Bio Data

Name : **DR. ANIL BHARDWAJ**

Date of Birth : June 01, 1967

Education :

B.Sc.	Physics	1985	Lucknow University
M.Sc.	Physics	1987	Lucknow University
UG Diploma	German language	1989	Banaras Hindu University
Ph. D.	Physics	1992	Inst. of Tech., Banaras Hindu University

Ph. D. Thesis Title : "Aurora and Airglow Processes on the Outer Planets and Comets".

Present Position : **Scientist SF**

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Employment :

April 1988–June 1990 :	Research Fellow, Inst. of Tech., Banaras Hindu University.
July 1990–July 1993 :	CSIR Senior Research Fellow, IT, Banaras Hindu University.
Aug. 1993–Dec. 1997 :	Scientist-SD, Space Physics Laboratory, VSSC, Trivandrum.
Jan. 1998–June 2002 :	Scientist-SE, Space Physics Laboratory, VSSC, Trivandrum.
July 2002–present :	Scientist-SF, Space Physics Laboratory, VSSC, Trivandrum.
Jan. 2004–Oct. 2005 :	NRC-National Academy of Science Senior Research Associate, NASA Marshall Space Flight Center, Huntsville, USA.

Refereed Publication	**60**
Chapter in Encyclopedia	**1**
Book Edited	**2**
Conference/Session Organized	**8**
Workshop Organized	**1**
Press Release on Research	**6 (5 by NASA; 1 by ESA)**

Research Area :

Theoretical and observational studies of planetary atmospheres, ionospheres, and their coupling with magnetosphere.

Current Research Interests :

Aurora and airglow processes in planetary atmospheres, chemistry of planetary and cometary ionospheres, Monte Carlo simulations of processes in atmosphere, ENA imaging of the Lunar surface and Earth's magnetosphere-ionosphere system, ground-based and space-based multi-wavelength (X-ray, UV, radio) imaging and spectroscopy of emissions from planetary bodies, and comparative planetology.

The planetary bodies on which worked include, Jupiter, Saturn, Uranus, Neptune, Io, Europa, Ganymede, Triton, Titan, Io plasma torus, Rings of Saturn, Mars, Earth, Moon, and Comets.

Important Scientific Contributions in Brief:

Dr. Bhardwaj has **achieved the distinction** of being a **multi-spectral** (X-ray, UV, radio) observer, a **planetary mission experimenter**, and an excellent **theoretical modeler**. **He has made pioneering contributions in the field of planetary atmospheres and ionospheres and their coupling with magnetospheres, especially in the areas of planetary X-rays, planetary airglow and auroral emissions, chemistry of cometary coma, Io and Io-Jupiter interactions, Monte Carlo simulations of charged particle degradation in planetary atmospheres, and also energetic neutral atom (ENA) imaging**. He has also made crucial contributions towards the growth of planetary science in his country.

Dr. Bhardwaj is an expert in the field of solar system X-rays, which is evident from (1) **a chapter in the 'Encyclopedia of the Solar System'**, (2) **invited reviews and several refereed publications in reputed journals**, and (3) a number of **invited lectures/talks** at foreign institutes and international conferences. Making observations with the sophisticated Chandra and XMM-Newton X-ray observatories, Dr. Bhardwaj has made an **invaluable contribution to the field of planetary X-ray astronomy.** His landmark accomplishments are:

1) Discovery of X-rays from the Rings of Saturn, and a convincing explanation that they are oxygen K-α emission from water-icy ring material.

2) Use of an unusual and innovative observation mode of Chandra to conduct the **first and the only observation so far of soft (<2 keV) X-rays from Earth's aurora.**

3) First detection of X-ray flare from the low-latitude disks of Jupiter and Saturn: demonstrating that these gas giant planets act as "*diffuse mirrors*" for incident solar X-rays. Also **made an extensive study** of low-latitude X-rays from Jupiter, which has **revealed very interesting correlation between Jovian X-rays and its magnetic field.**

4) Member of the team that **discovered X-rays from (i) Jupiter's satellites Io and Europa, and (ii) the Io plasma torus**, and **(iii) the first observation of the pulsating auroral X-ray hot-spot on Jupiter, which has revolutionized our understanding about the Jovian auroral X-ray phenomena**.

5) Unambiguous detection of X-rays from Mars halo (exosphere) and demonstrating its spectral similarity to cometary X-rays and extend to 8 Martian radii.

Dr. Bhardwaj's 1992 model predicted spectrum of bremsstrahlung auroral >2 keV X-rays on Jupiter **is confirmed by observations** recently made by the XMM-Newton and Chandra X-ray observatory.

Dr. Bhardwaj has developed a **unique coupled chemistry-transport-emission model, which involves over 600 chemical reactions**, for studying the effects of auroral electrons in the inner coma of comets. In recent years this **comprehensive model is successfully used** to (i) explain the chemistry of ions <40 amu in the coma of comet Halley, (ii) chemistry of metastable carbon C(^{1}D) and CI 1931 Å emission, and (iii) **prediction** on production of OI 6300 and 5577 Å emission, which has recently been **confirmed by high-resolution spectroscopy** observation of **comet Ikeya-Zhang**. His model calculations show the presence of **double-peak structure** in the ion production rate on comets with high gas production rates, which has important consequences for cometary coma physics.

A **Monte Carlo model, the first of its kind,** has been developed by Dr. Bhardwaj for degradation of electrons and protons in an atmosphere of H_2 and SO_2 gas, with applications to outer planets' airglow, Io's atmosphere and Io-Jupiter interactions. This model has been exceptionally successful in addressing the problems of "electroglow" and "optically thin H Lyman alpha" on the outer planets.

Dr. Bhardwaj has also developed an empirical cross section model for electron impact cross sections for planetary gases. Group from JPL (USA) has made use of Bhardwaj's cross section model to represent their laboratory measured cross sections for several planetary gases, like SO_2, H_2O, HD.

On the topic of Io and its interaction with Jupiter, Dr. Bhardwaj demonstrated a close coupling between Io's atmosphere and magnetospheric plasma of Jupiter observed by Galileo. He **provided the first explanation for the Hubble Space Telescope (HST) observed** neutral O and S UV emissions on Io. He also made the **first rigorous Monte Carlo calculation** for photoelectron excited emissions on Io and **proved that photoelectrons alone cannot excite emissions in Io's atmosphere**.

Venturing into the **multi-spectral** domain, **Dr. Bhardwaj innovatively use Giant Metrewave Radio Telescope** (GMRT) to make first GMRT observation of synchrotron radio emissions from Jupiter in 2003, which **showed evidence of day-to-day variability at 610 MHz – a finding that has dramatic consequences** for dynamics of Jovian radiation belts. Moreover, using **first simultaneous HST ultraviolet and Chandra X-ray observations** he showed **a clear spatial and temporal association** of the X-ray emission intensity with an auroral UV flare at Jupiter.

In the role of an experimenter, **Dr. Bhardwaj** is the Indian **Principal Investigator** of the **joint Indo-Swedish SARA experiment** on Indian lunar mission **Chandrayaan-1**. This novel experiment will perform **the first ever ENA imaging on an atmosphere-less planetary body** and provide the fundamental information on **elemental composition and magnetic anomalies on lunar surface**. He is also the PI of the ENA instrument on the upcoming **ISRO's Small Satellite program**, and a team member of the Indian **ASTROSAT mission**. He is currently the core team member for defining the **Indian Mission to Mars**, and other planetary bodies.

HONOURS AND AWARDS:

1. *Awarded NRC Senior Research Associteship* by US National Academy of Science in 2003. Worked at NASA Marshall Space Flight Center during January 2004 to October 2005 {on a Sabbatical EOL from ISRO/DOS}.
2. *Awarded* fellowship grant by *United Nations Office of Outer Space Affairs* (UN-OOSA), Vienna, Austria, 1996.
3. *Elected President* of Planetary Science Section of *Asia Oceania Geosciences Society* (AOGS) in 2005.
4. *Best paper award,* "Non-Stationary Plasma Processes on Comets and its Implications", PLASMA-95 Symposium, Banaras Hindu University, October 1995.
5. *Best paper award*, "First GMRT Observation of Jupiter's Synchrotron Radio Emission", Golden Jubilee Symposium on Radio Science (INCURSI-2007), National Physical Laboratory, New Delhi, February 2007.

SPECIAL RECOGNITION:

1. *Invited* to write a *Chapter* for *Encyclopedia of the Solar System* (published in 2007).
2. *AGU Journal Highlights* – Geophysical Research Letters (2005) paper by Bhardwaj et al. "Solar Control on Jupiter's Equatorial X-ray Emissions: 26-29 November 2003 XMM-Newton Observation", was selected by *American Geophysical Union* (AGU) as their Journal Highlights.
3. *Invited* by the Editor of "*Reviews of Geophysics*" (the highest impact factor journal in geosciences, and atmosphere, planetary and space sciences) to write a review article on 'Auroras of the Outer Planets', in 1998.
4. *Invited* by the Editor to write a *Review Article* on "Planetary X-rays" for the journal *Planetary and Space Science*, (in press) 2007.

SPECIAL MENTION:

1. Figure 1 of Bhardwaj and Gladstone (2000) article *made the Cover Page* of August 2000, vol. 38, No. 3, issue of the journal "*Reviews of Geophysics"*.
2. Figure 5 from Branduardi-Raymont, Bhardwaj, et al. (2007) paper *made the Cover Page* of the journal *Astronomy and Astrophysics*, vol. 463, No.2 (2007).

DISTINCT ACHIEVEMENT:

Press Releases by NASA and ESA on Discoveries and Landmark Research Findings, which formed the Breaking News at several science websites.

1. ***NASA Press Release***, Feb. 27, 2002, "*Jupiter Hot Spot Makes Trouble For Theory*", on the **Nature** paper by Gladstone et al. "A Pulsating Auroral X-Ray Hot Spot on Jupiter". It also made "*ASTRONOMY PICTURE OF THE DAY*" on March 1, 2002.
2. ***ESA Press Release*,** March 7, 2005, "*Jupiter: A Cloudy Mirror for the Sun*" on Geophysical Research Letters paper by Bhardwaj et al. "Solar Control on Jupiter's Equatorial X-ray Emissions".
3. ***NASA Press Release*,** May 25, 2005, "*NASA's Chandra Finds Saturn Reflects X-rays from Sun*" on Astrophysical Journal Letters paper by Bhardwaj et al. "Chandra Observation of an X-ray Flare at Saturn".

4. ***NASA Press Release***, March 2, 2005, "*Chandra Probes High-Voltage Auroras on Jupiter*", on Journal of Geophysical Research paper by Elsner et al. "Simultaneous Chandra X-ray, HST UV, and Ulysses Radio Observations of Jupiter's Aurora".
5. ***CXC-NASA Photo Press Release*****,** June 27, 2005, "Saturn's Rings Sparkle with X-rays" on Astrophysical Journal Letters paper by Bhardwaj et al. "Discovery of Oxygen Kα X-ray Emission from Rings of Saturn".
6. ***NASA Press Release*****,** Dec. 28, 2005, "*Chandra Looks Back At The Earth*" on Journal of Atmospheric and Solar-Terrestrial Physics paper by Bhardwaj et al. "First Terrestrial Soft X-ray Auroral Observation".

Special News Report on the Research Work: (just a few mentioned here)

1. "Telescope Captures Auroral Emissions of the Giant Planets", *Earth in Space*, 13(2), 3 (2000).
2. "Jupiter as mirror for the Sun's X-rays", *Science News (USA)*, vol.167, no.3, (March 2005).
3. "Jupiter mirrors flares on far side of Sun", *New Scientist* (UK) (March, 2005).
4. "Jovian mirror could show hidden solar activity", *Space Now*, March 8, 2005.
5. "Jupiter acts as giant mirror to Sun's back-side activity", *Space.com*, March 7, 2005.
6. "Jupiter a cloudy mirror for the Sun". *Space Daily*, March 8, 2005
7. "Jovian X-ray vision", *Astrobiology Magazine*, March 17, 2005.
8. "Jupiter Reflects the Sun's X-Rays", *Universe Today*, March 8, 2005
9. "Saturn reflects X-rays from Sun", *NASA Marshall Star*, Vol. 45, No.39 (2005).
10. "Natural Mirrors Reflect Sun's Hidden Flares", *MSNBC News*, May 25, 2005.
11. "Saturn reflects X-rays from Sun, discovers ISRO scientist", *IndiaDaily* and *HindustanTimes.com*, May 28, 2005.
12. "ISRO's Anil Bhardwaj finds Saturn and Jupiter reflects Sun's X-rays", *INDOlink*, 31 May, 2005.
13. "X-Rays Sparkle in Saturn's Rings", *Universe Today*, June 28, 2005.
14. "Chandra shows Saturn's rings sparkling with X-rays", *SpaceFlight Now*, July 5, 2005.
15. "Indian finds X-rays from the rings of Saturn", *HindustanTimes.com*, August 26, 2005.
16. Chandra looks back at Earth, sees aurora dance in X-rays, *SpaceFlight Now*, Dec. 29, 2005.
17. *Special Article* on research work carried out by Dr. Anil Bhardwaj at NASA MSFC was published in *NRC Research Associteship Newsletter* Autumn 2005, p. 15 (2005).

1. ***This article made the cover page of Earth in Space, vol.13, No.2, October 2000.***

Editor and Referee Responsibilities:

1. Editor-in-Chief, *Advances in Geosciences,* Volume 3 - Planetary Science, World Scientific Publication, Singapore, 2006.
2. Guest Editor of Journal, *Planetary and Space Science*, Special Issue on "AOGS05: Highlights in Planetary Science", 2007, in press.
3. Editor-in-Chief, *Advances in Geosciences,* Volume 7 - Planetary Science, World Scientific Publication, Singapore, 2007, in press.
4. *Referee*, International Journals - JGR, Icarus, ApJ, ASR, Planetary & Space Sci., GRL, RG, A&A.
5. *Referee*, Indian J. Radio Space Physics.

RESEARCH AND PROFESSIONAL EXPERIENCE :

RESEARCH PROGRAMS:

Experiments:

PI of the joint Indo-Swedish SARA experiment on the first Indian Lunar Mission Chandrayaan-1.
Team Member of soft x-ray telescope of ASTROSAT.
PI of the ENA experiment on the Small Satellite program of ISRO.

Observations:

Radio Observation of Jupiter with GMRT

PI on radio observation of Jupiter using GMRT – Feb. 2003.
Co-PI on the GMRT radio observation of Jupiter – May-June 2007.

X-ray Observation with Chandra, and XMM-Newton Space Observatories

Co-I on Chandra HRC-I Jupiter observation program during Cassini flyby (Dec. 2000).
Co-I on Chandra HRC-I observation program for Jupiter – 2001.
Co-I on Chandra ACIS Jupiter observation program – Feb. 2003.
Co-I on Chandra ACIS Saturn observation – Jan. 2004.
Co-I on Chandra Earth aurora observation – Dec. 2003-April 2004.
Co-I on XMM-Newton Saturn observation program – 2005.
Co-I on joint Chandra-XMM-Newton observation of Jupiter during New Horizon flyby of Jupiter – February-March 2007.

Ultraviolet Observation of Jupiter with Hubble Space Telescope

Co-I on HST-STIS (Jointly with Chandra ACIS) Jupiter observation program – Feb. 2003.

RESEARCH SUPERVISION :

Ph.D.'s produced - 1

Marykutty Michael, 2001. Ph.D. topic "Model for electron degradation and production of emission in the atmosphere of Io".

Ph.D.'s currently supervising - 1

M. Tech. Thesis Supervision - 2

K. Rajmohan, 1994. Dept. of Atmospheric Sciences, Cochin University of Science and Technology. M. Tech dissertation "Electron Excitation of Triton's Atmosphere".
K.B. Smart, 2003. Dept of Physical Oceanography, Cochin University of Science and Technology. M. Tech dissertation "Sputtering of Europa by Jovian Magnetospheric Plasma".

M. Sc. Thesis Supervision – 5

Recognized Research Guide of the Mahatma Gandhi University, and Kerala University.

TEACHING: (outside own laboratory)

1. Lectures on "Planetary Atmospheres and Ionospheres", *PLANEX Workshop* on Meteorites, Asteroids and Planets, Mt. Abu, December 15-18, 2001.
2. Nine lectures on "Atmospheres of Planets and Satellites", delivered to PG students of the *3rd United Nations-CSSTEAP Post Graduate Course* in Space Physics and Atmospheric Sciences, PRL, Ahmedabad, August 26-30, 2002.
3. Lectures on the topics "Planetary Atmospheres" and "Exploration of the Solar System", delivered to teachers from universities and colleges as a part of *UGC-Refresher course in Physics* at Academic Staff College, Univ. of Kerala, during January-February 2002, and November 2002.

4. Lecture on "Planetary atmospheric emissions", *PLANEX Workshop* on Planetary Atmospheres, Ionospheres, and Magnetospheres, SPL, VSSC, Trivandrum, February 17-22, 2003.
5. Lecture on "Satellites of Jupiter and Saturn", *PLANEX Workshop* on Remote Sensing of Planetary Bodies, PRL, Ahmedabad, October 22, 2003.
6. Ten Lectures on "Atmospheres of other Planets and Satellites" delivered to students of the *5th United Nations-CSSTEAP Post Graduate Course* in Space Physics and Atmospheric Sciences, PRL, Ahmedabad, September 12-15, 2006.
7. Two Lectures on "Planetary Physics", delivered to teachers from universities and colleges as a part of *UGC-Refresher course in Physics* at Academic Staff College, Univ. of Kerala, Sept. 19, 2006.
8. Four Lectures on "Structure of Outer Planetary Atmospheres" at *Winter School on Modeling of Planetary Atmospheres*, PRL, Ahmedabad, Dec. 18-20, 2006.
9. Lectures on "Outer Planets and Satellites", *PLANEX workshop*, PRL, Ahmedabad, Jan. 8-9, 2007.

Pubic Outreach:

Delivered several lectures in the area of Planetary and Space Sciences to students and college teachers as part of Space Week program of VSSC, and has given invited lectures at collages in Trivandrum to students of B.Sc. and M. Sc.
Regular lecturer at the *UGC Refresher course in Physics* at the Academic Staff College, University of Kerala, and has delivered lectures on Planetary Physics, Planetary Atmospheres, and Exploration of the Solar System.

Conference/Workshop Organized:

National

1. **Co-Convener**, *22nd Meeting of Astronomical Society of India*, Feb. 13-15, Trivandrum, 2003.
2. **Organizer**, *PLANEX workshop* on "Planetary Atmospheres, Ionospheres, and Magnetospheres", Feb 17-22, SPL, VSSC, Trivandrum, 2003.
3. **Co-Convener**, PS-3, *XIV National Space Science Symposium-2006*, Andhra University, Visakhapatnam, 9-12 February 2006.

International

1. **Convener**, Session SP18 on "Planetary Upper Atmospheres and Ionospheres and their coupling with Magnetospheres", *AOGS First Annual Meeting*, Singapore, July 5-9, 2004.
2. **Convener**, Session P02: "X-rays From The Solar System And Beyond"**,** *AGU 2005 Spring Meeting*, 23-27 May 2005, New Orleans, Louisiana, USA.
3. **Convener**, Session PS04 on "Planets, Comets, and Satellites: Surface, Atmosphere, Ionosphere System and coupling with Magnetosphere", *AOGS 2nd Annual Meeting*, Singapore, June 20-24, 2005.
4. **Co-Convener**, Session on "Comparative Magnetospheres", *AOGS 2nd Annual Meeting*, Singapore, June 20-24, 2005.
5. **Convener**, Session PS03-ST12 on "Comparative Planetary Atmospheres, Ionospheres and Magnetospheres", *AOGS 3rd Annual Meeting*, Singapore, July 10-14, 2006.
6. **Co-Convener**, session PS05-ST18, "Future Space Missions and Instrumentation for Planetary and Space Sciences", AOGS *3rd Annual Meeting*, Singapore, July 10-14, 2006.
7. **Convener**, Session PS04-ST07 on "Comparative Planetary Atmospheres, Ionospheres and Magnetospheres", *AOGS 4th Annual Meeting*, Bangkok, Thailand, July 30-Agust 4, 2007.
8. **Co-Convener**, Session PS12 on "Moon: Science and Exploration", *AOGS 4th Annual Meeting*, Bangkok, Thailand, July 30-Agust 4, 2007.

Invited Lectures/Colloquium at Institutes: (Abroad - Recent)

1. "Auroral Radiation of Jupiter", *Swedish Institute of Space Physics*, Kiruna, Sweden, May 30, 2002.
2. "Space Program of India", *Swedish Institute of Space Physics*, Kiruna, Sweden, May 31, 2002.
3. "The Indian Space Program", *Institut d'Astrophysique et de Géophysique*, Université de Liège, Liège, Belgium, June 10, 2002.
4. "X-Rays from Solar System Bodies", *Rutherford Appleton Laboratory*, Chilton, Oxford, UK, October 7, 2002.
5. "Solar System X-rays", *University of Virginia*, Charlottesville, VA, USA, October 10, 2002.
6. "Indian Space Program", *Southwest Research Institute*, San Antonio, TX, USA, October 23, 2002.
7. "Remote Sensing of Solar System Bodies in Soft X-Rays", NSSTC Space Science Colloquium, *NASA Marshall Space Flight Center*, Huntsville, AL, USA, September 24, 2004.
8. "X-rays from the Jupiter and Saturn Systems", *Jet Propulsion Laboratory*, Pasadena, CA, USA, December 9, 2004.
9. "Low Energy Neutral Atom (LENA) Imaging of the Moon Environment", *California Institute of Technology*, Pasadena, CA, USA, December 10, 2004.
10. "X-Rays from the Solar System Bodies", *Joint CSP-IAR Colloquium*, *Boston University*, Boston, MA, USA, February 15, 2005.
11. "Chandrayaan-1 Mission and the SARA Experiment", *Mullard Space Science Laboratory*, University College London, UK, August 5, 2005.
12. "X-rays from Saturnian System", *Mullard Space Science Laboratory*, University College London, UK, August 5, 2005.

Invited Lectures/Colloquium at Institutes: **(in India)**

1. "Comet Solar Wind Interactions", *Physical Research Laboratory*, Ahmedabad, Oct. 1996.
2. "Auroral Emissions of Jupiter", *Physical Research Laboratory*, Ahmedabad, Dec. 2001.
3. "Multi-spectral Aurora on Jupiter", *National Center for Radio Astronomy*, Pune, Dec. 2001.
4. "Multi-wavelength Observations of Jupiter", *Raman Research Institute*, Bangalore, May 2002.

Professional Responsibilities:

International

- *President*, Planetary Science Section of Asia Oceania Geosciences Society (AOGS).
- *Proposal Evaluator*, NASA Planetary Sciences Program.
- *Team Leader*, International Heliophysical Year - Coordinated Investigation Program "Universality of Auroral Structure".
- *Member*, Scientific Program Committee, 4th AOGS Meeting, Bangkok, July 31-Aug. 4, 2007.
- *Member*, American Geophysical Union.
- *Member*, Division of Planetary Sciences of American Astronomical Society.
- *Member*, Comparative Aeronomy in the Solar System Group.
- *Associate* of COSPAR.

National

- *Member*, Space Generation Task Group "Space Sciences and Interplanetary Missions" of ISRO - Vision 2000-2025.
- *Member*, ADCOS Science Panel 3, Planetary Exploration Program of ISRO.

- *Member*, PLANEX Research Program, a National Planetary Exploration Program of ISRO.
- *Core Team Member*, SENSE small satellite program of ISRO.
- *Member*, Key Project Working group of ASTROSAT.
- *Core Team Member*, Mars Mission proposal of ISRO.
- *Life Member*, Kerala Academy of Sciences.
- *Life Member*, Astronomical Society of India.

Professional Services and Activities:

- *Secretary*, Planetary Sciences, Asia Oceania Geosciences Society (2004-2005).
- *Member Evaluation Committee*, Outstanding student paper awards, AGU Fall 2004 Meeting, San Francisco, USA, 2004.
- *Contributor, International Astronomical Union Report* 2002-2005 on Commission 15: Physical Studies of Comets and Minor Planets.
- *Member*, LOC "Workshop on CAWSES India", October 2003, SPL, VSSC, Trivandrum.
- *Executive Me*mber, Indian Space Scientist Association, 2001-2002.
- *Member*, LOC "Workshop on Equatorial Aeronomy", Sept. 1996, SPL, VSSC, Trivandrum.
- *Member*, LOC "National Space Science Symposium" Dec. 1994, VSSC, Trivandrum.
- *Member*, LOC symposium "Advances in Planetary Physics", December 1987, Department of Applied Physics, Institute of Technology, Banaras Hindu University.
- *Member,* Experts Panel of Kerala Academy of Sciences for selection of students for "Red Rover Goes to Mars" competition organized by Planetary Society of USA.
- Generated Posters on (1) "The Sun" and (2) "Solar System" for VSSC Space Museum.
- Participation in Technical Hindi Workshops organized by VSSC and ISRO.
- *Joint Secretary*, Indian Space Scientist Association, 1995-2000.
- *Vice-President*, Lucknow University Physics Association, 1986-1987.

Laboratory Responsibilities:

- *Member,* VSSC Selection Committee for Junior Research Fellows.
- *Member*, Academic Committee of Space Physics Laboratory.
- *Coordinator*, preparation of Poster Panels of the SPL for Space Museum of VSSC.
- Coordinating/projecting new building requirements of SPL.
- *Focal Person*, Website of SPL.

Collaborative Research Programs :

Very vigorous collaborative research programs with several scientists from different institutions in USA, Europe and Asia. Areas of collaborative research span a wide range of topics, which are mentioned below along with collaborating institutions in bracket.

(1) Planetary X-ray Astronomy (NASA Marshall Space Flight Center; Southwest Research Institute, USA; Mullard Space Science Laboratory, UK; University of Kansas; Max-Planck-Institut fur Extratressestrische Physik, Germany; XMM-Newton SOC, Spain; University of Bergen, Norway; Harvard-Smithsonian Center for Astrophysics; Massachusetts Institute of Technology; Applied Physics Laboratory-Johns Hopkins University; Lawrence Livermore National Laboratory; NASA Goddard Space Flight Center).

(2) ENA Imaging and instrumentation (Swedish Institute of Space Physics, Sweden; ISAS/JAXA, Japan; University of Bern, Switzerland; ISRO Satellite Centre).

(3) Cometary emissions and modeling (Physical Research Laboratory; Banaras Hindu University; INAF Istituto di Astrofisica Spaziale e Fisica Cosmica (IASF), Italy; Padua Observatory, Italy).

(4) Io-Jupiter Interactions (Observatoire de Paris, France; Southwest Research Institute, USA; LPAP, University of Liege, Belgium).

(5) Electron Impact cross sections and Applications (Jet Propulsion Laboratory, USA).

(6) Comparative Planetary Aeronomy and Future Missions (Physical Research Laboratory, University College London, UK; University of Calgary, Canada; Boston University, USA; JAXA/ISAS, Japan; INAF Istituto Nazionale di Astrofisica, Italy).

(7) Radio Emissions of Jupiter (National Center for Radio Astronomy; Raman Research Institute; Tohoku University, Nagoya University, Japan).