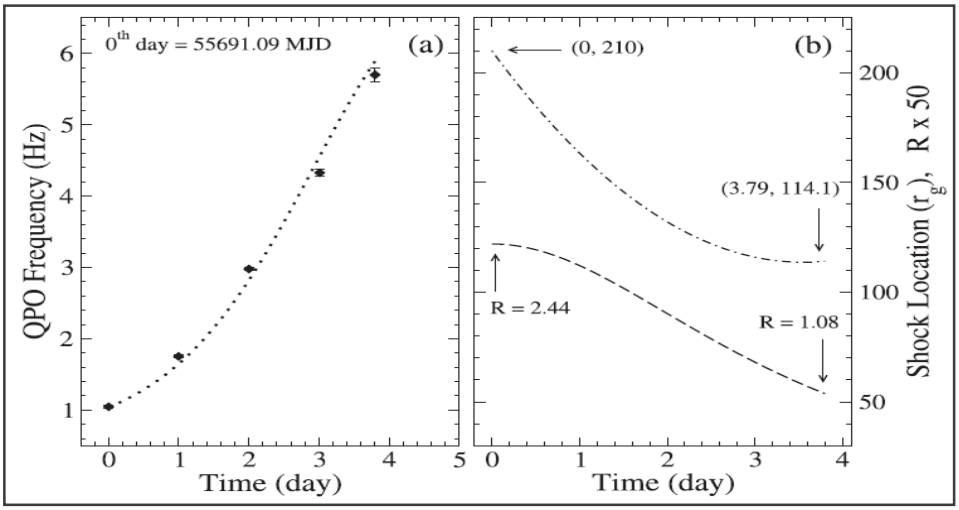


Figure 8: (a) Variation of observed QPO frequency with time (in day) during the rising phase, fitted with the POS model solution (dashed curve). In panel (b), variation of the POS model fitted shock locations (in r_g) and compression ratios (R) are shown.

Obs.	ID	MJD	ν_{Obs} (Hz)	ν_{POS} (Hz)	X_s (r_g)	V (cm s^{-1})	R	ν_{TCAF} (Hz)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	X-01-00	55,691.09	$1.05^{\pm 0.02}$	1.04	210.0	2450.0	2.44	$0.85^{\pm 0.06}$
2	X-01-01	55,692.09	$1.75^{\pm 0.02}$	1.65	163.4	2105.7	2.24	$1.12^{\pm 0.05}$
3	X-01-02	55,693.09	$2.98^{\pm 0.02}$	2.82	132.0	1760.1	1.81	$2.49^{\pm 0.14}$
4	X-02-00	55,694.10	$4.38^{\pm 0.05}$	4.56	115.9	1411.5	1.36	$4.67^{\pm 0.27}$
5	X-02-01	55,694.89	$5.70^{\pm 0.09}$	5.89	114.1	1139.0	1.08	$7.68^{\pm 1.11}$
6[a]	X-02-02	55,695.67	$5.08^{\pm 0.17}$	...	...	...	...	...
7	X-02-03	55,696.68	...	...	...	...	...	...

Notes. Here, "X" = 96371-02 signifies the initial part of an observation ID. Here ν_{Obs} is the observed QPO frequency, ν_{POS} is the theoretical QPO frequency calculated from the POS model fit, "V" is the velocity of the shock in cm s^{-1}, "R" is the shock compression ratio, and ν_{TCAF} is the calculated QPO frequency from TCAF model fitted shock parameters.

[a] This type-B QPO of SIMS does not fit with the POS, since the origins of the type-B QPOs are different.

Table: QPOs fitted with POS model and predicted from TCAF model fitted shock parameters.

iii) **Prediction of dominating type-C QPOs from TCAF model fitted shock parameters:**We showed that frequency of the dominating QPOs could be predicted from the TCAF model fitted spectral (shock) parameters. This is possible, because according to SOM, resonance oscillation of the shock is primarily responsible for origin of QPOs. In TCAF, we use same shock while solving transonic flow solution using set of radiative transfer equations. So, we can predict dominating type-C QPOs (if observed) from our TCAF model fitted shock (location and compression ratio) parameters. Type-C QPOs are observed during initial five observations of the early rising phase of the 2011 outburst of MAXI J15430564 is predicted here using TCAF model fitted shock parameters. We also compared these estimated QPOs with observed as well as POS model fitted frequency of the QPOs.

iv) **Mass Estimation of MAXI J1543-564 from TCAF Model fitted Constant Normalization Method:**By fitting the observational data (spectra) using TCAF model, we have predicted most probable range of the mass of the black hole candidate MAXI J1836-194. Here, we use same method to estimate mass of the source MAXI J1543-564 using same method. Indeed, each TCAF model fitted spectrum provides us one best fitted mass value. To estimate the most probable range of the mass of the black hole, we use the fact

that TCAF has a constant normalization. It may vary, if there is a precession of the disk occurs or if we miss any important physical process not included in the present TCAF. A narrow variation (~ 11.5-12.7) of the TCAF model normalization (N) is observed during the period of our analysis. The mass of the BH (M_{BH}) is found to vary also in narrow range of ~ 13.5-14.0 $M_{\odot}$. From POS model fitted QPO evolution, we obtained the best fit for M_{BH} =13 $M_{\odot}$with an allowable (upto 90% confidence level) range of ~ 12.6-14.0$M_{\odot}$. Now, combining these two methods, we estimated the most probable mass of MAXI J1543-564 as 12.6-14.0 $M_{\odot}$or $13^{+1.0}_{-0.4}$ $M_{\odot}$.

v) **<u>Comparative study of the accretion flow properties of H 1743-322 during its 2010 & 2011 outbursts with the TCAF Solution:</u>**We extend our earlier work to make a comparative study between two consecutive (2010 & 2011) outbursts of H 1743-322. We fitted spectral data with the current version of the TCAF model fits file to get information about the physical accretion flow parameters (two component i.e., Keplerian disk and sub-Keplrian halo accretion rates, shock location and compression ratio, etc.). Based on the variation of accretion rate ratio (ARR = ratio between halo to disk rate), and nature of QPOs (if present), we classified entire period of these two outbursts into four different spectral states, such as HS, HIMS, SIMS, SS, which are observed in the sequence of : HS(Rising) —> HIMS(Rising) —> SIMS(Rising) —> SS —> SIMS(Declining) —> HIMS(Declining) —>HS(Declining).

vi)**2004 Outburst of H 1743-322: Studied with the TCAF Solution:** To know details about the long term behaviour of the source, we studied the 2nd outburst in 2004 of the source after long quiescence of ~ 25 years. The source was re-discovered in 2003 by INTEGRAL satellite, where it was found to be unstable to form normal accretion flow configuration, which partially continued in 2004 outburst also. Similar to 2003,source was also unstable during initial phase of the 2004 outburst. After rediscovery, H 1743-322 showed recurring outbursts of ~ 2 months duration in every ~ 6 months to 2 years, except this 2004 outburst, which continued for ~ 4 months and 2003 outburst which continued for ~ 8 months. We studied detailed spectral and timing properties of the source during declining phase of the 2004 outburst to infer about the accretion flow dynamics around the black hole.

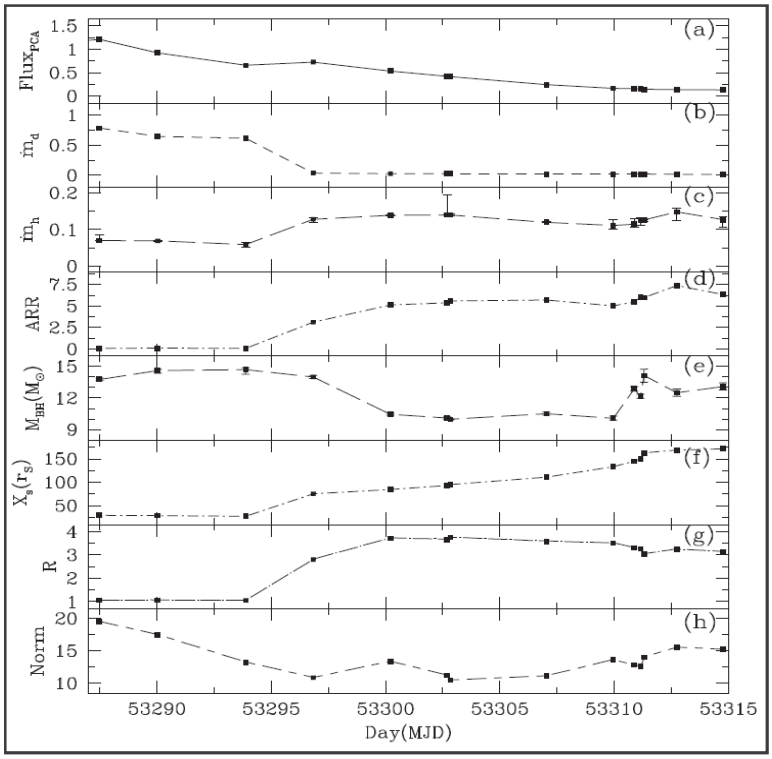


Figure 9: Variation of (a) the total PCA flux (in 10^{-9} ergs $cm^{-2}s^{-1}$), (b) the disc accretion rate ṁd (in Eddington units), (c) the subKeplerian halo accretion rate ṁh (in Eddington units), (d) the accretion rate ratio, ARR(=ṁh/ṁd), (e) the mass of the BH (in units of $M_{\odot}$), (f) the shock location X_s (in units of Schwardschild radius r_S), (g) the shock strength R and (h) the normalization of the TCAF model, with day (MJD).

X-ray/Gamma Ray Experiments and Balloon borne Earth and Space Science

(L to R): S.K. Chakrabarti, D. Bhowmick, A. Bhattacharya, R. Sarkar

(L to R): S. Middya, H. Roy, U. Sardar, R.C. Das

Under the “Dignity” programme of Indian Centre of Space Physics (ICSP), we have completed several missions (D90-D101) to collect important radiation data from space and earth atmosphere during last year. We deployed several payloads to study radiation characteristics from the atmosphere and space with different kinds of radiation detectors and ancillary equipments supporting the missions. We successfully tested new kind of plastic balloon carriers for relatively heavier payloads (~ 5 kg) and to achieve altitudes as high as 42 km. Since the Sun is in its minimal activity phase during this time we got radiations from the quiet sun and we could have the atmospheric radiation data due to cosmic ray interaction in it compare it with the previous data during maximum solar activity phase. During this time we have successfully detected radiation from Crab pulsar using the 5” phoswich detector with a better background rejection capability.For a proposed mission of radiation detection on board lunar lander we designed a payload for space exploration in X-rays from lunar surface. We optimized the payload and detector for the lunar mission and studied the scientific capability of such a payload during the mission.We discuss below some of the important facts and results we achieved during the last year.

Correlation of secondary cosmic ray in the atmosphere with solar activity:

We studied the variation of secondary cosmic ray in the atmosphere in low energy range (25-60 keV) throughout the atmosphere up to balloon ceiling height. We recorded the data during the 24th solar cycle from the maximum to minimum solar activity. We obtained the variation of radiation counts due to secondary cosmic rays throughout the atmosphere in two missions during solar maximum (October 2013) and near solar minimum (May 2016) periods. We found interesting anti-correlation between the solar activity which can be represented by sunspot number and the secondary cosmic-ray counts at the Pfotzer maxima where the radiation in the atmosphere has the maximum counts.

Radiation detection of from the Crab pulsar using 5" phoswich detector:

We used 5" diameter phoswich detector composed of 3 mm thick NaI(Tl) and 25 mm thick CsI(Na) crystals coupled together in anti-coincidence on board small plastic balloon. These balloons helped to reach the detectors above 41 km where the residual atmosphere is very tenuous and the source absorption is relatively small. Also due to the enhanced background rejection efficiency of the detector we were able to detect the radiation from Crab pulsar. We obtained the light curve detector throughout the whole mission (D93) where the excess radiation at the middle around 30.5 ks UT shows the radiation counts from Crab. We used special background reduction techniques for the spectral analysis of the data where we modeled the detector background during the source detection when simultaneous actual background radiation measurement was not available. We fitted the Crab radiation spectra with an absorbed power law which is a standard model for Crab spectrum.

Payload design for space exploration from lunar lander:

For a proposed mission of detection of space radiation from lunar surface on board lunar surface lander we designed a payload containing 2" diameter NaI scintillator detector. We studied in detail the scope of the scientific outputs in such mission and optimized payload design along with the collimator and shielding.Figure 10ashows the overall payload design optimized for the mission. We also conducted detailed stress-strain and vibration analysis of the payload under the extreme conditions such as launching and landing of the payload. Figure 10b shows an example of the stress distribution at various positions of the payload cover.

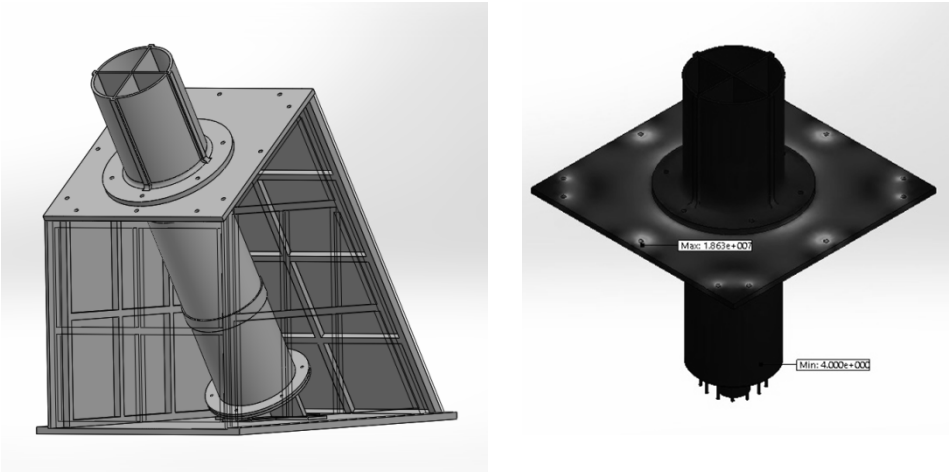


Figure 10: (a) The payload suitable for a lander pointing to the galactic plane as seen from the moon. (b) Stress analysis of the payload component.

VLF Radio Observations and Modeling

Top (L to R):*S. Sasmal, S.K. Chakrabarti, S. Palit, S. Pal, S. Chakraborty,*
Bottom (L to R): S. Ghosh, S. Ray, T. Basak, D. Bhowmick, A. Choudhury, B. Das

Seismo-Ionospheric Coupling

Pre and co-seismic ionospheric anomalies through sub-ionospheric Very Low Frequency (VLF) signals have been studied during Nepal earthquake (M=7.3) on May 12, 2015 at 07:05:19 UT. The recorded VLF signal of Japanese transmitter JJI (22.2 kHz) suffers from strong shifts in sunrise and sunset terminator times towards nighttime starting from three to four days prior to the earthquake. The signal showed a similar variation in terminator times during a major aftershock (M=6.7) on May 16, 2015. The maximum increase in overall VLF daylength observed was 32 minutes. These shifts in terminator times was numerically modeled using Long Wavelength Propagation Capability (LWPC) Programme.

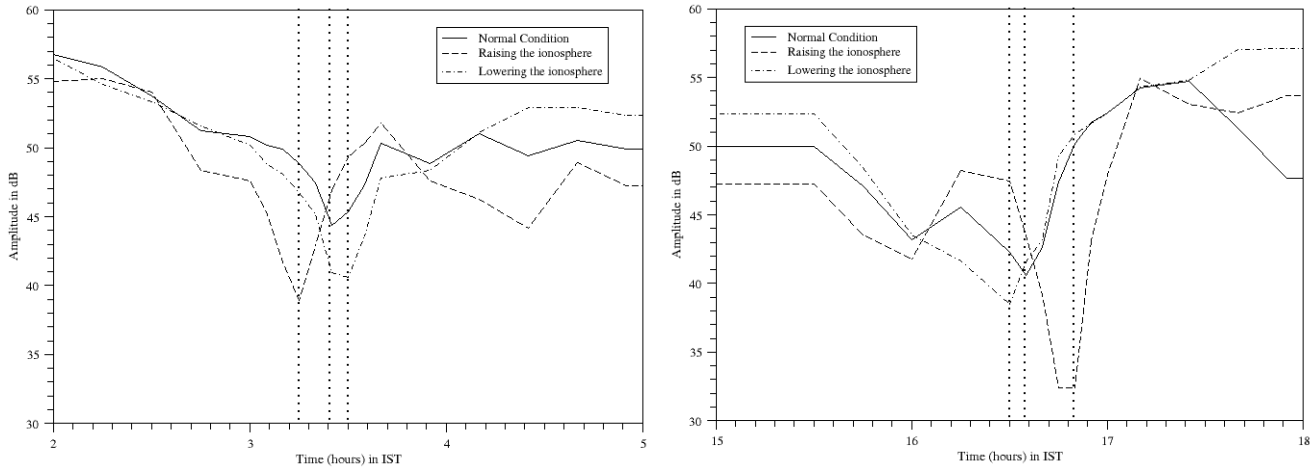


Figure 11: Normal and perturbed VLF signal during SRT (left) and SST (right)

The unperturbed VLF signal was simulated by using the day and night variation of reflection height (h′) and steepness parameter (β) fed in LWPC for the entire path and the seismic activity induced perturbed signal is obtained by additional variation of these parameters inside the earthquake preparation zone (EPZ). The solid, dashed-dotted and dashed curves of Figure 11 correspond to normal, lowering and raising of the ionospheric parameters within the EPZ. The three vertical dotted lines mark the corresponding terminator times. It is found that the shift of the terminator time towards nighttime happens only when the reflection height is increased and the total increase in daylength as obtained from simulation was 25 minutes. The electron density is also computed by the using the Wait's exponential formula for specified location over the propagation path. Figure 12 shows the simulated electron densities at thetransmitting location T (top panel figures), midpoint of the propagation path M (middle panel figures) and at the receiving location R (bottom panel figures). This shows an increase of ionospheric height implies a reduction in electron density.The unusualness critical frequency of F_2 layer (f_0F_2) has been studied during some major earthquakes in South American region. The semi-empirical Barbier's theorem of air-glow has been used to compute a parameter (F) which is function of f0F2and virtual height of F_2 layer. The ionograms as recorded from the Ionosonde in Jicamarca Radio Observatory (lat. 11.95° S, long 76.87° W) in Chile is used for the abovementioned calculation. It is found that the F parameter has been increased more than +3σ from the normal variation on 12 to 3 days prior to the earthquakes.

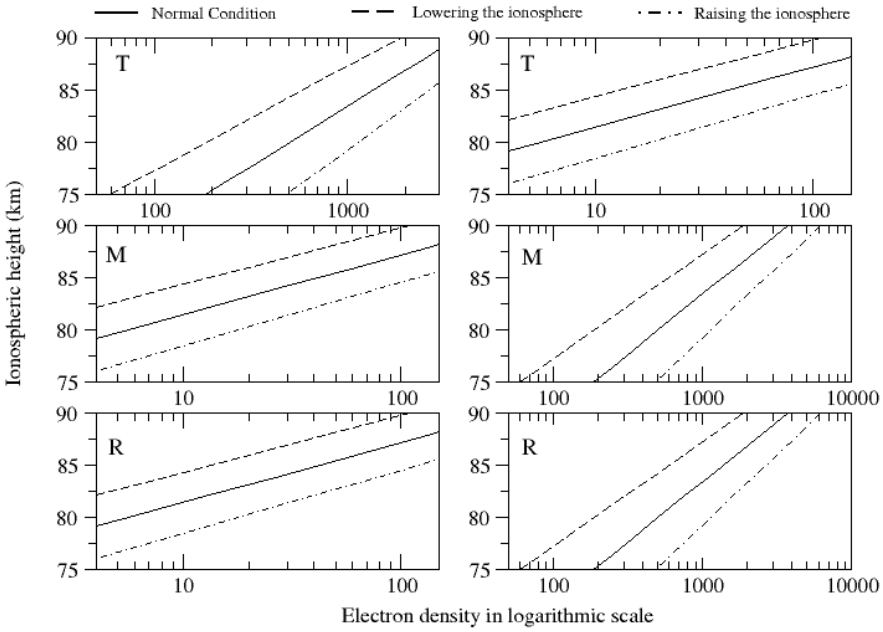


Figure 12: Variation of simulated electron density profile at different location of the propagation path for normal and perturbed condition.

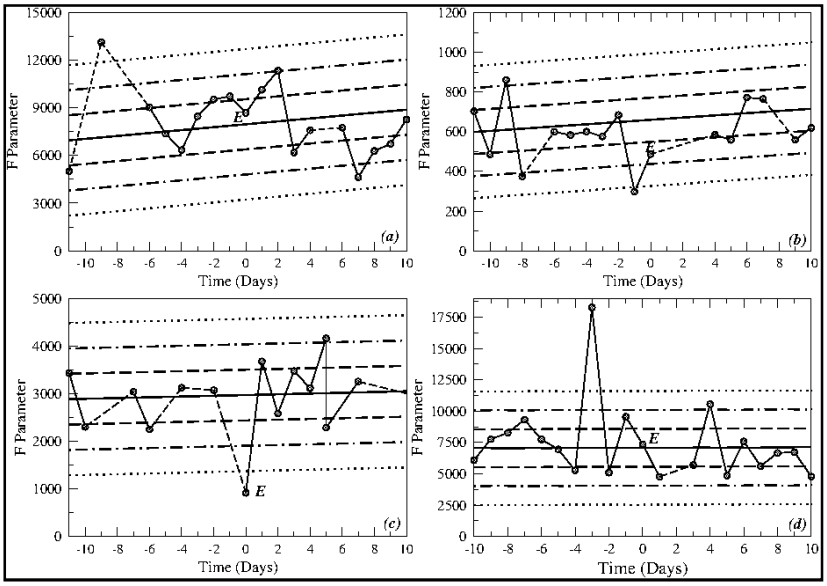


Figure 13: The variation of F-parameter as a function of day number around ±15 days of earthquake. For all the cases the F-parameter increased before the earthquake.

VLF Study in Antarctica

Long path VLF observation has been executed in Indian permanent Antarctic station Maitri and Bharati. Amplitude and phase of such signal depends largely on the solar illumination and for a very long path, the solar zenith angle varies widelyover the path and this has a significant influence on the propagation characteristics of VLF radio wave signal. The temporal variation of VLF signal has been simulated using solarzenith angle model coupled with the LWPC code by assuming a linear relationship between effective

reflection height (h'), steepness parameter (β) and solar zenith angle (Z).The zenith angle is computed over the path for both Maitri and Bharati station. Using LWPC, the temporal variation of signal amplitude for VTX and NWC transmitter has been simulated with sufficient precision (Figure 14).

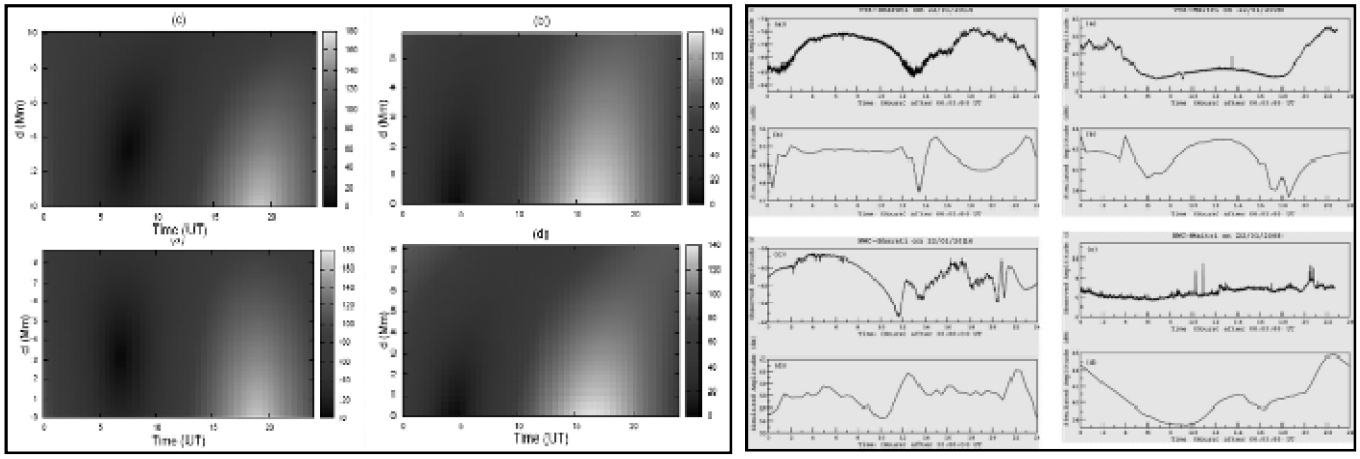


Figure 14: Calculated solar zenith angle profile for whole day for (a) VTX-Bharati, (VTX-Maitri)(Left), (NWC-Bharati) and (NWC-Maitri) path. Observed and simulated VLF signal amplitude profile(Right).

The simulated signal also established the attenuation of signal amplitude due to Antarctic ice mass.

Study of Sudden Stratospheric Warming (SSW) Events

The lower ionospheric disturbance has been observed during the major Sudden Stratospheric Warming (SSW) event of 2009 via the sub-ionospheric VLF/LF signals. The TIMED/SABER mission data are used to investigate the upper mesospheric conditions over the VLF/LF propagation path during the same time period. It has beenobserved that a decrease in neutral temperature and an increase in pressure at the height of 75–80 km around the peak time of the event.

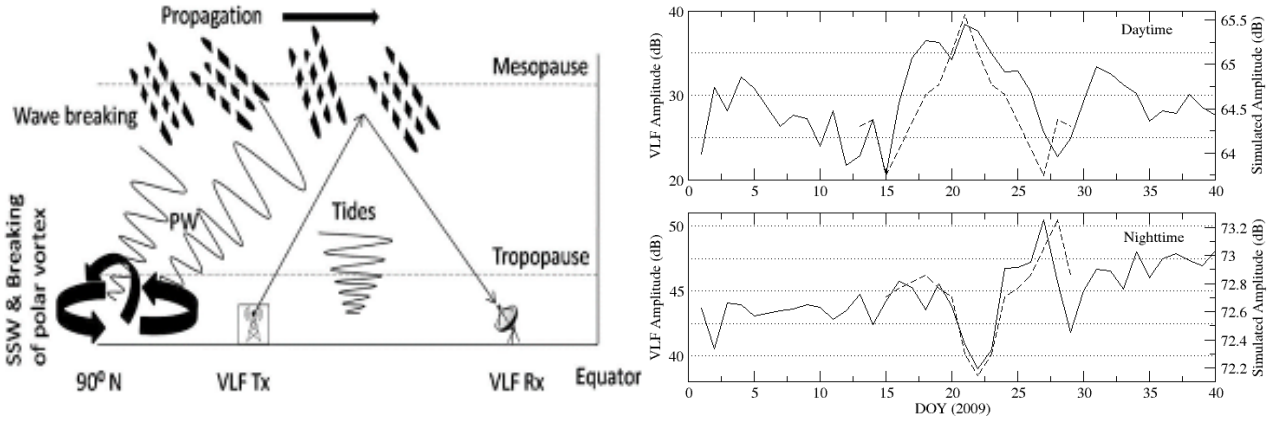


Figure 15: Schematic picture of SSW event(Left) and the corresponding VLF response (right)

Figure (left) shows the schematic picture of breaking of the polar vortex during the SSW event of 2009 and how planetary waves coupled with gravity waves may result to ionospheric perturbation detected by VLF/LF radio waves. Observed (solid) and simulated (dashed) amplitude disturbances of the NRK signal during the SSW time period (right).

Effects of Lightning and Lightning Induced Electron Precipitation (LEP)

The influence of varying location of localized ionospheric disturbance region due to lightning-induced electron precipitation (LEP) events on the received VLF signal amplitude has been studied. Due to lightning discharge, electromagnetic waves interacts with the magnetosphere and radiation belt. As a result of such wave-particle interaction, some of the electrons get trapped within the ionosphere and precipitate resulting in localized enhancement in ionization.

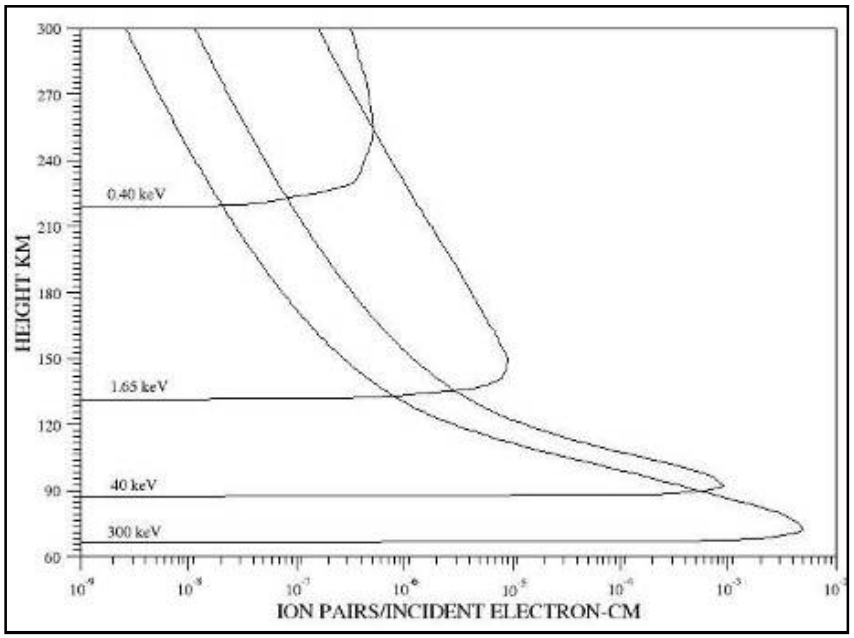


Figure 16: Ionization production by isotropic mono-energetic electrons

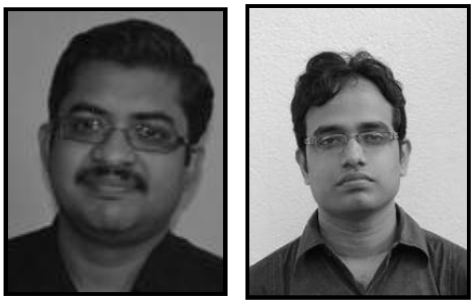
The ion production rate for isotropic mono-energetic electrons is numerically computed. Next, it has been assumed a Gaussian distribution of this source function implying its gradual decrease in intensity from the source region. The D region ion chemistry model will be incorporated to determine the electron density variation with ionospheric heights. Using these electron density profiles in LWPC and varying the locations of such disturbance regions over a chosen VLF propagation path (transmitter-receiver), the modulated signal amplitude can be achieved.

Airglow/Ozone Depletion/Seismological effects

(L to R): S. K. Midya, R. Chattopadhyay, P. K. Jana

Airglow and Ozone depletion activities are led by Prof. S.K. Midya and his collaborators. The activity includes study of effects of solar parameters on the airglow emission lines. Other work includes study of variation of Ozone over India and Antarctica. Some works on different tropospheric phenomena,lightning activity, ionospheric phenomena and earthquake are done by this group.

Radio Astronomy



(L to R, top):Sabyasachi Pal, Dusmanta Patra

ICSP radio group has been engaged in observation with Giant Meterwave Radio Telescope (GMRT) and Jansky Very Large Array (JVLA) for more than a decade. Our scientists have discovered about a dozen of supernova remnants from Galactic plane survey at 330 MHz . We received GMRT observing time to confirm this findings and do study of spectral properties of these supernova remnants. A micro-quasar near the Galactic Centre region has been discovered also. Time is awarded by GMRT to observe variability, spectral properties and to measure the distance of the source. Spectral ageing analysis of many giant radio galaxies are going on. The analysis for the source 3C 35 and 3C 61.1 has been completed. An interesting 'C' shaped wide angle tale radio galaxy has been discovered. Also, a transient radio source close to a galactic micro-quasar has been discover.

The ionospheric and earthquake research centre (IERC)

(L to R, top):Sudipta Sasmal, Sabyasachi Pal, Sujay Pal, Suman Chakrabarty and Rana Khan
(L to R, Middle): Amit Roy, Surya K. Maji, Dusmanta Patra, Dipak Sanki, S. Bhowmick
S. Ghosh

This Centre is located at Sitapur, about 100km away from Kolkata. Here, both the radio sky and optical sky are noise free. VLF antennas are placed here which monitor various stations continuously. A 0.25m optical telescope (MEADE) is used to watch the sky. A 0.61m telescope has been ordered . There are provisions of about 20 students/teachers who wish stay overnight for sky watching. College and High school students are invited, sky permitting, to use the facility to carry out small projects with the telescope and get familiar with the excitements of Astronomy. However, the 0.61m telescope would be used for research activities.

Executive Committee of ionospheric and earthquake research centre, Sitapur, Paschim Medinipur

Prof. Sandip Kumar Chakrabarti *Chairman.*
Mr. Subrata Burai *Vice-Chairman.*
Dr. Sudipta Sasmal *Convener/Member Secretary.*
Mr. Debashis Bhowmick *Member.*
Mr. Rana Khan *Member.*

Activities of the Indian Centre for Space Physics, Malda Branch

(L to R): A. Chatterjee, Asit K. Choudhury, and Wasimul Bari

The Malda Branch of Indian Centre for Space Physics organized various types of scientific activities along with research work since its inception. It has a VLF antenna and a receiver to continue their research on VLF sources and sudden atmospheric disturbances as well as lightning and earthquake. Some students are engaged in analysis of data obtained from IXAE and RXTE.

Achintya K Chatterjee President of ICSP Malda Branch, was invited to present a scientific talk on **September, 2016:**One day State Level Seminar – Invited Speaker **– Kaliyaganj College** – 21.09.2016. **November, 2016:**"Recent trends in Physics: "Astrophysics- Elementary Ideas", Attended West Bengal State Science and Technology Congress (Jalpaiguri Region)– 7- 8 November 2016, **March, 2017:**National Seminar – Invited Speaker – **Raiganj University** – 14.03.2017. **Jan, 2017:** 1. 'Current, Tend in Physics' – " Anomalous behavior of Ionosphere due to Solar Flare and Earth Quake", 2. **Malda Book Fare** – 13.01.2017 Seminar on – ' ki bhabe shikhbo, kibhabe janbo', 3. Rajya Shishu Vigyan Utsab – Pakuahat H S – 'Meet the Scientist' – 23.1.2017

Asit K Choudhury, Secretary of ICSP Malda Branch presented a talk on BIO FUEL at*Malda Town Hall on the occasion of WORLD BIO FUEL DAY* Organised by Ministry of Petroleum and Natural Gas and NYCS (National Youth Co-Operative Society, New Delhi).

Washimul Bari presented a paper in the First Regional State Science and Technology Congress, Jalpaiguri Division held on 7th& 8th November, 2016. His paper was selected as an Outstanding Paper.He participated in the 24th West Bengal State Science and Technology Congress, 2017 as a paper presenter held on 28th February & 1st March, 2017 in Science City, Kolkata. Mr. Bari submitted a paper titled "Study of class transition of light curves of different compact objects", with Achintya Kumar Chatterjee, in the congress to be published by the DST, Govt. of West Bengal.

Corresponding Address for Malda branch:

Dr. A.K. Chatterjee/ Mr. A. K. Choudhury/ Mr. S. Das
Indian Centre for Space Physics, Malda Branch, Atul Market, Malda, 732101.

Co-ordinating Body of the Malda Branch of the Centre

Dr. Achintya K. Chatterjee, *President* Mr. Kankar Bandopadhyay, *Vice President*
Mr. Asit K. Choudhury, *Secretary* Mr. Subhankar Das, *Treasurer*
Mr. Zahirul Islam, *Member* Mr. Gobinda Chandra Mandal, *Member*
Mr. Nilmadhab Nandi, *Member* Mrs. Sutapa Chatterjee, *Member*
Mr. Utpal Chatterjee, *Member*

Office Staff at the Head quarter and Eastern By-pass campus

Mr. Rajkumar Maiti (Accountant/ Office Assistant)

Mr.Jyotisman Moitra (Computer Assistant)

Mr. Ram Chandra Das (Office Attendant)

Mr. Uttam Sardar (Office Helper)

Mr. Parimal Das
(Security)

Independent Auditors' Report

To The Members of
Indian Centre for Space Physics

Report on the Financial Statements

We have audited the accompanying Financial Statements of **Indian Centre for Space Physics** ("the Institute")**,** which comprise the Balance Sheet as at March 31, 2017,the Statement of Income and Expenditure and the Cash Flow Statement for the year then ended, and a summary of significant accounting policies and other explanatory information.

Management's Responsibility for the Financial Statements

The Institutes'Management are responsible for the matters stated in section 134(5) of the Companies Act, 2013 ("the Act") with respect to the preparation of these financial statements that give a true and fair view of the financial position, financial performance and cash flow of the Institute in accordance with the accounting principles generally accepted in India, including the Accounting Standards specified under Section 133 of the Act, read with Rule 7 of the Companies (Accounts)Rules, 2014. This responsibility also includes maintenance of adequate accounting records in accordance with the provisions of the Act for safeguarding of the assets of the Institute and for preventing and detecting frauds and other irregularities; selection and application of appropriate accounting policies; making judgments and estimates that are reasonable and prudent; designing, implementation and maintenance of adequate internal financial controls, that were operating effectively for ensuring the accuracy and completeness of the accounting records, relevant to the preparation and presentation of the financial statements that give a true and fair view and are free from material misstatement, whether due to fraud or error.

Auditor's Responsibility

Our responsibility is to express an opinion on these financial statements based on our audit.We have taken into account the provisions of the Act, the accounting and auditing standards and matters which are required to be included in the

audit report under the provisions of the Act and the Rules made there under.
We conducted our audit in accordance with the Standards on Auditing specified under Section143(10) of the Act and other applicable authoritative pronouncements issued by the Institute of Chartered Accountants of India. Those Standards require that we comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement.
An audit involves performing procedures to obtain audit evidence about the amounts and the disclosures in the financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material mis-statement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal financial control relevant to the Institute's preparation of the financial statements that give a true and fair view in order to design audit procedures that are appropriate in the circumstances. An audit also includes evaluating the appropriateness of the accounting policies used and the reasonableness of the accounting estimates made by the Institute's Members, as well as evaluating the overall presentation of the financial statements. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion on the financial statements.

Opinion

In our opinion, and to the best of our information and according to the explanations given to us, the aforesaid financial statements give the information required by the Act in the manner so required and give a true and fair view in conformity with the accounting principles generally accepted in India, of the state of affairs of the Institute as at 31st March, 2017 and its surplus and cash flows for the year ended on that date.

Report on Other Legal and Regulatory Requirements

1. This being a company licensed to operate under section 8 of the Act, therefore, the matters specified in paragraph 3 and 4 of Companies (Auditor's Report) Order, 2016 ("the Order"), issued by the Central Government of India in terms of sub-section (11) of Section 143 of the Act are not required to be reported.

2. As required by Section 143(3) of the Act, we report that:

   a) We have sought and obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purpose of our audit;

   b) In our opinion, proper books of account as required by law have been kept by the Institute so far as it appears from our examination of those books;

   c) The Balance Sheet, the Income and Expenditure Account and the Cash Flow Statement dealt with by this report are in agreement with the books of account;

   d) In our opinion, the aforesaid financial statements comply with the Accounting Standards specified under section 133 of the Act read with Rule 7 of the Companies (Accounts) Rules, 2014;

   e) On the basis of written representations received from the directors as on March 31, 2017 taken on record by the Board of Directors, none of the directors is disqualified as on March 31, 2017 from being appointed as director in terms of Section 164(2) of the Act;

   f) With respect to the adequacy of the internal financial controls over financial reporting of the Company and the operating effectiveness of such controls, refer to our separate report in "**Annexure A**"; and

   g) With respect to the other matters to be included in the Auditor's Report in accordance with Rule 11 of the Companies (Audit and Auditors) Rules, 2014, in our opinion and to the best of our information and according to the explanations given to us:

      i. The Institute does not have any pending litigations which would impact its financial positions;
      ii. The Institute did not have any long-term contracts including derivative contracts for which there were any material foreseeable losses;
      iii. There has been no amount required to be transferred to the Investor Education and Protection Fund by the Institute; and

iv. The Institute has provided requisite disclosures in its financial statements (Note 12) as to holdings as well as dealings in specified bank notes during the period from 9th November, 2016 to 30th December, 2016 and the same are in accordance with books of account maintained by the Institute.

For SSKA & Associates
Chartered Accountants
FRN# 328751E

Jagdish Mohata, ACA
(*Partner*)

Kolkata, the 1st day of September, 2017.

M. No.#307910

Annexure - A to the Independent Auditors' Report

*(*Referred to in paragraph (2)(f) under '**Report on Other Legal and Regulatory Requirements**' section of our Report of even date)

Report on the Internal Financial Controls under Clause (i) of Sub-section 3 of Section 143 of the Companies Act, 2013 ("the Act")

We have audited the internal financial controls over financial reporting of **Indian Centre for Space Physics** ("the Institute") as of 31st March, 2017 in conjunction with our audit of the financial statements of the Company for the year ended on that date.

Management's Responsibility for Internal Financial Controls

The Institute's management is responsible for establishing and maintaining internal financial controls based on the internal control over financial reporting criteria established by the Company considering the essential components of internal control stated in the Guidance Note on Audit of Internal Financial Controls over Financial Reporting issued by the Institute of Chartered Accountants of India ('ICAI'). These responsibilities include the design, implementation and maintenance of adequate internal financial controls that were operating effectively for ensuring the orderly and efficient conduct of its business, including adherence to company's policies, the safeguarding of its assets, the prevention and detection of frauds and errors, the accuracy and completeness of the accounting records, and the timely preparation of reliable financial information, as required under the Companies Act, 2013 ("the Act")

Auditors' Responsibility

Our responsibility is to express an opinion on the Company's internal financial controls over financial reporting based on our audit. We conducted our audit in accordance with the Guidance Note on Audit of Internal Financial Controls over Financial Reporting (the "Guidance Note") and the Standards on Auditing, issued by ICAI and deemed to be prescribed under section 143(10) of the Act, to the extent applicable to an audit of internal financial controls,

both applicable to an audit of Internal Financial Controls and, both issued by the Institute of Chartered Accountants of India. Those Standards and the Guidance Note require that we comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether adequate internal financial controls over financial reporting was established and maintained and if such controls operated effectively in all material respects.

Our audit involves performing procedures to obtain audit evidence about the adequacy of the internal financial controls system over financial reporting and their operating effectiveness. Our audit of internal financial controls over financial reporting included obtaining an understanding of internal financial controls over financial reporting, assessing the risk that a material weakness exists, and testing and evaluating the design and operating effectiveness of internal control based on the assessed risk. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our qualified audit opinion on the Company's internal financial controls system over financial reporting.

Meaning of Internal Financial Controls over Financial Reporting

A company's internal financial control over financial reporting is a process designed to provide reasonable assurance regarding the reliability of financial reporting and the preparation of financial statements for external purposes in accordance with generally accepted accounting principles. A company's internal financial control over financial reporting includes those policies and procedures that –

(1) pertain to the maintenance of records that, in reasonable detail, accurately and fairly reflect the transactions and dispositions of the assets of the company;

(2) provide reasonable assurance that transactions are recorded as necessary to permit preparation of financial statements in accordance with generally accepted accounting principles, and that receipts and expenditures of the

company are being made only in accordance with authorizations of management and directors of the company; and

(3) provide reasonable assurance regarding prevention or timely detection of unauthorized acquisition, use, or disposition of the company's assets that could have a material effect on the financial statements.

Inherent Limitations of Internal Financial Controls over Financial Reporting

Because of the inherent limitations of internal financial controls over financial reporting, including the possibility of collusion or improper management override of controls, material misstatements due to error or fraud may occur and not be detected. Also, projections of any evaluation of the internal financial controls over financial reporting to future periods are subject to the risk that the internal financial control over financial reporting may become inadequate because of changes in conditions, or that the degree of compliance with the policies or procedures may deteriorate.

Opinion

In our opinion, the Company has, in all material respects, an adequate internal financial controls system over financial reporting and such internal financial controls over financial reporting were operating effectively as at 31st March, 2017, based on the internal control over financial reporting criteria established by the Company considering the essential components of internal control stated in the Guidance Note on Audit of Internal Financial Controls Over Financial Reporting issued by the Institute of Chartered Accountants of India.

For SSKA & Associates
Chartered Accountants
FRN# 328751E

Jagdish Mohata, ACA

(*Partner*)

Kolkata, the 1st day of September, 2017. M. No.#307910

INDIAN CENTRE FOR SPACE PHYSICS

Balance Sheet as at 31st March, 2017

Funds and Liabilities	Note	As at 31st March 2017 (Rs.)	As at 31st March 2016 (Rs.)
Capital Fund			
Life Membership Fees	**1**	23,000	23,000
Reserves and Surplus	**2**	16,833,885	10,915,616
		16,856,885	10,938,616
Current Liabilities	**3**	2,177,320	343,410
		2,177,320	343,410
Total		**19,034,205**	**11,282,026**
Assets			
Non-current Assets			
Fixed Assets	**4**		
Tangible		4,479,557	4,051,690
Intangible		69,669	92,894
		4,549,226	4,144,583
Current Assets			
Cash and Bank Balances	**5**	11,694,274	6,973,255
Short-term Loans and Advances	**6**	2,790,705	164,188

		14,484,979	7,137,443
Total		**19,034,205**	**11,282,026**
General Information	**14**		
Significant Accounting Policies	**15**		

As per our report of even date attached.
For SSKA & Associates
Chartered Accountants
FRN # 328751E

Jagdish Mohata, ACA
(Partner)
M. No. # 307910
Kolkata, 1st day of September, 2017.

For and on behalf of Board of Directors

Sd./- S.K.Chakrabarti
(Honorary Secretary, Indian Centre for Space Physics)

Sd./- S.Midya
(Honorary Treasurer, Indian Centre for Space Physics)

Sd./- B.B.Bhattacharyya
(Honorary President, Indian Centre for Space Physics)

INDIAN CENTRE FOR SPACE PHYSICS

Statement of Income and Expenditure for the Year Ended 31st March, 2017

Particulars	Note	Year ended 31st March 2017	Year ended 31st March 2016
		(Rs.)	(Rs.)
Grants and Other Incomes			
Grants Received	**7**	14,863,464	11,391,681
Other Income	**8**	900,178	1,171,352
		15,763,642	**12,563,033**
Expenditure			
Employee Benefits Expense	**9**	5,354,972	4,422,670
Depreciation & Amortisation Expenses	**4**	460,912	838,442
Other Expenses	**10**	9,501,246	6,181,414
		15,317,130	**11,442,526**
Tax Expense		-	(123,830)

Excess of Income over Expenditure for the year		**446,513**	**996,677**
General Information	**14**		
Significant Accounting Policies	**15**		

As per our report of even date attached.

For and on behalf of Board of Directors

For SSKA & Associates

Chartered Accountants

FRN # 328751E

Jagdish Mohata, ACA

(Partner)

M. No. # 307910

Kolkata, 1st day of September, 2017.

Sd./- S.K.Chakrabarti

(Honorary Secretary, Indian Centre for Space Physics)

Sd./- S.Midya

(Honorary Treasurer, Indian Centre for Space Physics)

Sd./- B.B.Bhattacharyya

(Honorary President, Indian Centre for Space Physics)

INDIAN CENTRE FOR SPACE PHYSICS

Cash Flow Statements for the year ended 31st March, 2017

		Year Ended March 31, 2017 (Rs.)	Year Ended March 31, 2016 (Rs.)
A.	**Cash Flow from Operating Activities:**		
	Excess of Income over Expenditure	446,513	996,677
	Adjustment for:		
Depreciation		460,912	838,442
	Operating Profit Before Working Capital Changes	907,425	1,835,119
	Adjustment for:		
	Current Assets	(2,626,517)	(45,127)
	Current Liabilities and Provisions	1,833,910	(1,752,809)
	Change in Working Capital	(792,607)	(1,797,936)
	Cash Flow From Operations	114,818	37,182
	Net Cash Generated by Operating Activities (A)	**114,818**	**37,182**
B.	**Cash Flow From Investing Activities**		
	(Purchase of Fixed Assets)	(865,555)	(879,949)
	(Investment in)/Maturity of Fixed Deposits	(3,417,646)	569,695
	Cash Flow From Investing Activities (B)	**(4,283,201)**	**(310,254)**
C.	**Cash Flow From Financing Activities**		

Corpus Fund Received	5,471,756	-
Cash Flow From Financing Activities (C)	**5,471,756**	**-**
D. Net Increase/(Decrease) in Cash and Cash Equivalents (A+B+C)	1,303,373	(273,071)
E. Opening Balance of Cash and Cash Equivalents	681,914	954,985
F. Closing Balance of Cash and Cash Equivalents (D+E)	**1,985,286**	**681,914**

Notes:

i. Cash and Cash Equivalents represents the amount as mentioned in Note 5 **'Cash and Cash Equivalents'.**

ii. All figures in brackets represent outflows.

As per our report of even date attached.

For SSKA & Associates

Chartered Accountants

FRN # 328751E

Jagdish Mohata, ACA

(Partner)

M. No. # 307910

Kolkata, 1st day of September, 2017.

Sd./- S.K.Chakrabarti

(Honorary Secretary, Indian Centre for Space Physics)

Sd./- S.Midya

(Honorary Treasurer, Indian Centre for Space Physics)

Sd./- B.B.Bhattacharyya

(Honorary President, Indian Centre for Space Physics)

INDIAN CENTRE FOR SPACE PHYSICS

Notes to Financial Statements

Particulars		31.03.2017 (Rs.)		31.03.2016 (Rs.)
Note-1				
Life Membership Fees				
Life Membership Fees		23,000		23,000
[`500/- for Forty Six members]				
		23,000		**23,000**
Note-2				
Reserves and Surplus				
Opening Balance	10,915,616		9,918,939	
Add: Excess of Income over Expenditure	446,513		996,677	
		11,362,129		10,915,616
Corpus Fund		5,471,756		-
(For purchase of Asset with Specific Direction)				
		16,833,885		**10,915,616**
Note-3				
Current Liabilities				
Unutilised Grants		**2,163,160**		329,610

Other Payables				
Liabilities for Expenses		14,160		13,800
		2,177,320		**343,410**

Note-4

Fixed Assets - Refer Next Page

Note-5

Cash & Bank Balances

Cash & Cash Equivalents				
Cash in hand	4,108		14,768	
Axis Bank Ltd.	1,969,210		656,792	
Central Co-operative Bank Ltd.	11,969	1,985,287	10,354	681,914
Other Bank Balances				
Fixed Deposits with Banks		9,708,987		6,291,341
		11,694,274		**6,973,255**

Note-6

Short-term Loans and Advances

Security Deposits	5,100	5,100
Advance to Employees	48,000	7,000
Balance with Revenue Authorities	163,096	102,979
Capital Advances	2,574,509	-
Advances recoverable in cash or in kind or for which the value to be received	-	49,109
	2,790,705	**164,188**

Note-7

Grant Received

Grant-in-Aid	14,863,464	11,391,681
	14,863,464	**11,391,681**

Note-8

Other Income

Guest House Rent	33,600	18,900
Interest on Fixed Deposits	601,163	632,564
Interest on Bank Deposits	415	366
Grant for Overhead Expenses	265,000	279,844
Misc. Income		239,678
	900,178	**1,171,352**

Note-9

Employee Benefits Expense

Salaries & Stipend	5,007,008	4,112,814
Contribution to Pension Fund	347,964	309,856

	5,354,972	**4,422,670**

Note-10

Other Expenses

Fund draw for Project Expenses	8,425,441	4,888,524
Office Expenses	164,683	286,394
Statutory Audit Fees	11,800	11,500
Other Services	12,695	-
Postage	15,272	26,122
Travelling & Conveyance	357,125	293,123
Telephone, Fax & Internet	25,982	78,250
Printing & Stationary	48,665	129,988
Professional Fees	9,000	52,177
Rent & Electricity	426,973	409,955
Miscellaneous Expenses	3,610	5,381
	9,501,246	**6,181,414**

Note-11

Details of Grants Received

Particulars

CSIR PROJECT, Delhi	-	73,505
West Bengal Government	9,357,350	6,588,490
MoES, Delhi	2,440,000	3,090,560
DST-FTYS, Delhi	1,060,000	900,000
DST-SERB, Delhi *	2,163,160	-
ICTP, Italy	211,114	400,970
INSPIRE PROJECT, DELHI	410,000	-
ISRO Projects, Bangalore	1,650,000	618,000
	(2,163,160)	-
Less: Received at the end of the year, fully unutilised Less: Grant for Overhead Expenses	(265,000)	(279,844)
	14,863,464	**11,391,681**

Note-12

Details of Specified Bank Notes (SBNs) held and transacted during the period from 9th November, 2016 to 30th December, 2016

Particular	**SBNs**	**Other Denomination Notes**	**Total**
Closing cash in hand as on 08.11.2016	---	44,624	44,624
(+) Permitted Receipts	---	115,000	115,000
(-) Permitted Payments	---	121,505	121,505
(-) Amount deposited in banks	---	---	---
Closing cash in hand as on 30.12.2016	---	38,119	38,119

Note-13

Funds Received with Specific Direction

From WB Government

For Purchase of Telescope	5,471,756	-

(Less: Paid as advances for purchase)	(2,574,509)	-
	2,897,247	**-**

INDIAN CENTRE FOR SPACE PHYSICS

Notes to Financial Statements

Note 14
General Information

*"**Indian Centre for Space Physics***" **(CIN:U73100WB1999NPL090718),** isa public limited company ("Limited by Guarantee")licensed to operate under section under section 8 of the Companies Act, 2013 (originally known as under section 25 of the Companies Act, 1956) as "Not for Profit Company" andis presently engagedin development and research projects related toSpace and Physics at its premises at**Chalantika 43, Garia Station Road, Kolkata - 700 084**.

Note 15

Significant Accounting Policies

(i) Basis of accounting & preparation of financial statements

The financial statements of the company have been prepared in accordance with the Generally Accepted Accounting Principle in India (Indian GAAP). The Company has prepared these financial statements to comply in all material respects with the accounting standards notified under Section 133 of the Companies Act, 2013('the Act'), read together with paragraph 7 of the Companies (Accounts) Rules, 2014. The financial statements have been prepared on accrual basis and under the historical cost convention.

(ii) Fixed Asset

Tangible Fixed Assets have been valued at cost plus other incidental expenses incurred in connection with acquisition thereof.

Intangible Fixed Assets have been valued at cost plus other incidental expenses incurred in connection with acquisition thereof.

(iii) Depreciation and Amortisation

Depreciation on Fixed Assets has been provided on Straight Line Method based on the useful life of tangible assets prescribed in schedule II to the Companies Act, 2013.

Amortisation on Intangible Fixed Assets has been provided by assuming the life of the asset is for 5 years.

(iv) Cash Flow Statement

Cash Flows are reported using the Indirect Method as set out in Accounting Standard - 3 : Cash Flow Statement, whereby profit before tax is adjusted for the effects of transactions of a non-cash nature, any deferrals or accruals of past or future operating cash receipts or payments and item of income or expenses associated with investing or financing flows. The Cash Flows from Operating, Investing and Financing activities of the Company are segregated based on the available information.

(v) Revenue Recognition

The Company receives grants for its operation and running the projects from various State and Central Government funding agencies. Some International research organization fund is also received. The Company submits Utilization Certificate and Statement of Expenditure. The funds are recognised only when it is received. Grants received are recognized as income on receipt basis. All these funds are spent according to their earmarking. Funds originating from overhead, Guest House income, and Interests on fixed deposit are treated net income to the Company spent for its own development purpose.

(vi)Employees Benefit

As per provision laid out in Rules and By Laws approved by the Governing Body, it has several academic and non-academic staff members who are treated as regular members who enjoy benefits as Permanent members including structured salary and National Pension System (NPS). Semi-permanent employees enjoy NPS benefits and a certain annual salary increment but not structured salary. The rest are strictly taken on contractual basis, renewable after a period subject to their good performance. Being an Autonomous Body, the Governing Body decides the career advancement policy for the permanent and semi-permanent members. Career path of contractual members are governed by respective funding agencies. The provisions of Employees Provident Fund (EPF) are not applicable to the Company as they have less than twenty Staff members.

(vii) Earning per Share

The Company is a Section 8 "Not for Profit Company". It does not generate any income/revenue from its activities and is also limited by Guarantee. Therefore, the provisions of AS-20 are not applicable.

(viii) Provisions and Contingencies

The Company creates a provision when there is present obligation as a result of a past event that probably requires an outflow of resources and a reliable estimate can be made of the amount of the obligation. A disclosure for a contingent liability is made when there is a possible obligation that may, but probably will not, require an outflow of resources. When there is a possible obligation or a present obligation in respect of which the likelihood of outflow of resources is remote, no provision or disclosure is made.

(ix) No related party transactions have been entered into by the Company during the Current financial year.

(x) Previous years figures have been regrouped/reclassified wherever necessary to correspond with the current year's classification/disclosure.

INDIAN CENTRE FOR SPACE PHYSICS

Note to Financial Statements

Note-4

Amount in Rs.

Fixed Assets

Particulars	Gross Block				Depreciation				Net Block	
	As on 01.04.16	Addition during the year	Sale during the year	As on 31.03.17	As on 01.04.16	During the year	Adjusted on deletion	As on 31.03.17	As on 31.03.17	As on 31.03.16
Tangible										
Computers	1,540,392		-	1,540,392	1,438,189	25,183	-	1,463,372	77,020	102,203
Furniture	123,371	-	-	123,371	117,203	-	-	117,203	6,168	6,168
Office Equipment	53,758	-	-	53,758	51,072	-	-	51,072	2,686	2,686
Scientific Equipment	3,743,634	278,317	-	4,021,952	2,184,449	286,532	-	2,470,981	1,550,970	1,559,185
Boundary Wall	1,338,020	-	-	1,338,020	197,361	59,458	-	256,819	1,081,201	1,140,659
Land * #	-	-	-	-	-	-	-	-	-	-
Expansion of laboratory	708,283	561,738	-	1,270,021	-	-	-	-	1,270,021	708,283
(Work-in-progress)										
Development of land	308,380	-	-	308,380	-	-	-	-	308,380	308,380
Car	161,794	-	-	161,794	126,592	11,086	-	137,678	24,116	35,202
Books	76,045	-	-	76,045	71,119	4,926	-	76,045	-	4,926
Electrical Items	432,740	25,500	-	458,240	248,743	50,503	-	299,246	158,995	183,998
Current Year	**8,486,417**	**865,555**	-	**9,351,973**	**4,434,728**	**437,688**	-	**4,872,416**	**4,479,557**	**4,051,690**
Intangible										
Software	116,118		-	116,118	23,224	23,224	-	46,449	69,669	92,894
Current Year	**116,118**	-	-	**116,118**	**23,224**	**23,224**	-	**46,449**	**69,669**	**92,894**
Current Year Total	**8,602,535**	**865,555**	-	**9,468,091**	**4,457,952**	**460,912**	-	**4,918,865**	**4,549,226**	**4,144,583**
Previous Year Total	**7,722,586**	**879,949**	-	**8,602,535**	**3,619,509**	**838,442**		**4,457,951**	**4,144,583**	**4,103,077**

* On lease from Govt. of West Bengal (Approx. Area 0.41 acres in Kolkata).

0.25 acres from private donation.

INDIAN CENTRE FOR SPACE PHYSICS

(CIN: U73100WB1999NPL090718)
43 Chalantika, Garia Station Road
Kolkata-700084, West Bengal
Email: root@csp.res.in
Phone: 033 24366003

BOARD'S REPORT

To

The Members of
INDIAN CENTRE FOR SPACE PHYSICS

Your Directors have great pleasure in presenting their **Eighteenth Annual Report** together with the Audited Financial Statements of the Company for the year ended 31stMarch, 2017.

1 FINANCIAL SUMMARY

The Financial Results of the Company for the year under report are as under:

Particuars	**Current Year 31st March, 2017**	**Previous Year 31st March, 2016**
Grant Received	14,863,464	11,391,681
Other Income	900,178	1,171,352
Total Income	**15,763,642**	**12,563,033**
Employee Benefits Expenses	5,354,972	4,422,670
Depreciation	460,912	838,442
Other Expenses	9,501,245	6,181,414
	15,317,129	**11,442,526**
Tax Expenses	**-**	**123,830**
Exess of Income over Expenditure for the year	**446,513**	**996,677**

2 OPERATIONAL REVIEW

Grant received for the year ended 31st March, 2017 aggregated to `**14,863,464/-** . The other income is `**900,178/-**. The Excess of Income over Expenditure for the year is `**4,46,513/-**

3 DIVIDEND

As the company falls under the purview of Section 8 of the Companies Act 2013, therefore, It is not applicable.

4 MEMBERSHIP

During the year no new Life Members of the company are enrolled . The total Life Members as on 31st March, 2017 is 46 (Forty Six).

5 DEPOSITS

The Company has not accepted any deposits within the meaning of Section 73 to Section 76 of the Companies Act, 2013 and the Rules framed there under.

6 DIRECTORSHIP

A Appointment of Directors /Cessation of Directorship

During the year one of the director Mr. Pranabananda Bandyopadhyay resigned from his post from 27-07-2016.

During the year Mr Subrata Kr. Midya and Mr Prabir Kr. Das was appointed as an additional director w.e.f. 05-08-2016 and 26-03-2017 respectively.

B Appointment of Independent Director/Woman Director/Small Shareholder Director

The provisions relating to appointment of Independent Director or Woman Director or Small Shareholder's Director are not applicable to the Section-8 Company. Therefore, no such directors are appointed.

C Retirement by rotation

Since the company is a Section-8 Company the provision of retirement of Directors by rotation is not applicable.

7 DETAILS OF HOLDING, SUBSIDIARY, JOINT VENTURE OR ASSOCIATE COMPANIES

The Company does not have any holding, subsidiary, joint venture or an associate Company during the year or at the end of the financial year.

8 AUDITORS

A STATUTORY AUDITORS

The Members of the Company had, at its 14th Annual General Meeting ("AGM") held on 21st September, 2014, approved the appointment of **M/s. SSKA & Associates,** (**Firm Registration No. 328751E**) Chartered Accountants, Kolkata, as the Statutory Auditors of the Company, to hold office from the conclusion of the 14th AGM until the conclusion of the 19th AGM held thereafter subject to ratification of the appointment by the Members at every AGM held thereafter.

In view of the above, the existing appointment of M/s. SSKA & Associates, (Firm Registration No. 328751E) Chartered Accountants, Kolkata covering the period from the conclusion of this ensuing AGM until the conclusion of the next Annual General Meeting to be held in the calendar year 2018, is being placed for members' ratification.

As required under Section 139 of the Companies Act, 2013, the Company has obtained a written consent from the Auditors to such continued appointment and also a certificate from them to the effect that their appointment, if ratified, would be in accordance with the conditions prescribed under the Companies Act, 2013 and the rules made there under.

B SECRETARIAL AUDITORS

Secretarial Audit has been made mandatory only for bigger Companies. Section 204 of the Companies Act, 2013 has kept this company out of the purview of Secretarial Audit. Therefore, there is no requirement to appoint secretarial auditor.

C COST AUDITORS

Section 148 of the Companies Act, 2013 (read with Rules framed there under) kept the Company out of the purview of maintaining of cost records and cost audit. Therefore, the Company need not to appoint any cost auditor.

9 COMMENTS ON QUALIFICATION, RESERVATION OR ADVERSE REMARK OR DISCLAIMER MADE

The Auditors Report to the Members on the Accounts of the Company for the financial year ended 31st March, 2017, does not contain any qualification, reservation or adverse remark. Further, the observations made in the Auditor's report are self explanatory and therefore, do not call for any further explanations.

10 DETAILS PERTAINING TO NET WORTH OF THE COMPANY

The Net worth of the Company at the beginning and at the end of the year were **`10,938,616/-** and **`16,856,885/-** respectively, and hence increases by **`59,18,269/-**.

11 REQUIREMENTS AS PER SECTION 134(3) OF THE COMPANIES ACT, 2013

A EXTRACT OF THE ANNUAL RETURN AS PER SECTION 92(3)

The extract of the Annual Return as on the Financial year ended 31st March, 2017 as provided under Section 92(3) of the Companies Act, 2013 in **Form MGT 9** is at **Annexure- I**.

B NUMBER OF MEETINGS OF THE BOARD OF DIRECTORS

During the Financial Year 2016-17, meetings of the Board of Directors of the Company were held, details of which are as follows:

Date of Meeting	Number of Directors Present
1/9/2016	5
29/09/2016	7
5/2/2017	6
26/03/2017	6

C DIRECTORS' RESPONSIBILITY STATEMENT

Pursuant to the requirement clause (c) of sub-section (3) of Section 134 of the Companies Act, 2013, your Directors confirms that:

(a) In the preparation of the annual accounts for the year ended 31st March, 2017, the Company has followed the applicable accounting standards and there are no material departures from the same;

(b) The directors have selected such accounting policies and applied them consistently and made judgments and estimates that are reasonable and prudent so as to give a true and fair view of the state of affairs of the Company at the end of the financial year.

(c) The directors have taken proper and sufficient care for the maintenance of adequate accounting records in accordance with the provisions of this Act for safeguarding the assets of the Company and for preventing and detecting fraud and other irregularities;

(d) The directors have prepared the annual accounts on a going concern basis;

(e) The Company being unlisted, sub clause (e) section 134(5) of the Companies Act, 2013 pertaining to laying down internal financial controls, is not applicable to the Company; and

(f) The directors have devised proper systems to ensure compliance with the provisions of all applicable laws and that such systems were adequate and operating effectively.

D NOMINATION AND REMUNERATION POLICY

Since all the Directors are holding Honorary posts, therefore no such policy is required.

E PARTICULARS OF LOANS GIVEN, INVESTMENTS MADE, GUARANTEES GIVEN, AND SECURITIES PROVIDED UNDER SECTION 186 OF THE COMPANIES ACT, 2013

There are no such loans and guarantees given or investments made under section 186 by the company.

F PARTICULARS OF CONTRACTS OR ARRANGEMENTS WITH RELATED PARTIES REFERRED TO IN SECTION 188(1) OF THE COMPANIES ACT, 2013

There are no contracts or arrangements with related parties under section 188(1) by the company.

G THE STATE OF COMPANY'S AFFAIRS

The Company continues to operate within the purview of its Memorandum of Association and no amendments were necessary. It's function has been normal.

H THE AMOUNTS, IF ANY, WHICH COMPANY PROPOSES TO BE CARRIED TO ANY RESERVES IN THE BALANCE SHEET

Corpus Fund of ` 5,471,756/-received during the year for purchase pf telescope from West Bengal Government forms the part of reserved fund.

I MATERIAL CHANGES AND COMMITMENTS, IF ANY, AFFECTING THE FINANCIAL POSITION OF THE COMPANY WHICH HAVE OCCURRED BETWEEN THE END OF THE FINANCIAL YEAR OF THE COMPANY TO WHICH THE FINANCIAL STATEMENTS RELATE AND THE DATE OF THE REPORT

There are no changes and commitments, affecting the financial position of the Company between the end of financial year of the Company to which the financial statements relate and the date of the report.

J PARTICULARS OF EMPLOYEES

Total number of employees (Academic & Non-Academic) is : 34.

K CONSERVATION OF ENERGY, TECHNOLOGY ABSORPTION, FOREIGN EXCHANGE EARNINGS AND OUTGO

Our company has partially implemented green energy policy. As a result there are Solar Pannels for generating power into office campuses.

L STATEMENT INDICATING DEVELOPMENT AND IMPLEMENTATION OF A RISK MANAGEMENT POLICY FOR THE COMPANY INCLUDING IDENTIFICATION THEREIN OF ELEMENTS OF RISK, IF ANY, WHICH IN THE OPINION OF THE BOARD MAY THREATEN THE EXISTENCE OF THE COMPANY

Not Applicable.

M DETAILS ABOUT THE POLICY DEVELOPED AND IMPLEMENTED BY THE COMPANY ON CORPORATE SOCIAL RESPONSIBILITY INITIATIVES TAKEN DURING THE YEAR

Not Applicable.

N STATEMENT INDICATING THE MANNER IN WHICH FORMAL ANNUAL EVALUATION HAS BEEN MADE BY THE BOARD OF ITS OWN PERFORMANCE AND THAT OF ITS COMMITTEES AND INDIVIDUAL DIRECTORS

Through General Body and Governing Body meetings.

O THE DETAILS OF SIGNIFICANT AND MATERIAL ORDERS PASSED BY THE REGULATORS OR COURTS OR TRIBUNALS IMPACTING THE GOING CONCERN STATUS AND COMPANY'S OPERATIONS IN FUTURE

There are no orders passed by the regulators or courts or tribunals impacting the going concern status and Company's operations in future.

P DETAILS PERTAINING TO REMUNERATION AS PER RULE 5(1) OF THE COMPANIES (APPOINTMENT AND REMUNERATION OF MANAGERIAL PERSONNEL) RULES, 2014

As the Company is a Section 8 Company, Rule 5(1) of the Companies (Appointment and Remuneration of Managerial Personnel) Rules, 2014 is not applicable.

Q ADEQUACY OF INTERNAL FINANCIAL CONTROL WITH REFERENCE TO FINANCIAL STATEMENTS

The Board has adopted the policies and procedures for ensuring the orderly and efficient conduct of its business, including adherence to the Company's policies, the safeguarding of its assets, the prevention and detection of fraud and errors, the accuracy and completeness of the accounting records, and the timely preparation of reliable financial disclosures.

R DISCLOSURE UNDER THE SEXUAL HARRASSMENT OF WOMEN AT WORKPLACE (PREVENTION, PROHIBITION AND REDRESSAL) ACT, 2013

The Company is committed to provide a safe and conductive work environment to its women employees. During the year under review, no case of sexual harassment was reported.

S DISCLOSURE RELATING TO HOLDINGS AND DEALINGS IN SPECIFIED BANK NOTES (SBN)

The Company has provided requisite disclosures in its financial statements (Note 12) as to holdings as well as dealings in specified bank notes during the period from 9th November, 2016 to 30th December, 2016 and the same are in accordance with books of accounts maintained by the company.

12 <u>ACKNOWLEDGEMENT</u>

Your Directors place on record their appreciation for employees at all levels, who have contributed to the growth and performance of your Company. Your Directors also wish to place on record their appreciation for the members for their continued support. Your Directors also thank the Central and State Governments, and other statutory authorities and other bodies engaged in solar and other projects like ISRO, FTS etc for their continued support.

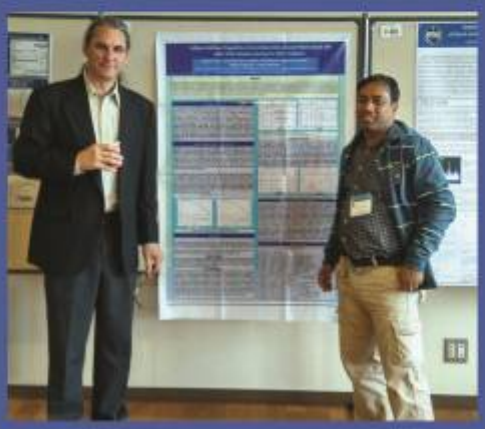
For and on behalf of the Board of Directors

SANDIP KUMAR CHAKRABARTI

Place: Kolkata *(Director)*

Date: The 1st day of September, 2017. **[DIN:00683375]**


Participants of the one day workshop on black hole data analysis jointly organized by ICSP and Astronomical Society of India (Left). Participants of ICSP at ASI meeting Jaipur (Right).


ICSP members attending the URSI RCRS meeting at NARL Tirupati (Left). Dr. Debnath during Poster presentationsession at RIKEN symposium at Riken, Santama, Japan (Middle).Dr. Das with one of his collaborators Dr. E.E. Etimon his right at IISC Bangalore (Right).



Sky watch program at IERC, Sitapur campus with students of Ramkrishna Mission Residential College, Narendrapur (Left) and of Maharaja Manindra Chandra college, Kolkata (Right). Prof. Sandip K. Chakrabarti gave an orientation lecture to the students at IERC campus, Sitapur, Paschim Medinipur (Middle).



Governing body members of ICSP at IERC campus, Sitapur, Paschim Medinipur (Left). Dr. Debnath with Prof. H.K. Chang and his students at national Tsing Hua University Hsinchu, Taiwan (Middle).Dr. Sasmal with his M.Sc Project student at ICSP (Right).


ব্রহ্মাণ্ডে উঁকি মারতে চাঁদেই ঘাঁটি বাঙালির
বেলুনে মহাকাশের রহস্যসন্ধান
To Russia wit
from Calcu
SMALL
VEHICLE
BIG
DREA
A spy in the sky
Balloon probes have led Calcutta scientists to believe pilots flying in tropical countries are exposed to very high doses of radiation. Manasi Shah has the story
MAJOR QUAKES
NEW LIGHT ON
BLACK HOLES
Indian scientists now have clinching evidence that