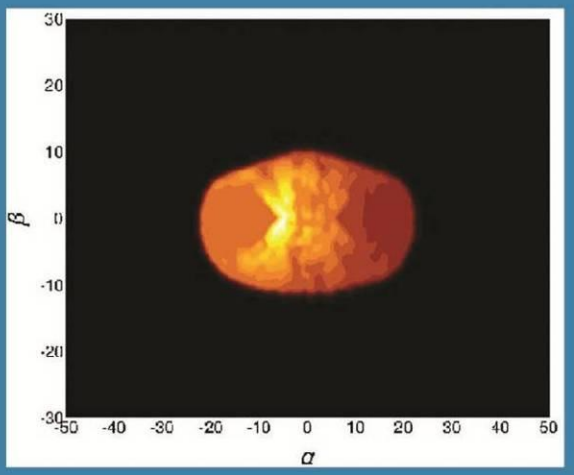
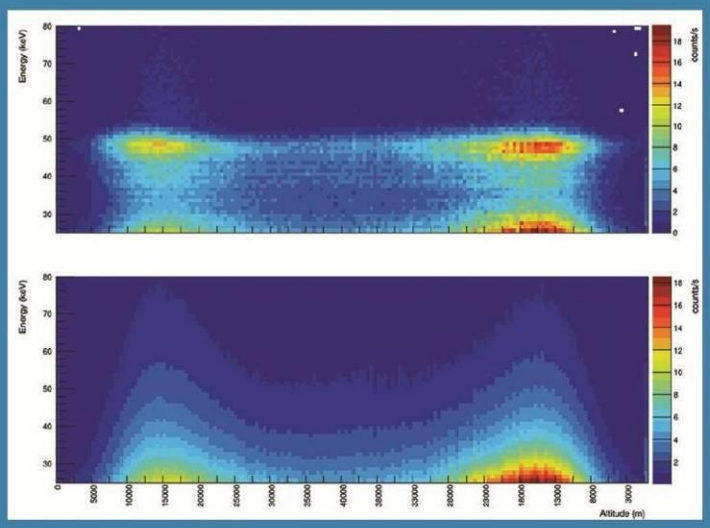
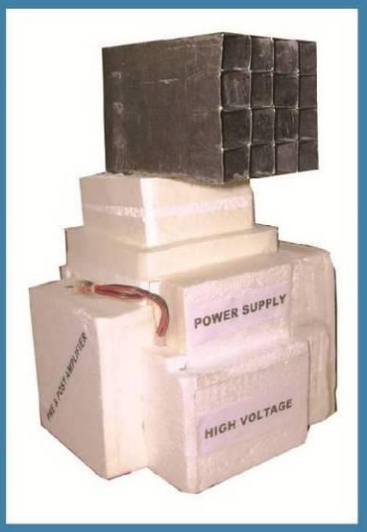
Annual Report 2014-2015

Indian Centre for Space Physics

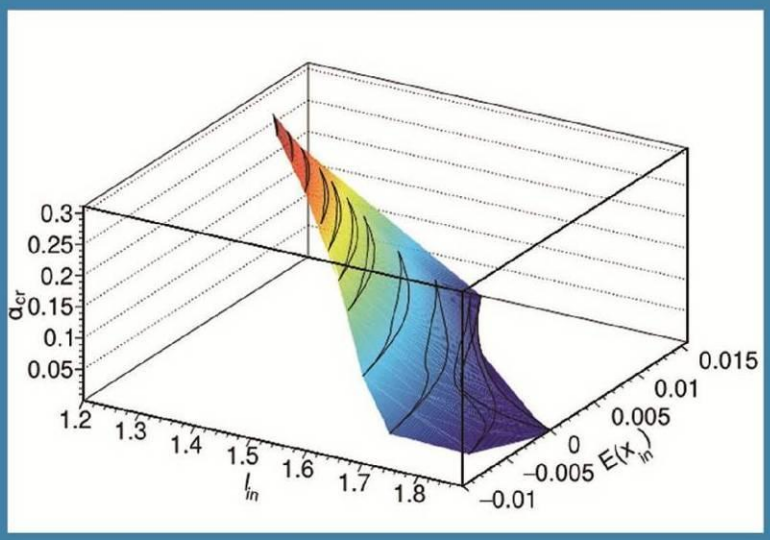


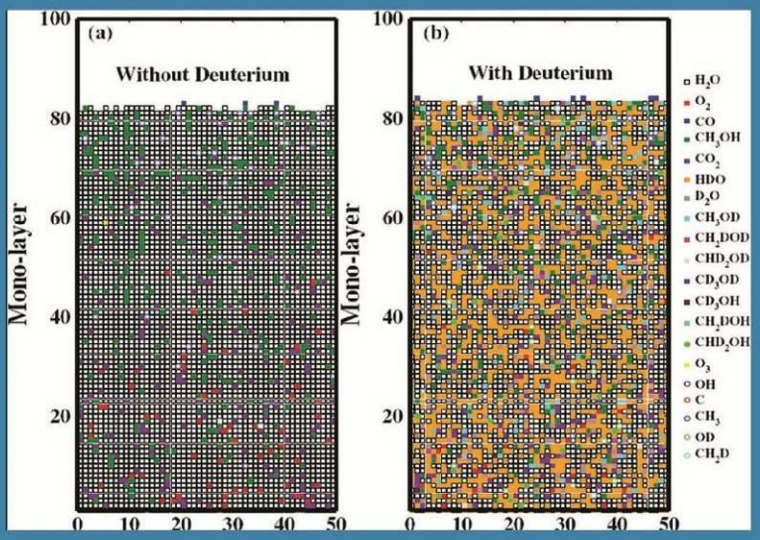
Preparing for D74 mission Balloon launch from Kulti (Left). Image of Compton cloud seen from an inclination angle of 82 degrees. Color code represents temperature (Right).





Dynamic Cosmic Ray Spectrum for D74 Mission with raw data and processed data (Left). Setup for vacuum test of payloads (Middle). A typical X-Ray scintillation detector payload for balloon missions (Right).





Parameter space showing variation of α_{cr} in the plane of energy at the inner sonic point $E(x_{in})$ and specific angular momentum at the horizon l_{in} which allow standing shocks (Left). Cross sectional view of Interstellar grain mantle a) without and b) with deuterium (Right).

INDIAN CENTRE FOR SPACE PHYSICS
ANNUAL REPORT
(2014-2015)

TABLE OF CONTENTS

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

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Extension Numbers:
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Department of Astrochemistry/Astrobiology: 22
Accounts: 23
Seminar Room: 24
Computer room: 25
Department of High Energy Radiation: 26
X-ray Laboratory: 27
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E-mail: root@csp.res.in **Website**: http://csp.res.in

Front Cover: Major activities in the ionospheric science (upper half) division (70 km to 250 km) and high energy radiation (lower half) division (250 km upwards) of the ICSP.
Back Cover: Major activities in the balloon borne earth and space science (upper half) division (0 to 42 km) and astrochemistry/astrobiology (lower half) division (solar/stellar systems; Interstellar molecules) of ICSP.

Report of the Governing Body

This is the Sixteenth Annual report of Indian Centre for Space Physics. The Centre has progressed phenomenally in all the fronts in the year 2014-2015.

The main goal of this centre has been to study all the aspects of the earth and its atmosphere, ionosphere, origin of life etc. As such, all its activities are focused to find relationship of the Earth including its atmosphere and biosphere, ocean etc. with the rest of the Universe.

One of the major goals of the Centre has been to advance its low cost balloon program. So far, we have shown our skill in exploring the atmosphere and the space (~ 40km) using rubber made weather balloons. This year, we also successfully launched polythene made weather balloons and have signed an MOU with TIFR balloon facility in order that more such balloons made at TIFR could be utilized in future studies of near space. We studied solar flares and pulsars. Some results are being prepared for the upcoming European Balloon and Rocket conference in Tromso, Norway. Three inch diameter scintillator detectors were assembled with CsI crystal and were especially vacuum-tested in the laboratory to mimic atmospheric conditions. High timing resolution has also been achieved to ensure that even millisecond pulsars are also seen. Crab has been detected by several of our missions. Cosmic ray variation with altitude and velocity, pressure, temperature etc. are part of our routine measurements.

As far as astrobiology/astrochemistry department is concerned, ours is one of the best in the world.
Our team represented in the 40th COSPAR general assembly in Moscow. Our past student Dr. Kinsuk Acharyya, presently at the University of Virginia is joining Physical Research Laboratory, Ahmedabad as a faculty. Another past student Dr. L. Majumdar joined University of Bordeaux, France as a post-doctoral fellow. Work on deuterium fractionation by our group is recognized worldwide. Several students are working.

In high energy Astrophysics division, our scientists have achieved unprecedented success. For the first time, all the data sets from several black hole candidates are fitted with TCAF solution after its implementation in NASA XSPEC package. The extracted physical parameters show how the accretion rates are changing with time in an evolving system. Indeed, two of our scientists, Dr. D. Debnath and Dr. S. Mondal went to NASA Goddard Space Flight Centre as a part of the training.

As far as Ionospheric science is concerned, the antennas placed at IERC, Sitapur; ICSP, Malda Branch; and Kochbehar are operating successfully. Especially important is the fact that several solar flares were observed by more than one receiver. They exhibit very important properties which would be useful to understand propagation characteristics of Very Low Frequency radio waves. Important results on the dependence of attenuation of signal on ice-mass of Antarctica were obtained after analyzing our past data of Maitri. A further expedition to Antarctica, especially to Bharati, is being proposed and preparations are made to have more receivers to setup a network. Two of our scientists, namely Dr. Sujay Pal and Dr. T. Basak are visiting University of Electrocommunications, Tokyo.

S.K. Maji and A. Choudhury have completed their Thesis work. S. Mandal and T. Katoch have submitted their thesis. L. Majumdar, S. Ray and Sushanta Mondal have received Ph.D. Degrees.

ICSP is grateful to International Centre for Theoretical Physics for support of a Ph.D. student of Nepal. S. Nagarkoti has been selected and is pursuing his study at ICSP. His predecessor, Dr. C.B. Singh, our past Nepalese Ph.D. student, is presently at the University of Sao Paolo, Brazil as a post-doctoral fellow.

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 sincerely thank them for all the encouraging supports. I thank everyone at ICSP who helped me compiling this report.

Prof. S.K. Chakrabarti, Honorary General Secretary
Indian Centre for Space Physics Kolkata: September 30, 2015

Governing Body (GB) of the Centre

Prof. B.B. Bhattacharyya, President
Prof. Sandip K. Chakrabarti, Secretary
Mr. P. Bandyopadhyay, Treasurer
Dr. Sonali Chakrabarti, Member
Dr. S. C. Chakravarty, Member
Prof. A. R. Rao, Member
Prof. Arun K. Tewari, Member
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Prof. B. G. Ananda Rao, Physical Research Laboratory, Ahmedabad
Prof. P. J. Wiita, Georgia State University, USA

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Dr. Dipak Debnath
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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 / 24622153,
Email: sandip@csp.res.in / sandipchakrabarti9@gmail.com)

Dean (Academic) and Finance Officer (Acting)

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Public Information Officer

Mr. Rajkumar Maiti (Tel.: +91 33 24366003 / 24622153 Extn: 23,
Email: rajkumar@csp.res.in / rajkumarmaiti24@gmail.com)

In Charge of the Departments

Ankan Das	Astrochemistry / Astrobiology
Dipak Debnath	High Energy Astrophysics
Sourav Palit (Acting)	Ionospheric Science
Debashis Bhowmick	Instrumentation for Space Exploration

Faculty Members

Dr. Ankan Das	Assistant Professor
Dr. Dipak Debnath	Assistant Professor
Dr. Ritabrata Sarkar	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	Assoc. 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

Project Scientists

Dr. Sabyasachi Pal (MoES)	Dr. Sourav Palit (MoES)
Dr. Sudipta Sasmal (MoES)	Dr. Liton Majumdar (MoES) [left for Univ. Bordeaux]

Post Doctoral Fellow

Mr. Santanu Mondal (MoES)	Dr. Tamal Basak (MoES) [left for Univ. of Electrocom. Tokyo]

Senior Research Fellows

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

Junior Research Fellows

Md. Aslam Ali Molla (MoES)
Mr. Arghajit Jana (ISRO)
Mr. Debjit Chatterjee (DST)
Mr. Ajoy Roy (DST)
Mr. Suman Chakraborty (MoES)
Mr. Prasanta Gorai (DST)
Mr. Pikesh Pal (MoES)

ICTP Junior Research Fellow

Mr. Shreeram Nagarkati (ICTP)

Visiting Research Fellows

Mr. Asit K. Choudhury
Mr. Surya K. Maji
Mr. Tilak B. Katoch
Mr. Washimul Bari
Mr. Dipak Sanki
Mr. Bakul Das
Mr. Amit Chowdhury
Mr. Sanjay Adak

Part Time Research Scholar

Mr. Soujan Ghosh

Engineers / Laboratory Staff

Mr. Debashis Bhowmick	Hardware Engineer
Mr. Subhankar Chakraborty	Junior Engineer
Mr. Susanta Middya	Technical Assistant (MoES)
Mr. Arnab Bhattacharya	Junior Engineer
Mr. Hriday Roy	Laboratory Assistant
Mr. Tanmay Das	Technical Assistant (MoES)

Office Staff

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

Security Staff

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 512 Kbps 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.

Facilities at other branches of the Centre:

IERC at Sitapur: The Ionospheric and Earthquake Research Centre (IERC) for studying VLF, radio and optical astronomy was inaugurated at Sitapur, Paschim Medinipur, West Bengal on 22nd January 2012. It has computing and internet facilities, VLF antennas and receivers, Radio Dish antenna; 10" Meade Optical Telescope and a two element interferometer. It has a guest house. Solar power for electricity and submersible pump for water supply keep this remote Centre running round the clock.

Balloon Facility at Bolpur: 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.

ICSP branch at Malda: The 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 small library. It has VLF antennas to receive VLF signals from transmitters all over the world.

Antenna at Kochbehar: This antenna is used to receive data from various transmitters around the globe.

Brief Profiles of the Scientists of the Centre

Dr. Achintya K. Chatterjee: He is the 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 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 a DST First track project Junior Research Fellow and is working on theoretical studies in High energy astrophysics as a Junior Research Fellow.

Mr. Arka Chatterjee: He is a MoES project Senior Research Fellow in Black Hole Astrophysics. He is working on Effects of Photon Bending on the spectral properties of black holes.

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 a Teacher at the L.M.S.M. Institution, Malda and is an honorary Senior Research Fellow of the 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 Junior Research Fellow working in a MoES sponsored project. He is working on observational studies on Black Hole properties in X-Ray energy band.

Mr. Bakul Das: He is a Teacher at Kalimpong Govt. High School and is a part time visiting research fellow. He works on VLF and Earthquake related 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 Y. S. Palpara College, Purba Medinipur and has completed his Ph.D. as a "Teacher Fellow" at ICSP under "Faculty Improvement Programme" of UGC. He is working on the data analysis of X-ray emission from accretion disks around black holes. He is joining R.B.C. College. He is an honorary Scientist of ICSP.

Mr. Debashis Bhowmick: He is a hardware 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 Department of the ICSP. He is also Acting Administrative officer of the centre. His main research interest is in observational and theoretical studies of properties of transient stellar mass black hole candidates during their outbursts.

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

Mr. Dusmanta Patra: He is a 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 also does study of multi-wavelength properties of Galactic micro-quasars.

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

Mr. K. Chakrabarti: He is an Associate Professor at Hooghly Mohasin College (Teacher in Charge) and is an honorary Senior Research fellow of ICSP. He is working on similarities of accretion flows around black holes and fluid dynamics in a converging-diverging duct.

Mr. K. K. Chakrabarti: He was the Director of Positional Astronomy Center. His field of interest is Cyclonic activity and its cause. He is in the Research Advisory Committee.

Dr. Liton Majumdar: He is a Project Scientist (MoES) in Astrochemistry/Astrobiology. He is working on quantum chemical calculation of reaction cross sections and the evolution of complex molecules in star forming regions. Presently, he is a post doctoral fellow of Univ. of Bordeaux.

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. Pikesh Pal: He is a Junior Research Fellow posted at IERC of ICSP working in a MoES project. He is working on the earthquake prediction studies using VLF signal amplitude and phase anomalies.

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

Dr. R. Chattopadhyay: He is a 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 a 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 Telescope.

Dr. Ritabrata Sarkar: He is an Assistant Professor at ICSP. He is mainly analyzing the data of balloon borne experiments which includes 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 an honorary Professor, 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 balloon borne studies; ionospheric perturbations due to terrestrial and extra-terrestrial phenomena and their effects on very low frequency radio waves; Chemical Evolution of star forming regions.

Mr. Santanu Mondal: He is a CSIR Senior Research Fellow. He is doing his research on effects of Comptonization on the properties of transonic accretion flows around Black Holes and satellite data analysis.

Dr. Sonali Chakrabarti: She is an Associate Professor at the Maharaja Manindra Chandra College and an honorary Associate 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 a part time Research Scholar working at IERC.

Dr. Sourav Palit: He is a MoES Project Scientist at ICSP. He is involved on 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 outflow rates from accretion disks around black holes.

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

Dr. Sujay Pal: He is a MoES Project Scientist 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 Junior 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 visiting scientist. He is in the VLF group and is working on the earthquake related anomalies of VLF signals.

Mr. Surya Maji: He is Teaching in a School in W. Medinipur and an honorary Senior Research Fellow at IERC/ICSP. 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.

Mr. 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 Technical staff 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 a Teacher in Malda and is an honorary Junior 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

Chakrabarti, S.K. Bhowmick, D., Chakraborty, S., Palit, S., Mondal, S.K., Bhattachiaryya, A., Middya, S. & Chakrabarti, S., Study of properties of cosmic rays and solar X-ray flares by balloon borne experiments, Ind. J. Phys., 2014, 88, 333.

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Total Impact Factor during the year 2014-2015

Impact Factor 2014-2015				
Sl. No	**Journal Name**	**Impact Factor (IF)**	**No. Of publications**	**Total IF**
1	ApJ	5.993	3	17.979
2	MNRASL	5.521	1	5.521
3	ApJL	5.339	2	10.678
4	MNRAS	5.107	3	15.321
5	Ap&SS	2.263	3	6.789
6	Ind. J. Phys	1.377	4	5.508
7	Advances in Space Research	1.358	2	2.716
8	New Astronomy	1.146	2	2.292
9	Indian J.Earth System Science	1.04	1	1.04
10	J. Ind. Geo. Union.	0.313	1	0.313
Cumulative Impact Factor				68.157

Impact Factor in last five years

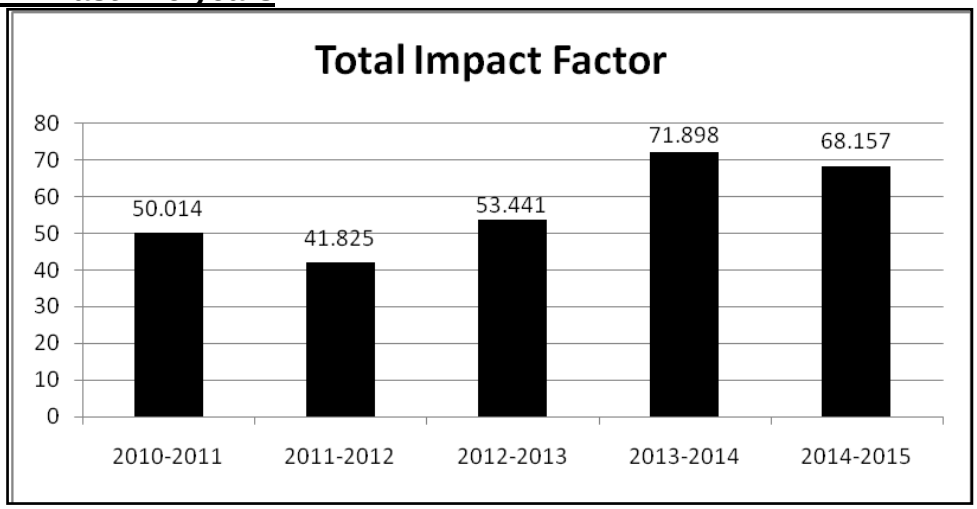


Figure 1: Chart showing the Impact factor in last five years

Number of Publications in last 10 years

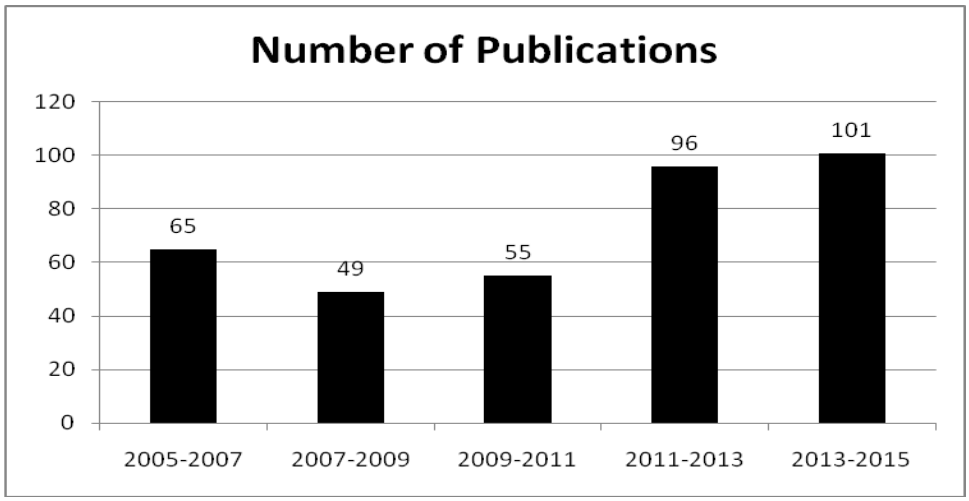


Figure 2: Chart showing the number of publications in last ten years

Number of Students who received Ph.D. from our Institute in last 10 years

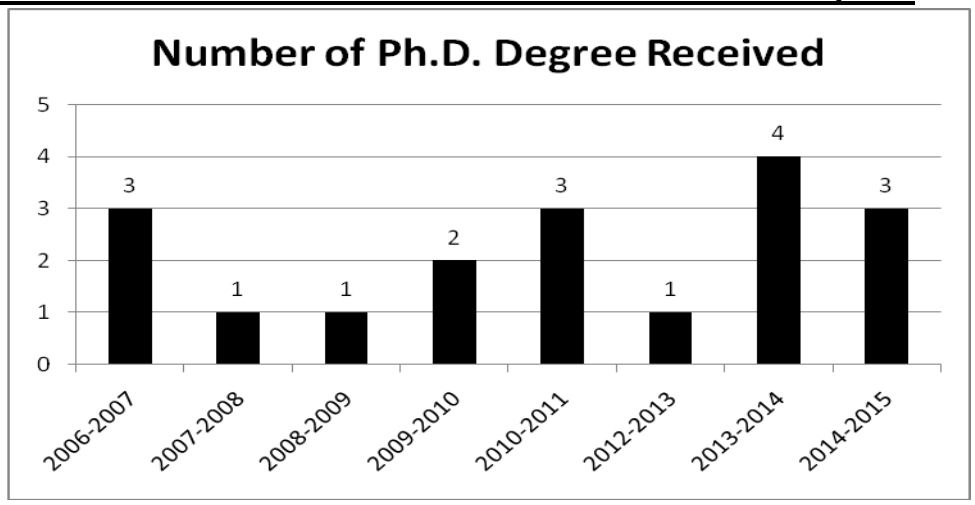


Figure 3: Chart showing the number of students who received their Ph.D. Degree in last 10 years

Departmental Progress Reports (2014-2015)

Department of Astrochemistry/Astrobiology

It is a long-standing aspiration to use chemical properties of various interstellar species for the measurement of physical properties of molecular clouds. In our department, we investigate various conditions which are responsible for the chemical composition of the interstellar medium. This year we have published 4 papers in refereed journals and 9 proceedings. This year, one of our group members, Mr. Liton Majumdar (Project Scientist, funded by MoES) has been awarded the Ph.D degree from the University of Calcutta and at present appointed as the PDF at the University of Bordeaux from November, 2014. During the year, we received one new project (2014-2017) from DST. Mr. Prasanta Gorai has joined as a JRF under this project from September, 2014. In October, 2014, we successfully completed one project which was a 3 year project funded by ISRO-RESPOND. Mr. Dipen Sahu was the student under this project. At present Mr. Sahu is working as a SRF with the financial help from MoES. Prof. Sandip K. Chakrabarti, Dr. Ankan Das and Dr. Liton Majumdar visited Moscow for the participation in COSPAR meeting. Dr. Das visited various National Institutes (PRL, BIT MESRA, Ranchi) for presenting the group activities. Mr. Dipen Sahu attended UST-GUAS radio astronomy winter school at Jeju Island, South Korea during February, 2015. Mr. Prasanta Gorai visited IISER, Pune for attending a workshop.

Ankan Das

(Dr. Ankan Das)
HOD, Astrochemistry/Astrobiology

Department of High Energy Astrophysics

Various theoretical and observational aspects of black holes are studied in this department. There are total several regular (Dr. Dipak Debnath, Mr. Santanu Mondal, Mr. Arka Chatterjee, Mr. Shreeram Nagarkoti, Mr. Aslam A. Molla, Mr. Arghajit Jana, Mr. Debjit Chatterjee) and visiting members (Prof. Sandip K. Chakrabarti, Dr. Broja Gopal Dutta and Mr. Nirmal Saha) who are working in this group. A total five scientific papers are published in high impact refereed international journals and seven papers are published in conference proceedings of international journals during 2014-15. During this period, we went to Moscow, Russia to attend Zeldovich Birth Centenary Conference at Space Research institute (Prof. S. K. Chakrabarti) and 40th COSPAR Conference at Moscow University (Prof. S. K. Chakrabarti, Dr. D. Debanth); to Hyderabad TIFR Balloon facility to attend a workshop on ASTROSAT/LAXPC (Prof. S. K. Chakrabarti, Dr. D. Debanth) and presented our scientific research works. Myself (Dr. Dipak Debnath) and Mr. Santanu Mondal visited NASA Goddard Space Flight Center (GSFC), Maryland, United States to work with Prof. Keith A. Arnuad as a visiting scientist during Sept. 1-28, 2014. Most importantly, two scientific research projects (one from DST, Govt. of India and another from ISRO, Govt. of India), each of total three years duration came at this department during this financial year. Mr. Arghajit Jana, and Mr. Debjit Chatterje have joined as JRFs under these sanctioned research projects. Md. A. A. Molla is working in MoES project.

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 have been carried out in this department. VLF, Radio instrumentation and overall maintenance are also done in this department. Successful Development of different lab facilities like vacuum chamber, have been done for potting and testing the detector etc. There are several members (Prof. Sandip K. Chakrabarti, Mr. Debashis Bhowmick, Dr. Ritabrata Sarkar, Mr. Arnab Bhattacharya, Mr. Susanta Middya, Mr. Hriday Roy, Mr. Uttam Sardar) who are working in this group. Eighteen successful balloon missions were conducted during this year. One scientific paper is published in high impact refereed international journals during this financial year, 2014-15. During this period, our team went to Moscow, Russia to attend 40th COSPAR Conference at Moscow University (Prof. S. K. Chakrabarti, Dr. R. Sarkar). Two project students from Narendrapur have submitted final year experimental project from this department.

Debashis Bhowmick

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

Department of Ionospheric Sciences

Both theoretical and experimental studies about ionosphere and near-earth space including Ozone layer to magnetosphere have been done at the fundamental level in this department. Cutting-edge experimental facilities for Ionospheric research are running at IERC, Sitapur, Malda branches and Coochbehar.. Total of 12 members are working together in this department. Five papers in highly reputed international journals and a total of 10 international conference proceedings as full papers have been published during 2014-2015. Mr. Suman Ray and Mr. Sushanta Kr. Mondal have been awarded Ph.D. degree from the Calcutta University in this year. Dr. Sujay Pal has been on leave as an Assistant Professor in the University of Electro-Communication, Tokyo, Japan. During this year Dr. Tamal Basak has joined the IERC, Sitapur branch as a post-doctoral fellow and later he joined the University of Electro-Communication, Tokyo, Japan as a post-doctoral research assistant. Dr. Sudipta Sasmal got his second opportunity to revisit the Antarctica during 2015-16 for VLF-ionospheric research from the National Centre for Antarctic & Ocean Research, Goa under the Ministry of Earth Science. Dr. Sudipta Sasmal, Dr. Sourav Palit, Dr. Suman Ray and Prof. S.K. Chakrabarti participated in the 40th COSPAR General Conference at Moscow University, Russia and Dr. Sudipta Sasmal, Dr. Sujay Pal participated in the 31st URSI General Assembly at Beijing, China to present our research works. Dr. Palit and Dr. Sasmal also guided four M.Sc. students for final semester project work during this year.

Sujay Pal

(Dr. Sujay Pal)
HOD, Ionospheric Sciences

Members of Scientific Societies/Committees

Sandip K. Chakrabarti became a member of the following i) International coordination committee of "14th Marcel Grossman Conference on General Relativity and Cosmology", Rome, 2015; ii) Editorial Board member: Indian Journal of Physics and Bulletin of Astronomical Society of India; iii) Scientific Organizer of VLF session in COSPAR 2014 General Assembly (C0.4) Moscow, August, 2014. He is also the Head of i) Dept. of Astrophysics and Cosmology; ii) Academic and Research Advisory Committee (ARPAC); iii) Departmental Research Committee (DRC); iv) Consultative Advisory Committee (CAC); v) Students' curriculum and Research Evaluation Committee (SCREC) of SNBNCBS. He is the In Charge, Academic Affairs, the General Secretary of the Governing Body; and the Chairman of the Academic Council of ICSP.

Ph.D. Degree Received

Suman Ray received Ph.D. degree on **"**Study of Very Low Frequency (VLF) Radio Wave Propagation in Earth-Ionosphere Wave-Guide and its Applications for Possible Correlations of VLF Signal Anomalies with Seismicity" (University of Calcutta).

Liton Majumdar received Ph.D. degree **"**Hydrodynamics and Evolving Composition of the Collapsing Interstellar Clouds" (University of Calcutta).

Sushanta K. Mondal received Ph.D. degree on "Study of High Energy Phenomena in the Universe using Earth's ionosphere as a detector" (Jadavpur University).

Ph.D. Thesis Submitted

Santanu Mondal submitted Ph.D. thesis on **"**Spectral properties of accretion flows around black holes in presence of Comptonization and Mass Loss" (University of Calcutta).

Tilak B. Katoch submitted Ph.D. thesis on "Study of solar flares using Indian payloadsRoentgen Telescope -2 (RT-2) on Board Coronas-Photon Satellite: instrumentation, Observation & data analysis" (Jadavpur University).

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. Ankan Das and Dipak Debnath also gave MSc (Astrophysics) course at Gour Banga University, Malda.

Participation in National / International Conferences & Symposia

Sandip K. Chakrabarti gave following oral presentations: **April, 2014:** Astrochemical research: "Generation and Storage of Reaction Cross-Sections", Inter-University Accelerator Centre, New Delhi, **June, 2014:** "Complete Solution of Black Hole accretion including viscosity and radiative Transfer", Zeldovich Birth Centenary Conference at Space Research institute (IKI), Moscow, **August, 2014 :** Programme on "Very Low Frequency Radio Waves", 40th COSPAR conference, Moscow University; "Two Component Advective Flows Around Black Holes": Theory, simulations and observational verifications, 40th COSPAR conference, Moscow University; "Unique Programme using large rubber Balloons", 40th COSPAR conference, Moscow University; "Formation of Two Component Advective Flow by Numerical Simulations and Monte-Carlo simulations of their spectral properties", 40th COSPAR conference, Moscow University; "GRBs and Blazers testing General relativity and Cosmology", 40th COSPAR conference, Moscow University. Other than above five talks, he was co-author of 35 other

conference, Moscow University. Other than above five talks, he was co-author of 35 other papers presented by collaborators at 40th COSPAR conference, Moscow University; "Chemical Evolution of the Universe and origin of Life", Institute of Culture, Kolkata; **September, 2014:** Accretion Disks Around Black Holes: A review, Hard X-ray Astronomy by ASTROSAT", The International Centre, Goa, **October, 2014:** "Accretion Disks Around Black Holes: A review", ARIES, Nainital; **November, 2014: "**Chemical Evolution of the Universe and Origin of Life", Dept. Of Atmospheric Chemistry, Calcutta University; **December, 2014:** Two Component Advective Flows, TIFR, Mumbai, December, 2014, LAXPC, "Observations of Stellar Black Holes: Predictions of Two component Advective Flows", TIFR balloon facility, Hyderabad, December, 2014.

Ankan Das gave oral presentations in **April, 2014:** "Modeling of Interstellar Gas-Grain Chemistry and study the spectral properties of some complex Interstellar molecules", DST meeting 1st April 2014, BIT, MESRA, Ranchi, India. **August, 2014**: "Chemical composition of interstellar dust", 5th August 2014, B0.5 COSPAR, Moscow, Russia."Co-relation of the degree of Ionization of a molecular cloud with the depletion of the neutral species on the interstellar dust" , 5th August 2014, B0.5 COSPAR. **January, 2015:** "Evolution of life in the universe, popular lecture", Chaipath, Midnapore, **March, 2015**: "Study of the Interstellar processes leading to the deuterium enrichment" in ISRO Respond meeting, 12-13th March, 2015, PRL, Ahmedabad, India**.**

Dipak Debnath delivered oral presentations on "Characterization of few transient black hole candidates with TCAF model during their outbursts" at session E1.13 and on "Inclusion of TCAF model in XSPEC to study accretion flow dynamics around black hole candidates" at session E1.18 of 40th COSPAR scientific assembly, 2-10 August, Moscow, Russia. He also presented two posters on "Velocity of shock propagation and evolution of quasi-periodic oscillations in outbursting black holes" and "Study of the spectral and the temporal properties of few black hole candidates with TCAF model" at 40th COSPAR. At the end of his one month (Sept. 2014) visit at NASA/GSFC, he presented a summary of his work done during the visit at NASA/GSFC Lecture room on "Inclusion of Two-Component Advective Flow model in XSPEC as an additive table model to study accretion flow dynamics around black hole candidates". He gave an oral lecture on "Inclusion of Two-Component Advective Flow model in XSPEC to study accretion Flow Dynamics around Black Hole Candidates" on 16th Dec. 2014 at TIFR Balloon facility, Hyderabad.

Ritabrata Sarkar gave oral presentation in **August, 2014**: "Atmospheric Effects on X-ray Detectors at Balloon Heights, 40th COSPAR Scientific Assembly, Moscow, Russia, Aug. 2 - 10, 2014.

Sourav Palit gave following oral presentations: **August, 2014:** "Finding solar spectrum and light curve during a flare from VLF observation" and "Modeling VLF signal modulation during solar flares with Geant4 Monte Carlo simulation, a simple chemical model and LWPC" at COSPAR 2014, Moscow, Russia.

Sudipta Susmal gave following oral Presentations: **August, 2014:** "Study of precursors of earthquakes using amplitude and phase of very low frequency radio signal", "Study of long path VLF signal propagation characteristics as observed from Indian Antarctic station", Maitri, "Study of dependency of precursory effects of earthquakes on propagation paths", 40th COSPAR Scientific Assembly, Moscow, Russia; "Studies of VLF signal anomalies due to seismic effects, XXXI URSI General Assembly and Scientific Symposium", 16th to 23rd August, 2014, Beijing, China, "Study of long path VLF signal propagation characteristics as observed from Indian Antarctic station", Maitri, XXXI URSI General Assembly and Scientific Symposium, 16th to 23rd

August, 2014, Beijing, China; delivered oral presentation at the Popular Science Meeting in **February, 2015: "**Possibilities of Earthquake Prediction: Earlier and Ongoing Efforts", 5th February, 2015, Baruna Satsanga High School, Chaipat, Midnapore (W). Gave following Poster Presentations: **August, 2014:** Studies of precursory effects in the VLF signal for some recent earthquakes, S. Sasmal, B. Das and S. K. Chakrabarti, Unusual fluctuations in phase of VLF signal for NWC-IERC baseline during seismic events, 40th COSPAR Scientific Assembly, Moscow, Russia; "Studies of precursors of earthquakes using anomalies in Very Low Frequency signal", S. Sasmal, S. K. Chakrabarti, B. Das and S. Ray, XXXI URSI General Assembly and Scientific Symposium, "Studies of seismo-ionospheric correlations using anomalies in phase of Very Low Frequency signal", P. Pal, S. Sasmal and S. K. Chakrabarti, XXXI URSI General Assembly and Scientific Symposium, "Magnetospheric-Ionospheric Coupling as a precursory effects of earthquake", V. U. J. Nwankwo, S. Sasmal and S. K. Chakrabarti, XXXI URSI General Assembly and Scientific Symposium, "Correlation between seismic events and anomalous VLF day-length for west-east and east-west propagation paths", S. Ray, S. K. Chakrabarti and S. Sasmal, XXXI URSI General Assembly and Scientific Symposium, "Unusual shifts in terminator times of the VLF signals before the Pakistan (M=7.4) occurred on 18th January, 2011", S. Ray, S. K. Chakrabarti and S. Sasmal, XXXI URSI General Assembly and Scientific Symposium, "Effects of solar flares on ionospheric VLF radio wave propagation, modeling with GEANT4 and LWPC and determination of effective reflection height", S. Palit, S. Sasmal, T. Basak, S. Pal, S. K. Mondal and S. K. Chakrabarti, XXXI URSI General Assembly and Scientific Symposium, "Study of low-latitude ionospheric D-region negative ion profile during an M-class solar flare using VLF propagation effects", T. Basak, S. K. Chakrabarti, S. Sasmal and S. Pal, XXXI URSI General Assembly and Scientific Symposium, 16th to 23rd August, 2014, Beijing, China.

Suman Ray presented talks in **August, 2014:** "Correlation between seismic events and anomalous 'VLF day-length' for west-east and east-west propagation paths", at '40th COSPAR Scientific Assembly' (Scientific Event C0.4), Moscow, Russia. "Correlation between night time VLF amplitude fluctuations and seismic events in Indian sub-continent", at '40th COSPAR Scientific Assembly' (Scientific Event A3.1), Moscow, Russia. He presented a talk on "Study of ionospheric behaviour during total solar eclipse of July 2009 using the Characteristic of Very Low Frequency (VLF) signals'', Physical Research Laboratory (PRL), Ahmedabad in **February, 2014**.

Santanu Mondal gave an oral presentation in **September, 2014:** "Accretion flow dynamics around black holes using TCAF model" NASA/GSFC, Maryland, USA.

Dipen Sahu presented a paper in **Dec, 2014:** "Methyl Acetate and its singly deuterated isotopomers in the interstellar medium", IDMC, Tezpur University, Assam. Presented a poster at UST-GUAS radio astronomy winter school,10-13th February, 2015, Jeju Island, SOUTH KOREA.

Arka Chatterjee presented following talks: **December, 2014**: One Day Seminar on "Black Hole Astrophysics" at S. N. Bose National Centre for Basic Sciences Talk Title: "Effect of Photon Bending on the Visual Appearance of Black Holes*".*

Shreeram Nagarkoti presented the following talks: **December, 2014:** One day seminar on "Black Hole Astrophysics" "Estimation of viscosity parameter in accretion flows around black hole", SNBNCBS, Kolkata, 12th December, 2014.

Prasanta Gorai gave a poster presentation in **December, 2014**: "Methyl acetate and its singly deuterated isotopomers in interstellar medium'' IISER PUNE, PUNE December 12-16, 2014.

Sabyasachi Pal and **Dushmanta Patra**, visited National Centre for Radio Astrophysics (NCRA), GMRT, Pune, May-June, 2014 to carry out observations related to the project 'Multifrequency observation of Giant Radio Galaxy'.

Conference organized

Dr. Sudipta Susmal was the Deputy Organizer of the Scientific Session C0.4 in 40th COSPAR Scientific Assembly, 02-10 August, 2014.

Visits abroad from the Centre

Sandip K. Chakrabarti Visited Space Research Institute (IKI) Moscow in June, 2014, to attend Zeldovich's birth Centenary celebration meeting.

Dipak Debnath and Santanu Mondal visited NASA/GSFC for the implementation of TCAF model as local model in XSPEC, 01-28 September, 2014, USA.

Dipen Sahu UST-GUAS radio astronomy winter school,10-13th February, 2015, Jeju Island, SOUTH KOREA.

Sandip K. Chakrabarti, Sudipta Sasmal, Suman Ray, Liton Majumdar, Ankan Das, Sourav Palit, Ritabrata Sarkar, Dipak Debnath attended 40th COSPAR meeting in August, 2014 in Moscow.

Collaborative research & project work

Study of the Interstellar processes leading to the deuterium enrichment, A. Das (ICSP), S.K. Chakrabarti (SNBNCBS and ICSP), D. Sahu (ICSP): Funded by RESPOND (ISRO).

Abstract: Magnetic fields control star formation rate in ISM. To have an idea of strength of magnetic field, it is essential to extract information about degree of ionization of ISM. In this project, we are trying to explore various possibilities to co-relate deuterium fractionation with degree of ionization of ISM. Armed with degree of ionization, we want to construct a hydro-chemical model to study chemical evolution under these circumstances. Moreover, spectral properties of several deuterated molecules will be theoretically explored by quantum chemical simulation.

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 have been discovered in the interstellar medium (gas and ice) and thousands of chemical species have been 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.

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), A. A. Molla (ICSP), A. Roy (ICSP), D. Chatterjee (ICSP).

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, taken 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), A. Jana (ICSP).

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 advectie flow (TCAF) model as a local model in HeaSARC's spectral analysis software package in XSPEC.

M.Sc. project students guided by ICSP members

1. Dr. Dipak Debnath supervised Mr. Ashok Kumar Mondal and Mr. Raju Goswami from Ramakrishna Mission Residential College (Auton.), Narendrapur, Kolkata, for their M.Sc project works entitled "Spectral property study of the black hole candidate H 1743-322 during its entire phase of 2004 outburst" and "Timing property of H 1743-322 during its entire phase of 2004 outburst" respectively.

2. Dr. Ritabrata Sarkar supervised Biswanath Bag and Rajashik Paul of Ramkrishna Mission Residential College (Auton.), Narendrapur, Kolkata, for their M. Sc. project work entitled “Characterization of Scintillator Detectors for X-ray Detection Using Radiation Sources at Different Distances” and “Study of Scintillator Detector Characteristics for X-ray Detection Using Radiation Sources at Different Angles” respectively.

3. Dr. Sudipta Sasmal supervised Mr. Kingshuk Sarkar and Mr. Debarghya Mallick from Ramakrishna Mission Residential College (Auton.), Narendrapur, Kolkata, for their M.Sc project works entitled "Study of seismo-ionospheric co-relation using the characteristics of daytime perturbation of VLF amplitude" and "Study of the characteristics of Night Time Very Low Frequency signal amplitude perturbation and its correlation with seismic events". Presently Dr. Sasmal is supervising Mr. Anjan Samanta from Panskura Banamali College for his ongoing M.Sc. Project work.

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): L. Majumdar, D. Sahu and P. Gorai

The role of molecules in astronomy has been recognized to be so important that we can define a sizable portion of the Universe as “The Molecular Universe”. Recent successes in this field are due to the advances in observational, experimental, theoretical and modeling activities. Our departmental work clears some of the hazy aspects of the molecular Universe. Outcome of our work is geared to explain observational results from ongoing as well as forthcoming observational facilities. Spectral properties of the interstellar species are studied as a tracer of the chemical as well as physical history in different regions of ISM. In some regions, density of the spectral lines are so weak that it is difficult to assign it for certain species. In our study we explore spectral features of some important gas/grain species and pre-biotic as well as some bio-molecules in and around different regions of the interstellar medium.

Our major work so far has been to compute chemical evolutions of over 700 species which make an interstellar medium in which a star with a proto-disk is being formed. We developed three sophisticated codes: (i) A time dependent hydrodynamic code to follow the collapse of rotating, self-gravitating clouds into a proto-star; (ii) A Monte-Carlo simulation to produce lighter molecules through grain phase chemistry and (iii) A chemical evolution code in the gas phase to track time dependence of mass fractions of various species. For these, we require cross-sections of various reactions and these are computed using quantum calculations using Gaussian Software. We are also looking at the intensity of rotational/vibrational lines emitted from a cloud. We also compare our predicted results with observed and experimental results.

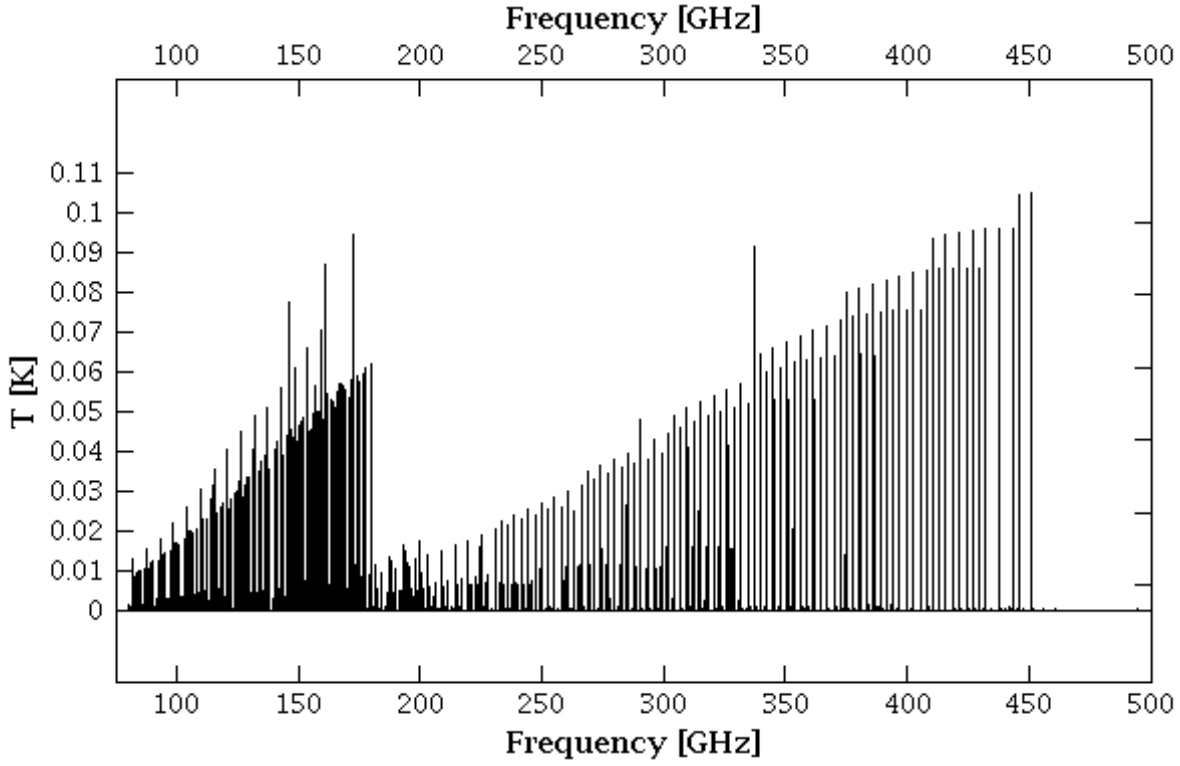


Figure 4: Emission spectra of ethyl formate. We model this spectrum by using CASSIS software in LTE (assuming the transitions are optically thin).

Deuterium is constantly getting depleted ever since big bang. However, many complex molecules could be formed with deuteratium replacing one or more hydrogen. Surprisingly, ratios of these deuterated isotopomars and their hydrogeneted counterparts are much higher compared to the D/H ratios. We study these so-called deuterated fractionation for several specfies. In Figure 2 we show results of fractionations of H_2O, H_2CO and CH_3OH. Note that different elements are differently fractionated. Especially interesting is that H_2O could have fractionation of about 0.3 while CH_3OH could have fractionation of about 0.1.

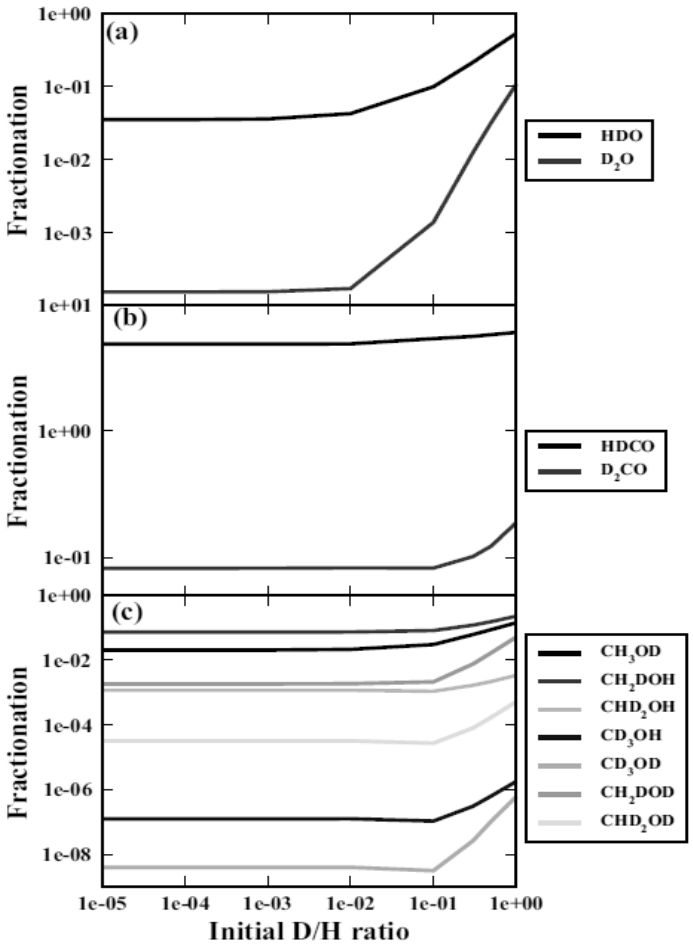


Figure 5: Deuterium fractionation of the ice phase for the H2O, H2CO and CH3OH molecules.

Sources of High Energy Radiations



(L to R): S. K. Chakrabarti, S. Mondal, D. Debnath,


(L to R): A. Chatterjee, S. Nagarkoti

Black Hole environments are the sources of very high energy radiations as the matter which are attracted by the black holes can loss up to 40% of their rest mass in the form of radiation energy. There are thousands of stellar mass black holes in our own galaxy alone apart from one of about 4 million solar mass at the center of Milky Way, which is only 8 kilo parsec away from us. These radiations along with radiations emitted by neutron star/white dwarf accretion, supernovae outbursts, as well as energetic phenomena on the sun are affecting the upper atmosphere of the planet Earth. Under this hostile condition, the Earth's life form survives by the selective absorbance of its atmosphere. The radiation is known to ionize the atmosphere. It seeds the clouds and affects the climate of our planet. We have a dedicated team to study various types of sources of radiation, model them, carry out numerical simulations and fit our models with satellite observations.

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, 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 deformation of the disk image, Doppler and gravitational redshifts and time-lags among various energy components.

Simulated images of black hole accretion disk: A study of physical parameters

Photon trajectory from an accretion disk is guided by the geometry created by the spacetime around the Black Hole. We develop a new technique of visualization of Black Holes surrounded by an accretion disk. First, we reproduce how an axisymmetric Keplerian disk around a Schwarzschild Black Hole would look like. We calculate time lag of photons that are coming from different parts of accretion disks (Chatterjee & Chakrabarti, 2015). With change of inclination angle, we show the variation of time lags between hard and soft photons, flux and a newly defined parameter space (consisting of redshift, effective potential of photons and temperature). Our code is well suited for 3D accretion disk geometry. For example, we image an optically thick toroidal disk (CENBOL) which acts as the Comptonization cloud (see, inside cover). To generate the structure of the centrifugal pressure supported boundary layer or CENBOL, we consider natural angular momentum distribution of thick disks (Chakrabarti 1985). Photon emission process is guided by the Local Thermo dynamical Equilibrium (LTE). The same process has been tested for Kerr geometry with different spin parameters. Coupling photon bending with Monte-Carlo code led us to track

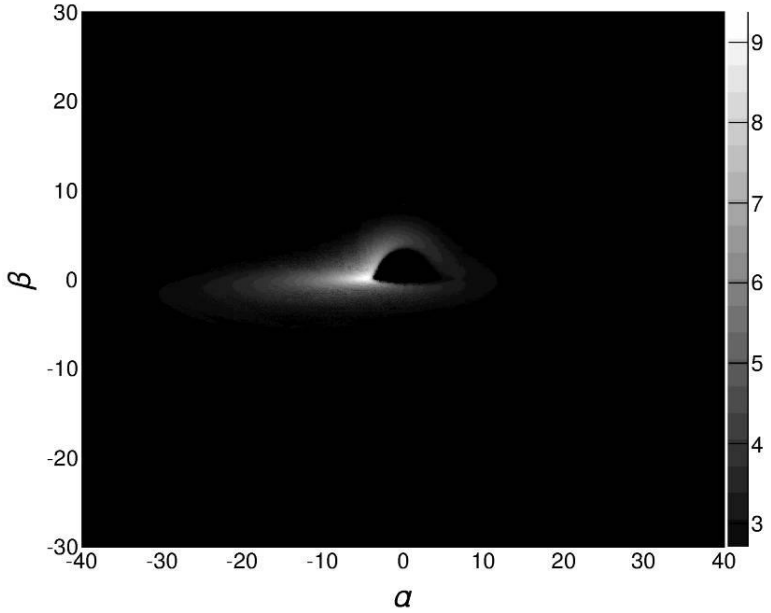


Figure 6: This is how a black hole surrounded by an axisymmetric Keplerian disk would look like when imaged from a close distance.

the scattered photons. With the inclusion of TVD, the time dependent image variation of disk structure during the evolution of an outburst is obtained (A. Chatterjee, S. K. Chakrabarti and H. Ghosh).

Highest theoretical value of viscosity parameter (α) for shock formation around black holes: It is well understood that for matter to accrete and finally fall into the black hole, angular momentum must be transported outwards. Viscosity is the agent which facilitates thi s. We use α parameter of Shakura & Sunyaev (1973). We modify this prescription to address presence of jets/outflows, and then determine the highest value of α for which an accretion flow is allowed to have standing/dissipative shocks. We find that in absence of outflows, standing shocks can form at α as high as 0.3 but dissipative shocks will form only up to α ~ 0.27. In reality the region of the parameter space is significant only if the alpha parameter is up to ~ 0.1 which is very good since the simulations of other workers also do not come up with viscosity larger than this. This implies that the shocks will remain important to explain the spectral and timing properties of black holes (Nagarkoti & Chakrabarti, 2015, submitted).

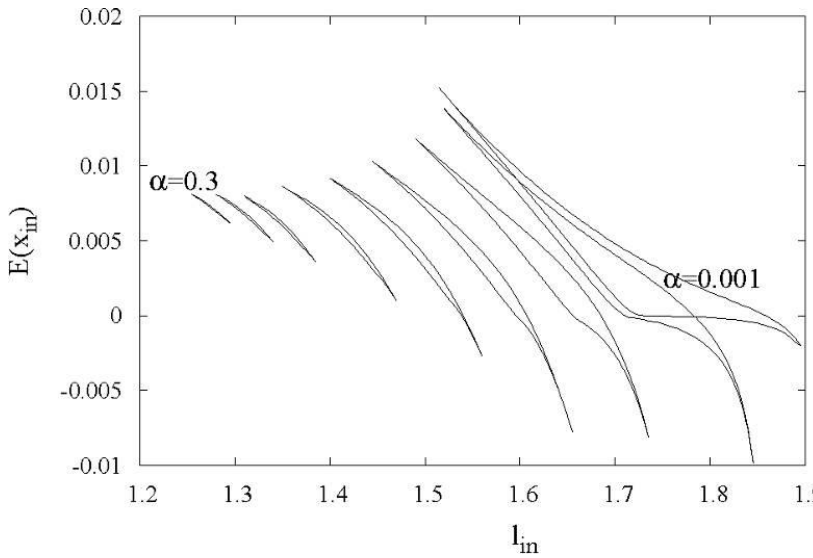


Figure 7: Parameter space allowing standing shock in absence of outflows and cooling.

Inclusion of Two Component Advective Flow (TCAF) model into XSPEC as an additive table model:

We have been able to successfully implement the Two Component Advective Flow solution of our group into HEASARC's XSPEC software so that the X-ray spectra of any black hole may be fitted by this physical model. After a fit, accretion rates of the Keplerian and sub-Keplerian accretion rates, size of the CENBOL and the shock strength were obtained. So far, in other models, one could only compute average temperature and optical depth of the Compton cloud. From the TCAF model fitted shock location (CENBOL Size) and shock strength (inverse of the compression ratio), we can even predict observed dominating QPO frequencies. This is the first time that the spectral and temporal properties of a black hole observation can be explained by the same model through a single fit. Also one could find a strong correlation between spectral and temporal properties of black holes during their outburst in physical *accretion-rate ratio intensity diagram* (ARRID), where different spectral states are correlated in different branches of the hysteresis plot. (S. K. Chakrabarti, D. Debnath, S. Mondal, A. Jana, D. Chatterjee, and A. A. Molla).

Is Compton cooling sufficient to explain evolution of QPO frequency during rising and declining phases of transient black hole candidates ? :

Our past work over the last decade, shows that quasi-periodic oscillation (QPO) frequency generally evolves monotonically during rising and declining phases of the outbursts of transient black hole candidates. More precisely, this evolution of QPOs occurs during hard and hard-intermediate spectral states from both the phases of the outburst. In the rising phase, QPO frequency monotonically goes up until a soft intermediate states of the outburst. In the propagating oscillatory shock (POS) model, oscillation of the Compton cloud is thought to cause QPOs. Thus, in order to increase QPO frequency, the Compton cloud must collapse steadily in the rising phase. In decline phases, the exact opposite should be true. We investigate causes of this evolution of the Compton cloud. The same viscosity parameter that increases the Keplerian disk rate also moves the inner edge of the Keplerian component inwards thereby reducing the size of the Compton cloud and reducing the cooling timescale. In Mondal et al. (2015), we show that cooling of the Compton cloud by inverse Comptonization is enough for it to collapse sufficiently so as to explain the QPO evolution. In the two-component advective flow (TCAF) configuration of Chakrabarti–Titarchuk, centrifugal force-induced shock represents the boundary of the Compton cloud. We take the rising phase of 2010 outburst of Galactic black hole candidate H 1743-322 and find an estimation of variation of the α parameter of the sub-Keplerian flow to be monotonically rising from 0.0001 to 0.02, well within the range suggested by magnetorotational instability. We also estimate the inward velocity of the Compton cloud to be a few meters per second, which is comparable to what is found in several earlier studies of our group by empirically fitting the shock locations with the time of observations (S. Mondal, S. K. Chakrabarti, and D. Debnath).

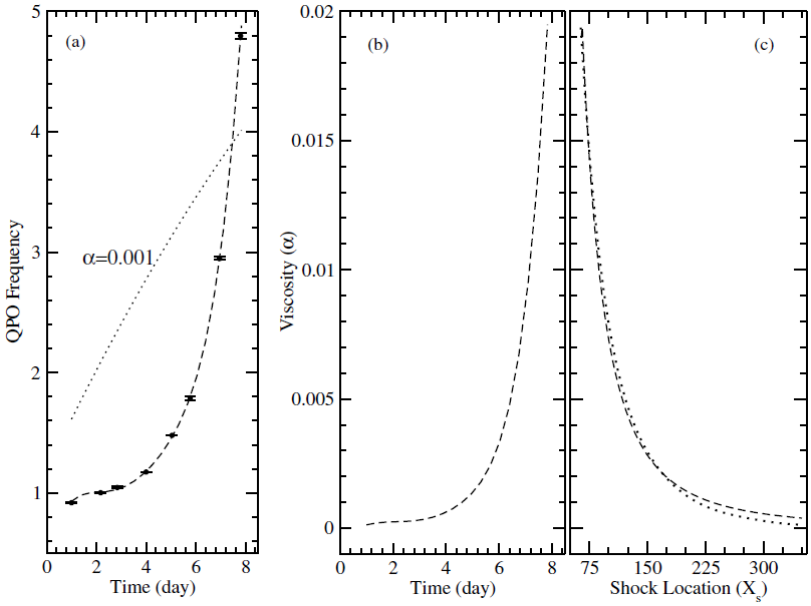
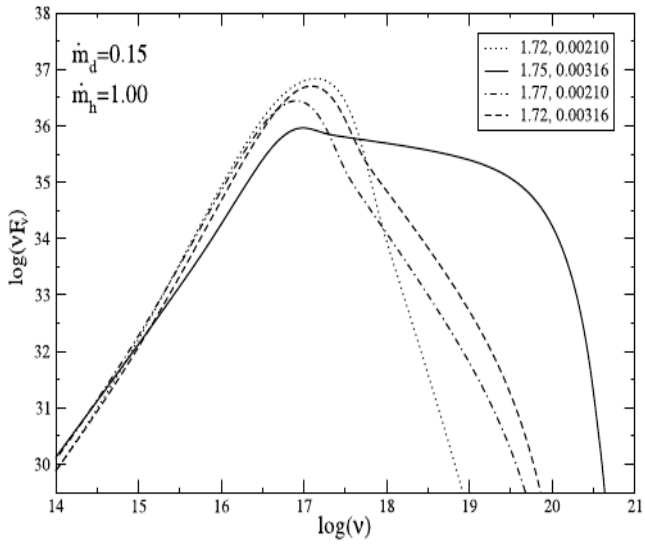


Figure 8: Variation of (a) QPO frequency with progressive days during the rising phase of the 2010 outburst of H 1743-322, both obtained from observation and analytical solutions. In panel (b), the variations of viscosity with time (in days) and (c) with shock location are shown.

Spectral Signature of dissipative standing shock and mass outflow in presence of Comptonization around a black hole: Accretion flows having positive specific energy are known to produce outflows and winds which escape to a large distance. According to Two Component Advective Flow (TCAF) model, centrifugal pressure dominated region (CENBOL) of the flow just outside the black hole horizon, with or without shocks, acts as the base of this outflow. Figure 9 shows the spectral states of accretion disk for different sets of energy and angular momentum, when disk rate (0.15) and halo rate (1.00) are fixed. For higher sets of energy and angular momentum outflow rate is also higher (solid line), which is around 7%. In hard states, usually the shock is far from the black hole and the size of the Compton cloud is also high. Thus a large no. of soft photons are intercepted and up scattered and produce a hard power-law tail in the emitted spectrum.



As the angular momentum of the flow decreases for the same value of energy shock forms closer to the black hole and decreases the Compton cloud size and produces soft spectrum (dashed line). This also decreases the outflow rate as the inner region has not sufficient pressure to push the matter out. This result directly correlates the spectral state with jet from the theoretical point of view (S. Mondal, S. K. Chakrabarti, and D. Debnath).

Figure 9: Variation of spectral shape for different sets of energy and angular momentum of the flow.

X-ray Astronomy

(L to R): D. Debnath, S. Mondal, A. K. Choudhury and S.K. Chakrabarti

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

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.

Spectral and Temporal properties of GX 339-4 during its 2010-11 outburst with TCAF Solution: We fit RXTE PCA spectral data **GX 339-4** during its 2010-11 outburst with TCAF solution for the entire data set and find how the physical quantities such as two component (Keplerian disk and sub-Keplerian halo) accretion rates, shock parameters change. We also compare our TCAF model fitted spectral results with that of the combined disk black body and power-law model fitted results (Nandi, Debnath, Mandal & Chakrabarti, 2012). We found physical reason for the classification of spectral states during the outburst based on variation of accretion rate ratio (ARR; ratio between halo to disk rates) and nature of QPOs (if present).

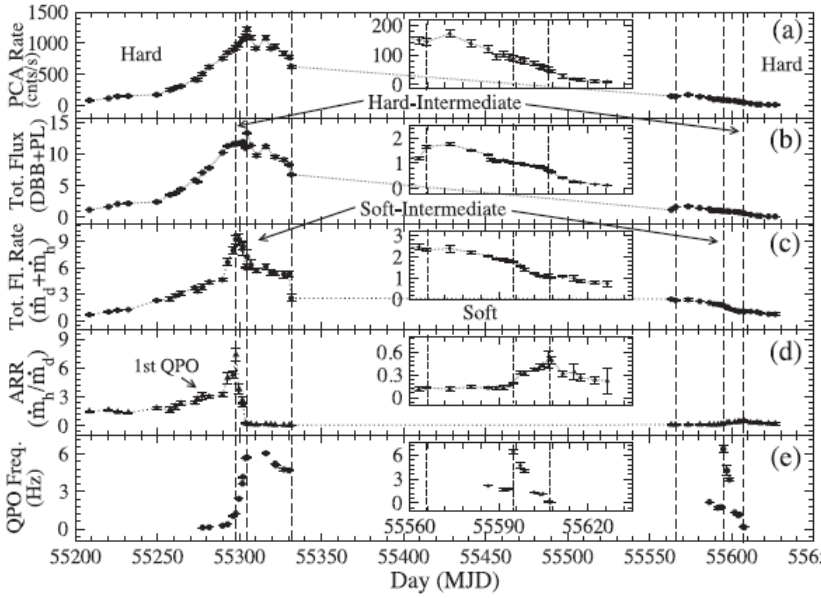


Figure 10: Variation of PCA count rate, total flux (DBB+PL), total flow rate, Accretion Rate Ratio (ARR), and observed QPO frequencies during 2010-11 outburst of GX 339-4 as a function of day.

We also studied variation of shock parameters (location and strength) during the entire phase of the outburst. During the transition from hard to hard-intermediate state or vice-verse, ARR is observed in a local maxima of the rising or the declining phase of the outburst. Similarly, on hard-intermediate to soft-intermediate transition days frequency of the monotonically increasing type 'C' QPOs are observed in both the rising and declining phases of the outburst (D. Debnath, S. Mondal, and S.K. Chakrabarti).

Properties of MAXI J1659-152 from TCAF Solution during its 2010 outburst: We fit the spectral data **MAXIJ1659-152** during its 2010 outburst with TCAF solution and find how the physical quantities vary. Since RXTE PCA started to observe the source a few days after its discovery, we missed its hard state in the rising phase. Our spectral and temporal analysis show that the source was in hard-intermediate, soft-intermediate, and hard (declining only) states, and no soft state was observed. We termed this outburst as a '*failed*' outburst, since no soft state was observed during the entire epoch of the outburst. TCAF model fitted physical flow parameters provide us a better understanding on accretion flow dynamics around the source during its outburst. The QPO frequency rises steadily in the rising phase and goes down in the declining phase as in other outbursting sources. The ARR ratio is weakly maximum on the day the object changed from hard-intermediate to hard state.

Similar to other transient black candidates, during the rising phase of the outburst, shock was fund to move inward with weakening strengths and opposite scenario was observed during declining phase of the outburst (D. Debnath, A. A. Molla, S.K. Chakrabarti, and S. Mondal).

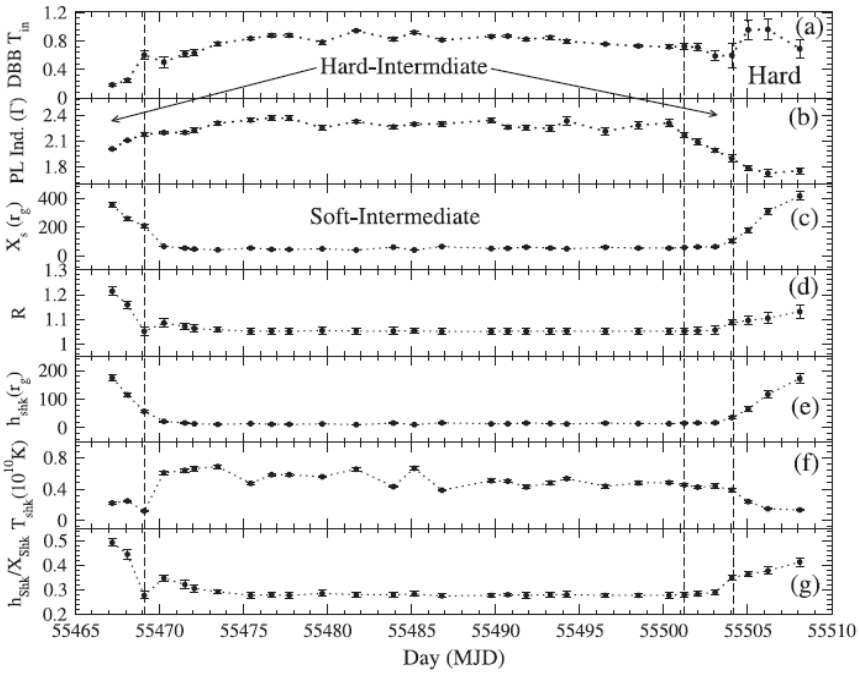


Figure 11: Variations of combined disk blackbody and power-law model fitted (a) disk temperature T_{in} (in keV) and (b) PL photon index (Γ) with day are shown in the top two panels. Variations of TCAF model fitted/derived shock (c) location (X_s in Schwarzschild radius r_g), (d) compression ratio (R), (e) temperature (T_{shk} in 10^{10} K), (f) height (h_{shk} in r_g), and (g) ratio between h_{shk} and X_s with day are shown.

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

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

(L to R): S. Palit, A. Bhattacharya, S. Middya, H. Roy

(L to R): U. Sardar, R.C. Das

Observation of extraterrestrial radiations and cosmic-rays is one of the most interesting and very important fields in the astronomical research. The information from the astronomical objects in the X-ray reveals a great deal to understand their behavior. There are several astronomical missions which use various detection techniques on board satellites and scientific balloons. From the economical point of view, the satellite missions are not always feasible due to huge cost. So balloon borne missions for the X-ray observations is an alternative solution. Moreover, with the technological advancement we can have miniaturized instruments which reduce mission cost further. In this regard, Indian Centre for Space Physics has concentrated to develop balloon borne radiation and particle detectors for the purpose of measurement of radiation through and above the Earth's atmosphere at about 35-42 km. We develop and test light weight and low cost detectors using scintillators, proportional and GM counters. This requires development of other peripheral sensors like payload attitude measurement (using IMUs), GPS units, payload location transmitter, pressure and temperature sensors etc. We developed a technique to fly payloads with small weather balloons to attain the desired altitude above atmosphere at a much lower cost. We indigenously design payloads to serve our goal and test and calibrate detectors in our laboratory for their optimum performance.

Design of a vacuum chamber to test payloads under reduced atmospheric pressure with altitude:

With the altitude increase the atmospheric physical parameters like temperature, pressure also changes. We must be assured about the performance of the detector and other payload components under such ambient conditions. So we must test the detectors under such conditions to ascertain their performances and to take necessary measures to encounter these situations. For this purpose we have built a vacuum chamber arrangement to simulate the reduced atmospheric pressure situations at higher altitudes. In this test bench we can validate the payload performance. A picture of the vacuum chamber arrangement is shown in the inside cover of this report.

A complete spectral profile of the secondary radiation in the atmosphere due to cosmic-ray interaction and wind velocity distribution up to ~42 km:

Despite magnetic shielding and a strong atmosphere around the Earth cosmic-rays from Galactic and extra-galactic origin continuously bombards the Earth and interact with the atmosphere to produce secondary radiations in its course to the Earth. The secondary cosmic radiation intensity depends on the space conditions such as Solar activities (Solar winds). We have been able, from our balloon missions, to measure the entire spectral profile of secondary radiation due to cosmic ray interaction in the atmosphere up to about 42 km. With balloon flights at different times we can see space weather condition from this data. A dynamic change of secondary cosmic-ray spectral profile with time is shown in Figure 12 below. The upper panel shows the raw data as obtained by the detector and the lower panel shows the profile after subtracting the background due to the lead shielding of the detector.

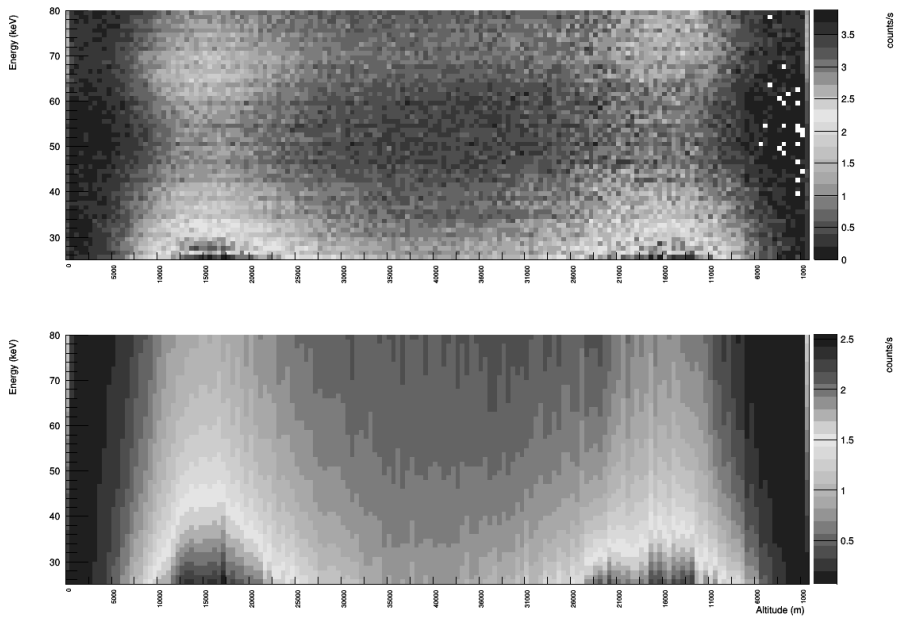


Figure 12: Dynamic profile of the secondary cosmic-ray data throughout the atmosphere.

Along with the radiation data we also measure other atmospheric parameters like temperature, pressure, wind velocity etc. which can be very useful for modeling the atmospheric behavior. In the Figure 13 we have shown altitude variation with time in the left and the measured wind velocity in X and Y direction along with the balloon velocity in the Z direction in the right panel.

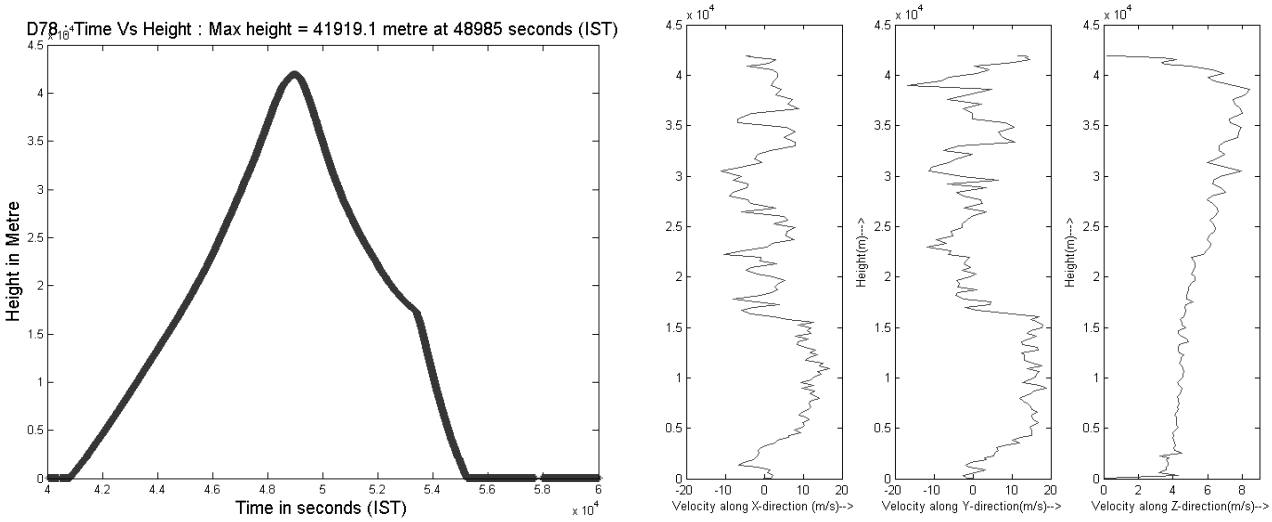


Figure 13: Height of the payload with time (left) and the measured wind velocity at various altitudes (right).

Detection of solar flares and radiation from the Crab pulsar:

Above ~30 km, the residual atmosphere is thin and the background radiation due to the cosmic-ray interaction with the atmosphere is small. Also, absorption of X-rays due the atmosphere is reduced. Under such favorable condition it is possible to detect radiations from point like bright X-ray sources such as Solar radiation, pulsars, X-ray binaries etc. We have detected such solar

flares and radiation from the Crab pulsar in a mission where the Sun and the Crab were in the FOV of the detector at different times. In Figures 14 and 15 we show light curve and dynamic spectrum showing the detection of the solar flares and Crab radiation.

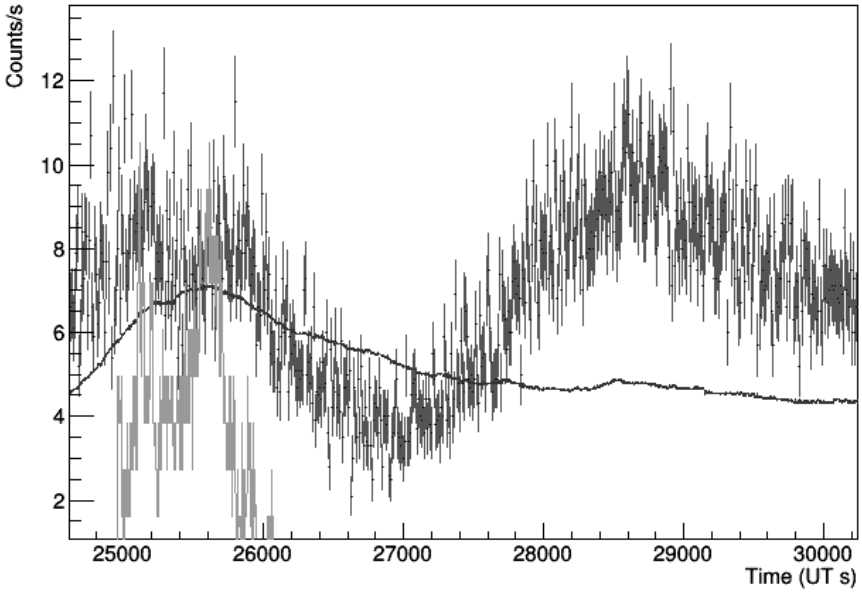


Figure 14: Light curve of cosmic rays with other sources in the energy range of 25-60 keV at the height above 22 km where solar flares (around 25.2 ks and 25.8 ks) and Crab (around 28.6 ks) are detected as the payload scans all azimuthal angles. The gray lines are Goes data showing the Solar activity in units of watt m^{-2}. The low energy activity (1.0 - 8.0 A) is scaled to 10^7 (dark gray) and high energy activity (0.5 - 4.0 A) is scaled to 10^9 (light gray).

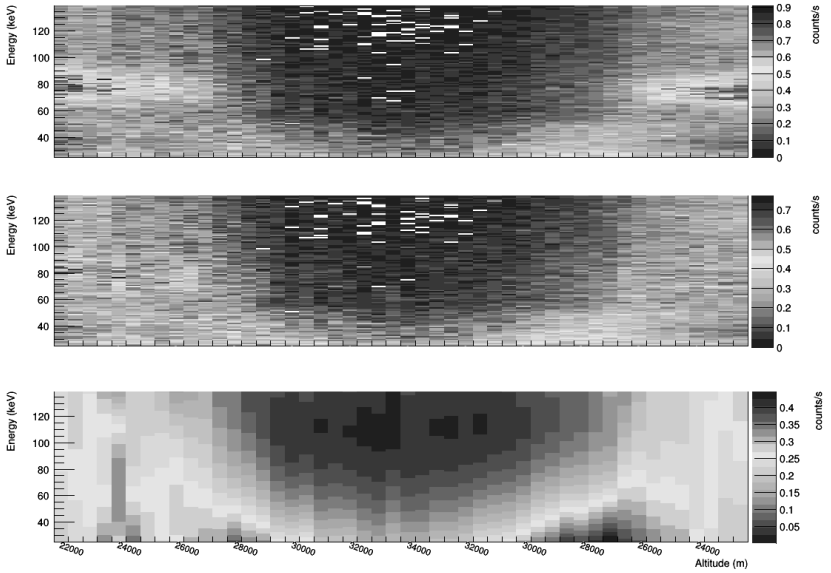


Figure 15: Dynamic spectrum and background noise elimination of the data above 22 km during ascend and descend. The upper panel shows raw spectrum with background, the middle panel shows the same after subtraction of the Lead emission line counts. In the lower panel we show the 2nd order polynomial functions fitting the spectra to suppress statistical fluctuations of the data and to show gross behavior of the spectra at different altitudes. In the lower panel we can find evidences of two solar flares at around 24 km and 28 km during the ascend and Crab data around 27 km during descend of the payload.

Simulation of the atmosphere for the X-ray interaction:

We need to simulate X-ray interaction with the atmosphere for two main purposes: to estimate the minimum altitude where our detector with specific energy range can operate to detect the extraterrestrial radiation and to have a response matrix which can be used to deconvolve absorbed radiation due to atmosphere to the original one. For this purpose we have constructed a simulation framework having a detailed model of the atmosphere and calculated the result of the interaction of radiation with the atmosphere.

Real time payload tracking system:

We have developed a tracking system for the payload which provides us with the real time position information of the payload during the flight which is very crucial for the recovery of the payload. We have developed a transmission-receiving system based on wireless communication system to get the GPS position and altitude of the payload during its flight.

Patents being filed by ICSP on Balloon technologies:

ICSP is readying the papers to file three important patents in the subject of weather balloon borne space science technology. These are:

i) ***Use of multiple balloons for long duration flights***
ii) ***Use of attitude measurements to identify sources for each photon on the sky plane***
iii) ***Use of specially made light weight radio tracker to track payloads in its entire journey in order to have speedy recovery.***

VLF Radio Observations and Modeling

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

Modeling of VLF signal modulation during Total Solar Eclipse (TSE) of 22nd July, 2009

To reproduce effects of Total Solar Eclipse (TSE) on ionosphere and VLF signal propagating through it, a D region ion chemistry model coupled with Long Wave Propagation Capability (LWPC) code and an solar-disk obscuration function have been used to find significant short time effects in the local ionospheric properties. Monte-Carlo simulation has been used for finding ionization due to UV and X-ray photons in the lower ionosphere or D-region in day time. The outcome is fed to a simplified chemistry model to find the residual electron and ion densities and finally LWPC code is used to find the VLF amplitude perturbation. The work has been done on the theoretical understanding of the sluggishness properties of the lower ionosphere under such circumstances. Exact equations governing peak time delays in lower ionospheric electron densities at different heights for various propagation paths have been written down. This is very helpful in proper timing observation of consecutive events and also finding properties of those events and chemical properties of the respective regions.

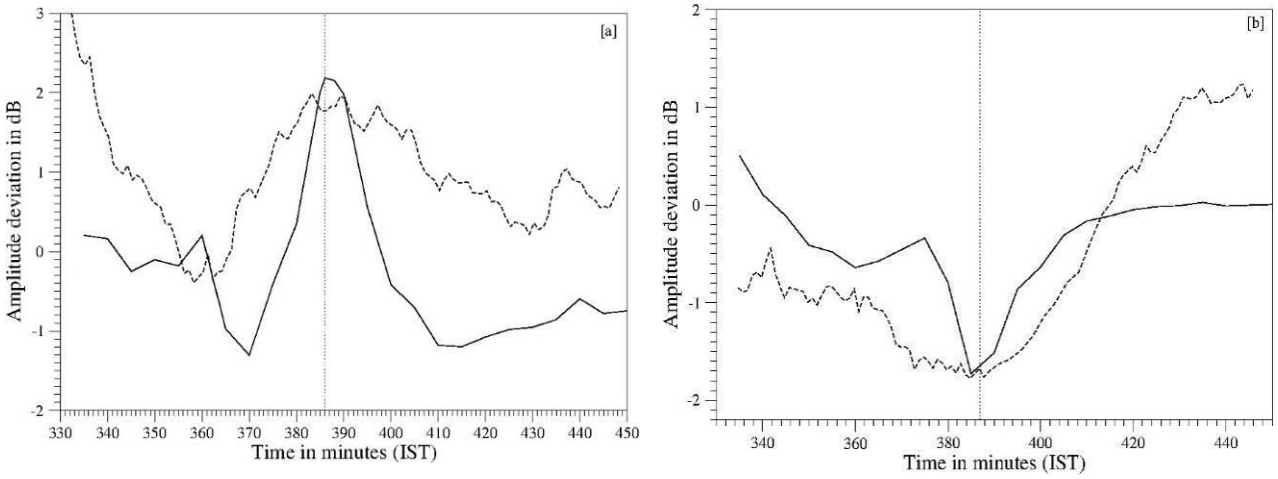


Figure 16 : Observed (Dashed) and Simulated(Solid) VLF signal amplitude variation for Kolkata (Left) and Malda (Right).

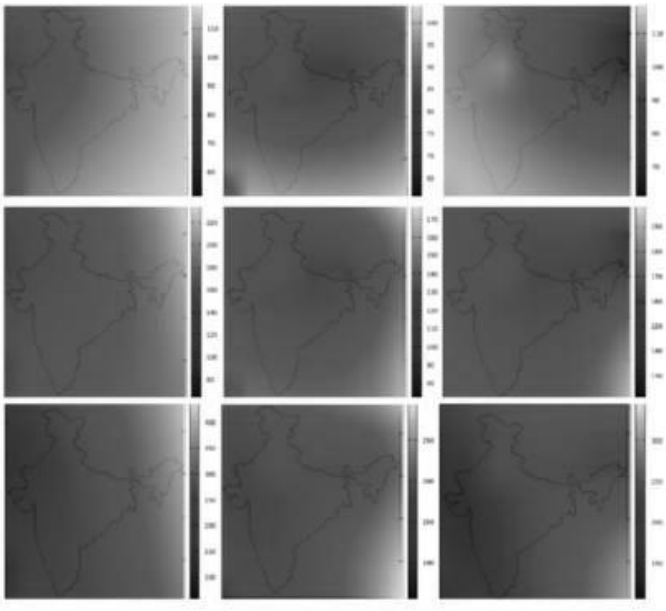


Figure 16 shows VLF amplitude deviations during the eclipse from corresponding normal day values for Kolkata (Left) and Malda (Right) receiver. The solid curve represents simulated deviation and the dashed curve shows observed deviations. In general, there is a resemblance between the simulated and the observed deviations of VLF amplitudes.

Electron density distribution has been calculated over the Indian landmass during the eclipse. Figure 17, represents two dimensional plots showing the shadow of the moon cast in electron density during the solar eclipse passing through Indian sub continent along the course of eclipse.

Figure 17: Variation of electron density profile over Indian landmass during a total solar eclipse.

The Figures in the top panel correspond to values of electron densities at 68 km. The middle and the bottom panels correspond to that of 72 km and 76 km respectively. The leftmost Figures are of 00:50:00 UT hours. The middle and rightmost Figures correspond to 01:00:00 hours and 1:10:00 minutes in UT respectively.

Modeling of VLF signal modulation during solar flares

A theory has been developed to find spectrum and light-curve of solar flares, GRB etc. from VLF signal modulation. The soft X-ray region of solar flares has been deduced from electron density calculated from VLF signal. Presently, we are in a process to extend the study towards lower heights to find hard X-ray region of the spectrum.

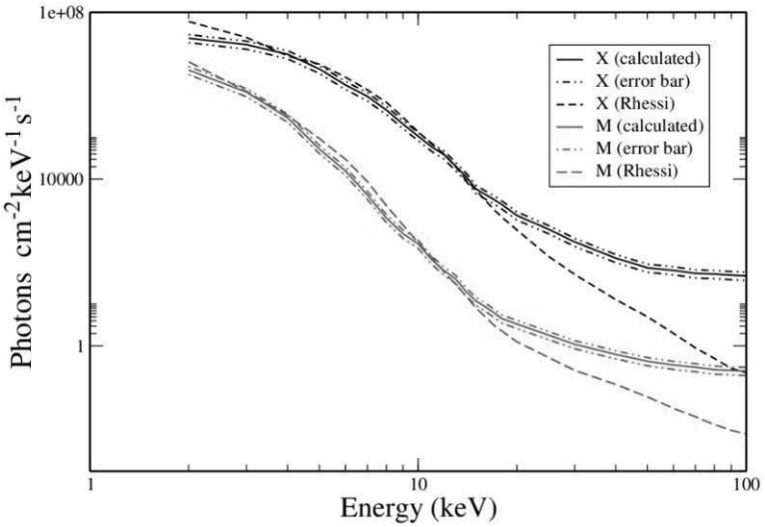


Figure 18: Simulated spectra of M-class and X-class solar flare.

Figure 18 represents Spectra of an M-class (upper pair) and an X-class (lower pair) solar flares calculated from ionospheric VLF observation (solid) and corresponding RHESSI data (dashed).

Observation and modeling of VLF signal as observed from Antarctica

Characteristics of VLF signal propagated though a very long path (more than 10000 km) and received at Indian Antarctic station Maitri has been simulated using D-region ion chemistry model and LWPC code. LF signal from VTX and NWC has been recorded though NWC signal shows high attenuation. It has been observed that this attenuation is due to the ice mass of Antarctic continent. VTX signal is very stable and quiet with low attenuation than NWC signal which does not cross this huge ice mass during propagation. This shows that our methodology is useful to measure ice-mass length along the propagation path sitting within our laboratory itself. Indirectly this allows us to monitor global warming as well.

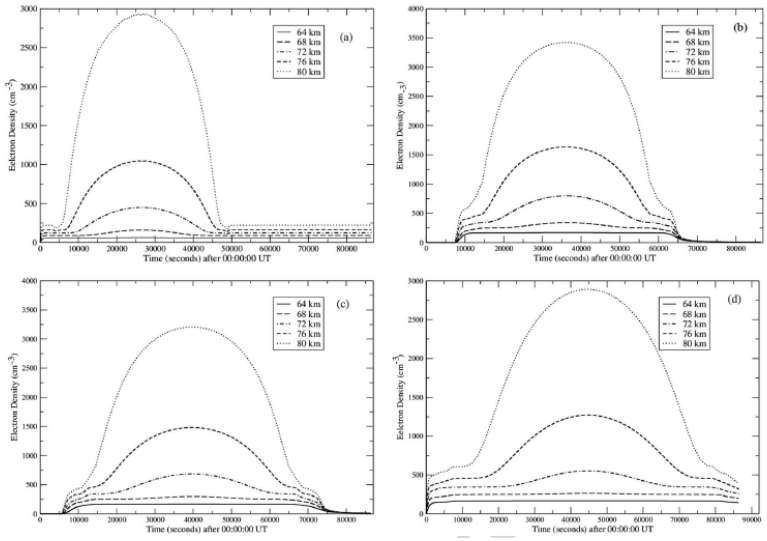


Figure 19: Variation of electron density with height at transmitter, receiver and middle locations.

Figure 19 shows variations of electron density as a function of time, spanning the whole day for five different heights as calculated from ion chemistry model. (a) and (d) are the locations of the VTX transmitter and the receiver at Maitri station in Antarctica where (b) and (c) for two places along the propagation path in between the transmitter and the receiver.

Computed electron density is fed into LWPC code and the spatial distribution of VLF amplitude of VTX signal has been reproduced. Figure 20 shows the variation of calculated signal amplitude for VTX as a function of distance between the transmitter and the receiver. Upper curve is for 00:00:00 UT, and the lower curve is for 12:00:00 UT. The dashed vertical lines indicate locations of 20 segments of the entire path, and thick vertical dashed line indicates the location of the receiver. Simulated nighttime amplitude is larger than the daytime part, which validates the observation.

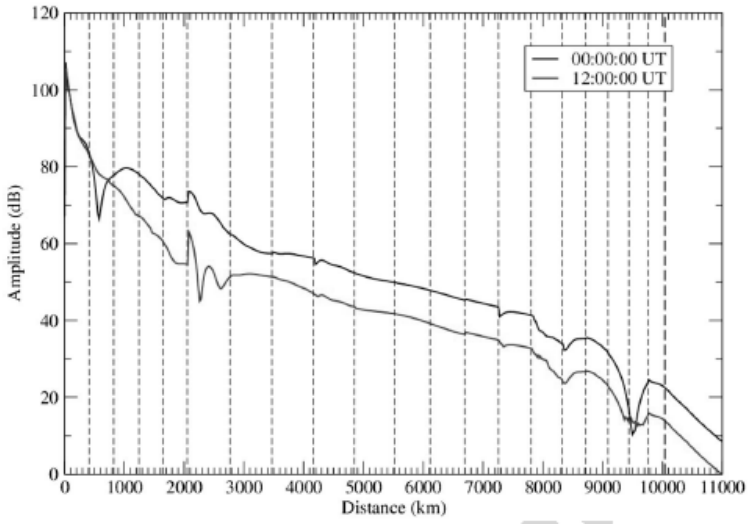


Figure 20: Spatial variation of VTX signal amplitude at 00 UT and 12 UT.

Seismo-Ionospheric Correlation

We have observed significant correlation between VLF signal anomalies and seismic events for past and recent earthquake. LWPC code has been used to reproduce perturbed signal theoretically. Using the Wait's exponential profiles electron densities have been calculated for both normal and perturbed day. In parallel it has also examined that the values of critical frequency of F2 layer of ionosphere (f0F2) becomes unusual for some large earthquakes in Peru region and a parameter has been computed using the f0F2 values which increases abruptly during or prior to those earthquakes (Sasmal, Ghosh, Chakrabarti).

Solar activity and Ionospheric Correlation and correlation with seismic effects

The solar activity controls almost every aspects of the earth, including the ionosphere. Charged particles arriving on earth perturb the magnetosphere and may produce VLF signal anomaly. Thus, it may be difficult to separate events related to seismic effects and those arising out of solar activities. ICSP members have now taken a task to find out and classify all such anomalies and to see if, when effects of solar events, atmospheric gravity waves, meteo-tsunamis etc. are eliminated, any effect is left over which can be characterized as solely due to earthquakes. Some progress has been made with reported cases and it was found that at least 33% of the cases the reported earthquake related anomalies may be influenced by solar effects (Sasmal, Ray, Nwankwo, Chakrabarti).

Off to Antarctica!

Our Project Scientist Dr. Sudipta Sasmal, who already went to 27th Antarctica mission, has again been selected to carry out important experiments during 35th expedition. Preparations are under way. VLF antennas will be installed in Maitri as well as the new station Bharati and cosmic rays on the ground level would be measured during about two months of stay at Antarctica. Instruments are being fabricated by the Instrumentation laboratory.

Airglow/Ozone Depletion/Seismological effects

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

Airglow and Ozone depletion activities are conducted mostly by the visiting and honorary scientists of ICSP. The work is lead 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. Prof. Midya has also found strong correlation between the ozone content and the day of the year. In a study which spanned for several years, he showed that in pre-monsoon session, the Ozone content rises with the day of the year, while during the monsoon and in the post-monsoon sessions the trend is opposite. Efforts are made to model these theoretically. This group is also interested in Earthquake related study. They studied the Gutenberg-Richter parameter 'b' for epicentral regions of large earthquake in Japan, California, China, India, Chile, Italy, New Zealand and Sumatra. They reported a decreasing trend of 'b' before every major earthquake. After a major earthquake this parameter rises again.

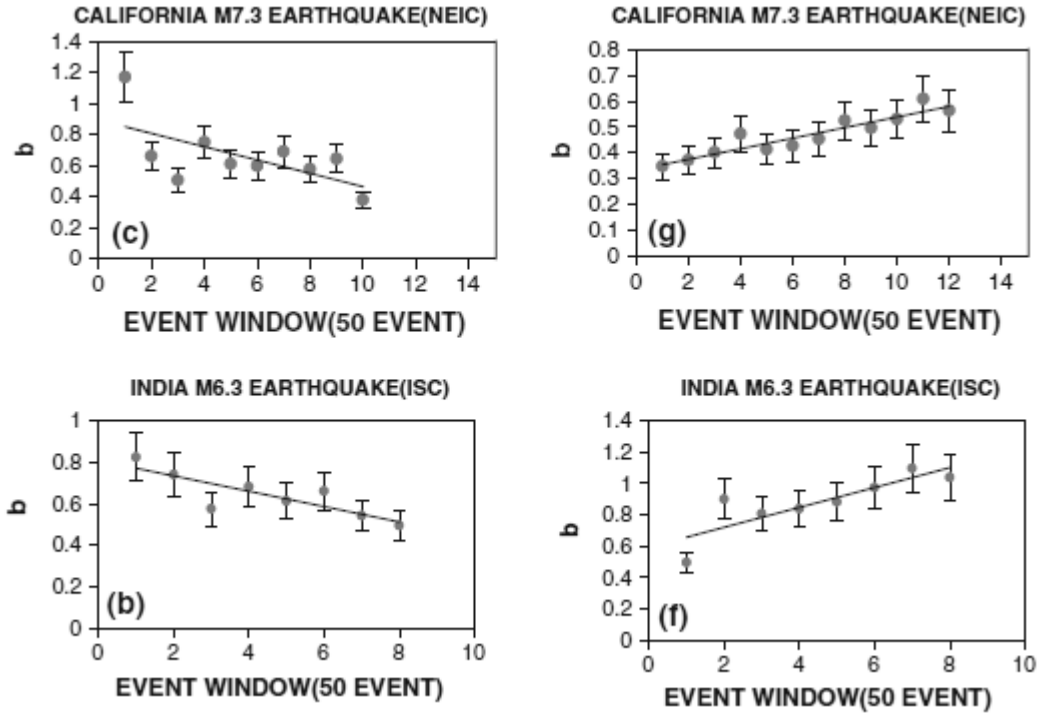


Figure 21: Demonstration of the decreasing and increasing trends of 'b' parameter before and after major earthquakes.

Radio Astronomy



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

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.

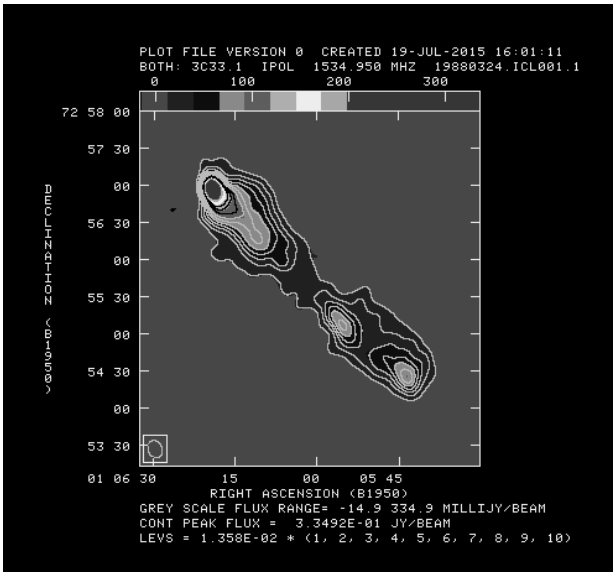


Figure 22: The radio galaxy 3C61.1 observed by Jansky Very Large array in L band (Right).

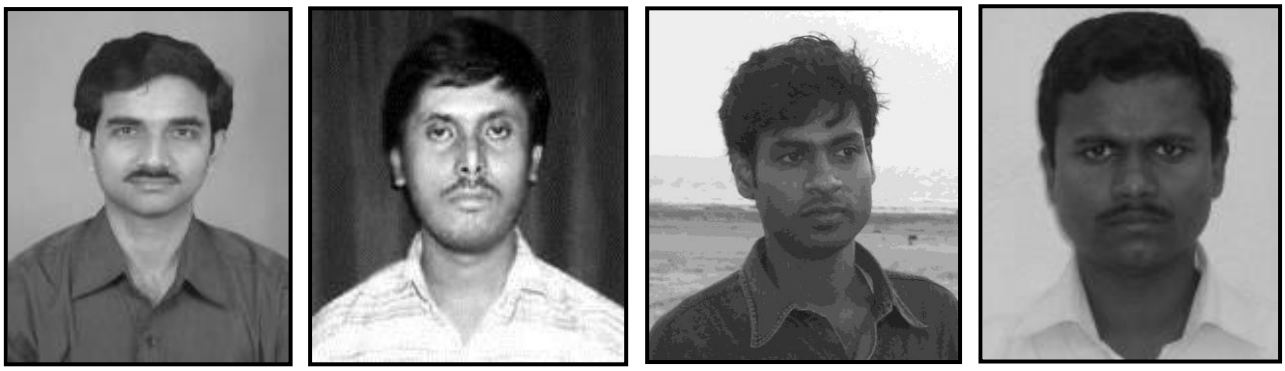
Spectral ageing analysis of many giant radio galaxies are going on. The analysis for the source 3C 35 and 3C 61.1 has been completed. An interesting 'C' shaped wide angle tale radio galaxy has been discovered. Also, a transient radio source close to a galactic micro-quasar has been discovered.

The ionospheric and earthquake research centre (IERC)

(L to R, top): **Sabyasachi Pal, Sudipta Sasmal, Sujay Pal, Pikesh Pal and Rana Khan**
(L to R, bottom): **Amit Roy, Surya K. Maji, Dusmanta Patra, Dipak Sanki, Sanjoy Adak**

In order to receive quiet Radio signals in kHz to GHz range, and to have clear night skies for optical observation, ICSP uses a field station at about 100km from Kolkata away at a remote village named Sitapur, Paschim Medinipur, West Bengal, India. VLF antennas with SoftPAL and AWESOME receivers, Two element interferometer have been installed there. A ten inch optical telescope (MEADE) is used to study the night sky.

Office Staff at the Head quarter



Mr. Rajkumar Maiti (Accountant/ Office Assistant)

Mr.Jyotisman Moitra (Computer Assistant)

Mr. Ram Chandra Das (Office Attendant)

Mr. Uttam Sardar (Office Helper)

Activities of the Indian Centre for Space Physics, Malda Branch



(L to R): Achintya 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 RXTE. Several scientific papers on class transitions and earthquake have been published.

Achintya K Chatterjee, President of ICSP Malda Branch, was invited to present a scientific talk on '***Earthquake and Precautions'*** in '*West Bengal Jnan o Bijnan Utsav'* at Ramkrishna Mission Vivekananda Vidyamandir, Malda organized by Sarbasiksha Mission.

ICSP Malda branch members **Washimul Bari, Achintya K chatterjee** and **Asit K Choudhury** attended the 22nd West Bengal State Science and Technology Congress 2015 held in North Bengal University from February 28, 2015 to March 1, 2015.

Washimul Bari and **Achintya K Chatterjee** presented a poster on "Direct evidence of class transition of GRO J1655-40 during the 2005 outburst." at 22nd West Bengal State Science and Technology Congress 2015 held in North Bengal University from February 28, 2015 to March 1, 2015.

Asit K Choudhury and **Bakul Das** attended a live discussion on '*Earthquake and Precautions'* at Malda Cable Network.

A scientific paper entitled '**Study of unusual behaviour of VLF signals during solar flares for different propagation paths**' Asit K Choudhury, Bakul Das, Sandip K Chakrabarti, Arnab Sen, and Rajashree Nath is being completed.

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

Independent Auditor's 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, 2015,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 Institute's Members 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 and financial performance 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 Insitute'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, *but not for the purpose of expressing an opinion on whether the Institute has in place an adequate internal financial control system over financial reporting and the operating effectiveness of such controls*. 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, 2015, its Profit and its Cash Flow 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, 2015 ("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, 2015 taken on record by the Board of Directors, none of the directors is disqualified as on March 31, 2015 from being appointed as director in terms of Section 164(2) of the Act; and
   f) 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; and
      iii. There has been no amount required to be transferred to the Investor Education and Protection Fund by the Institute.

For SSKA & Associates
Chartered Accountants
FRN # 328751E

Jagdish Mohata, ACA
(*Partner*)
M. No. # 307910

Kolkata, the 5th day of September, 2015.

INDIAN CENTRE FOR SPACE PHYSICS
43 Chalantika, Garia Station Road
Kolkata-700084
Balance Sheet as at 31st March, 2015

Funds and Liabilities	Note	As at 31st March 2015 (₹)	As at 31st March 2014 (₹)
Capital Fund			
Life Membership Fees	1	23,000	16,500
Reserves and Surplus	2	99,18,939	1,13,86,383
		99,41,939	1,14,02,883
Current Liabilities	3	20,96,220	21,59,730
		20,96,220	21,59,730
Total		**1,20,38,159**	**1,35,62,613**
Assets			
Non-current Assets			
Tangible Fixed Assets	4	41,03,077	67,00,535
		41,03,077	67,00,535
Current Assets			
Cash and Bank Balances	5	78,16,021	68,51,328
Short-term Loans and Advances	6	1,19,061	10,750
		79,35,082	68,62,078
Total		**1,20,38,159**	**1,35,62,613**
Notes to Financial Statements	12		
Significant Accounting Policies	13		

As per our report of even date attached.

For SSKA & Associates
Chartered Accountants
FRN # 328751E

Jagdish Mohata, ACA
(Partner)
M. No. # 307910

Kolkata, 5th day of September, 2015.

For and on behalf of Board of Directors

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

Sd./- P. Bandyopadhyay
(Honorary Treasurer, Indian Centre for Space Physics)

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

INDIAN CENTRE FOR SPACE PHYSICS

43 Chalantika, Garia Station Road

Kolkata-700084

Statement of Income & Expenditure for the Year Ended 31st March, 2015

Particulars	Note	Year ended 31st March 2015	Year ended 31st March 2014
		(₹)	(₹)
INCOME			
Grants Received & Utilised	**7**	1,44,37,670	89,96,200
Other Income	**8**	6,60,189	16,80,723
		1,50,97,859	**1,06,76,923**
EXPENDITURE			
Employee Benefits Expense	**9**	37,32,336	32,54,390
Depreciation	**4**	11,82,949	14,460
Other Expenses	**10**	1,01,67,019	72,45,588
		1,50,82,304	**1,05,14,438**
Excess of Income over Expenditure for the year		**15,555**	**1,62,485**
Notes to Financial Statements	**12**		
Significant Accounting Policies	**13**		

As per our report of even date attached.

For and on behalf of Board of Directors

For SSKA & Associates

Chartered Accountants
FRN # 328751E

Sd./- S.K.Chakrabarti

(Honorary Secretary, Indian Centre for Space Physics)

Sd./- P. Bandyopadhyay

(Honorary Treasurer, Indian Centre for Space Physics)

Jagdish Mohata, ACA

(Partner)

M. No. # 307910

Kolkata, 5th day of September, 2015.

Sd./- B.B.Bhattacharyya

(Honorary President, Indian Centre for Space Physics)

INDIAN CENTRE FOR SPACE PHYSICS
Chalantika 43, Garia Station Road
Kolkata - 700 084
Cash Flow Statements for the year ended 31st March' 2015

	Year Ended March 31, 2015	Year Ended March 31, 2014
	(₹)	(₹)
A. Cash Flow From Operating Activities:		
Excess of Income over Expenditure	15,555	1,62,485
Adjustment for:		
Depreciation	11,82,949	14,460
Operating Profit Before Working Capital Changes	11,98,504	1,76,945
Adjustment for:		
Current Assets	(1,08,311)	(5,650)
Current Liabilities and Provisions	(63,510)	(12,23,110)
Change in Working Capital	(1,71,821)	(12,28,760)
Cash Flow From Operations	10,26,683	(10,51,815)
Net Cash Generated by Operating Activities (A)	**10,26,683**	**(10,51,815)**
B. Cash Flow From Investing Activities		
(Purchase of Fixed Assets)	(68,490)	(94,477)
(Investment in)/Maturity of Fixed Deposits	(21,17,919)	(47,43,117)
Cash Flow From Investing Activities (B)	**(21,86,409)**	**(48,37,594)**
C. Cash Flow From Financing Activities		
Membership Fees Received	6,500	-
Cash Flow From Financing Activities (C)	**6,500**	**-**
D. Net Increase/(Decrease) in Cash and Cash Equivalents (A+B+C)	(11,53,226)	(58,89,408)
E. Opening Balance of Cash and Cash Equivalents	21,08,211	79,97,620
F. Closing Balance of Cash and Cash Equivalents (D+E)	**9,54,985**	**21,08,211**

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.

***** On Net Basis

As per our report of even date attached.

For SSKA & Associates

Chartered Accountants
FRN # 328751E

Jagdish Mohata, ACA

(Partner)

M. No. # 307910

Kolkata, 5th day of September, 2015.

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

Sd./- P. Bandyopadhyay
(Honorary Treasurer, Indian Centre for Space Physics)

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

INDIAN CENTRE FOR SPACE PHYSICS

43 Chalantika, Garia Station Road

Kolkata- 700084

Particulars	For the Year ended 31.03.2015 (₹)	For the Year ended 31.03.2014 (₹)
Note-1		
Life Membership Fees		
Life Membership Fees	23,000	16,500
[`500/- each for Forty Six members (P.Y. Thirty Three)]		
	23,000	**16,500**
Note-2		
Reserves and Surplus		
Opening Balance	1,13,86,383	1,12,23,898
Add: Excess of Income over Expenditure	15,555	1,62,485
(Less: Adjustment relating to Fixed Assets) [Refer Note 4]	(14,82,999)	-
	99,18,939	**1,13,86,383**
Note-3		
Current Liabilities		
Unutilised Grants*		
EMJDP, Italy	23,459	23,459
CSIR PROJECT, Delhi	-	2
MoES, Delhi	19,07,544	6,91,152
DST-FTYS, Delhi	-	4,28,689
ICTP, Italy	1,18,368	4,17,568
ISRO Projects, Bangalore	35,449	4,55,939
Other Payables		
Liability for Expenses	11,400	1,42,921
	20,96,220	**21,59,730**
***Refer Note-11 below**		
Note-5		
Cash & Bank Balances		
Cash & Cash Equivalents		
Cash in hand	14,330	8,399
Axis Bank Ltd.	9,31,609	20,91,306
Central Co-operative Bank Ltd.	9,046	8,506
Other Bank Balances		
Fixed Deposits with Banks	68,61,036	47,43,117
	78,16,021	**68,51,328**
Note-6		
Short-term Loans and Advances		
Security Deposits	5,100	5,100
Advance to Employees	6,000	4,000
Balance with Revenue Authorities	39,230	-
Advances recoverable in cash or in kind	68,731	1,650
	1,19,061	**10,750**

Note-7

Grant Received & Utilised

Grant-in-Aid	1,44,37,670	89,96,200
	1,44,37,670	**89,96,200**

Note-8

Other Income

Guest House Rent	52,400	48,900
Interest on Fixed Deposits	6,06,478	11,71,880
Misc. Income	1,311	4,59,943
	6,60,189	**16,80,723**

Note-9

Employee Benefits Expense

Salaries & Stipend	35,37,603	30,66,635
Contribution to Pension Fund	1,94,733	1,87,755
	37,32,336	**32,54,390**

Note-10

Other Expenses

Fund draw for Project Expenses	72,18,387		54,14,541	
Less: Overhead Recovered	(5,19,320)	66,99,067	(2,03,196)	52,11,345
Office Expenses		27,16,531		14,22,781
Statutory Audit Fees		11,400		4,000
Postage		2,378		2,276
Travelling & Conveyance		2,40,197		2,14,744
Telephone, Fax & Internet		73,288		65,914
Printing & Stationary		39,342		83,501
Filing Fees		8,000		4,800
Rent & Electricity		3,73,110		2,33,914
Miscellaneous Expenses		3,706		2,312
		1,01,67,019		**72,45,588**

Note-11

Details of Grants Utilised

Particulars	**Opening**	**Funds Received**	**Funds Utilised**	**Balance Unutilised**
EMJDP, Italy	23,459	-	-	23,459
CSIR PROJECT, Delhi	2	2,50,670	2,50,672	-
West Bengal Government	-	72,04,000	72,04,000	-
MoES, Delhi	6,91,152	49,25,000	37,08,608	19,07,544
DST-FTYS, Delhi	4,28,689	14,50,000	18,78,689	-
ICTP, Italy	4,17,568	-	2,99,200	1,18,368
ISRO Projects, Bangalore	4,55,939	6,08,000	10,28,490	35,449
	20,16,809	**1,44,37,670**	**1,43,69,659**	**20,84,820**

INDIAN CENTRE FOR SPACE PHYSICS

Notes to Financial Statements

Note 12

General Information

*"**Indian Centre for Space Physics**"* **(CIN: U73100WB1999NPL090718),** is a public limited company ("Limited by Guarantee") licensed to operate under section u/s 8 of the Companies Act, 2013 as "Not for Profit Company" and is presently engaged in development and research projects related to Space and Physics at its premises at **Chalantika 43, Garia Station Road, Kolkata 700 084**.

Note 13

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) Tangible Fixed Asset

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

(iii) Depreciation

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

(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 received from various research organisations. The Company submits Utilisation Certificate and Statement of Expenditure. The funds are recognised only when it is received. Grants received are recognised as income on receipt basis. Interest received on unutilised grants are accounted as Other Income.

(vi) Employees Benefit

The Company does not have any permanent employment structure. All the employees of the Company are hired on a contractual basis, renewable after a periodical duration subject to their good performance. The Company follows a Contractual-Career-Path as approved by the Board in compliance with the provisions laid out in the Cabinet Note approved by government. Hence, the provisions of AS-15 are not applicable.

However, since the provisions of the Employees Provident Fund Act' 1952 are applicable to the Company, contributions are made towards employee's provident fund which is recognised in Statement of Income and Expenditure in the year in which the contribution is made.

(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.

INDIAN CENTRE FOR SPACE PHYSICS

Chalantika 43, Garia Station Road
Kolkata - 700 084

Note-4 **Amount in**

Tangible Fixed Assets

Particulars	Gross Block				Depreciation				Net Block	
	As on 01.04.14	Addition during the year	Sale during the year	As on 31.03.15	As on 01.04.14	During the year	Adjustment*	As on 31.03.15	As on 31.03.15	As on 31.03.14
Computer & Software	14,16,354	68,490	-	14,84,844	2,07,605	5,72,830	5,87,932	13,68,367	1,16,477	12,08,749
Furniture	1,23,371	-	-	1,23,371	18,506	-	98,697	1,17,203	6,168	1,04,865
Office Equipment	53,758	-	-	53,758	8,064	-	43,008	51,072	2,686	45,694
Scientific Equipment	37,43,634	-	-	37,43,634	5,61,545	3,16,891	7,53,362	16,31,799	21,11,836	31,82,089
Boundary Wall	13,38,020	-	-	13,38,020	66,901	66,386	-	1,33,287	12,04,733	12,71,119
Land **	-	-	-	-	-	-	-	-	-	-
Development of land	3,08,380	-	-	3,08,380	-	-	-	-	3,08,380	3,08,380
Car	1,61,794	-	-	1,61,794	24,269	60,549	-	84,818	76,976	1,37,525
Books	76,045	-	-	76,045	7,495	61,489	-	68,984	7,061	68,550
Electrical Items	4,32,740	-	-	4,32,740	59,176	1,04,804	-	1,63,980	2,68,760	3,73,564
Current Year Total	**76,54,096**	**68,490**	**-**	**77,22,586**	**9,53,561**	**11,82,949**	**14,82,999**	**36,19,509**	**41,03,077**	**67,00,535**
Previous Year Total	**74,85,311**	**1,68,785**	**-**	**76,54,096**	**9,39,101**	**14,460**	**-**	**9,53,561**	**67,00,535**	**66,20,518**

**** On lease from Govt. of West Bengal**
(Approx. Area 0.46 acres)

***Note:**

Pursuant to the enactment of the Companies Act, 2013, the Company has applied the estimated useful lives as specified in Schedule II as the life of the assets. Accordingly, the unamortised carrying value is being depreciated over the revised/remaining useful lives. The Written Down Value of Fixed Assets amounting to ` 14,82,999/-, whose lives already expired till 31st March, 2014 have been adjusted with the opening balance of Retained Earnings.

Some present and past Scientists of ICSP at 40th COSPAR Scientific Assembly, August 2-10, Moscow, Russia (Left). Participants of C0.4 Session organized by ICSP scientists at 40th COSPAR Scientific Assembly (Right).

Dr. Dipak Debnath and Mr. Santanu Mondal at NASA Goddard Space Flight Center (Sept. 2014) (Left). Dr. Debnath and Mr. Mondal are seen with Dr. Keith A. Arnuad of NASA/GSFC (Right).

Dr. S. Pal receiving the "URSI Young Scientist Award" from the URSI President (Left). Dr. S. Sasmal presenting a poster at URSI meeting at Beijing (Middle). Dr. S. Pal presenting a talk at 91st workshop of Japan Society of Atmospheric Electricity, Gunma University, Japan, July 11-12, 2014. (Right).

Some M.Sc. Project students With their Instructors (Left). Mr. Prasanta Gorai receiving Gold medal award from the State Educational Minister for securing 1st class 1st position in M.Sc. (Right).

भारतीय अन्तरिक्ष भौतिक विज्ञान केन्द्र