

Bhas Bapat, Curriculum Vitae

June 2016

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Date of Birth: 10 August 1970

Academic Track

- Dean (Academic Affairs), IISER Tirupati (additional charge at IISER Pune)
since Aug 2015
- Associate Professor at IISER Pune (on lien from PRL Ahmedabad)
since Jul 2014
- Associate Professor at IISER Mohali (on sabbatical leave from PRL Ahmedabad)
Jan–May 2012
- Faculty member at Physical Research Laboratory, Ahmedabad
Associate Professor since Jul 2009
Reader Jul 2004 to Jun 2009
Scientist-D Dec 2001 to Jun 2004
- Visiting Scientist at Centre for Advanced Technology, Indore
Dec 2000 – Oct 2001
- Post-doctoral fellow, Fakultät für Physik, Albert-Ludwigs-Universität, Freiburg, Germany
Jan 1998 – Oct 2000
- Ph D from Tata Institute of Fundamental Research (Mumbai University); thesis entitled “Two-electron processes in collisional ionisation”
Dec 1997
- MSc in Physics from Indian Institute of Technology, with first rank in the class
May 1992
- BSc in Physics with Mathematics and Statistical Techniques as subsidiary subjects from Pune University with Distinction
Jun 1990

Awards

1. S N Seshadri Memorial Instrumentation Award for the Year 2006, by the Indian Physics Association.
2. Prof S N Ghosh Young Scientist award of the Indian Society for Atomic and Molecular Physics at the XIV National Conference on Atomic and Molecular Physics, Santiniketan, January 2003.
3. Best Thesis award of the Indian Physics Association, at the XIIth National Conference on Atomic and Molecular Physics, Udaipur, January 1999.
4. Silver Medal for the first rank at the Master of Science programme at Indian Institute of Technology, Mumbai, May 1992.

Research

Recent Past

The main focus of my work in the last ten years has been on performing kinematically complete experiments to understand dissociative ionisation. Such experiments help in establishing the energetics and the pathways of dissociation of multiply ionised molecular ions. Depending on the details of the measurement, further information, such as lifetimes of metastable ions and symmetries and geometries of the dissociation precursors can be determined.

Experiments were mostly done on simple molecules such as CO, CO₂ and SO₂. These demonstrated the strength of the technique. In case of CO₂, experimental measurement of fragment kinetic energy distributions, and theoretical studies in collaboration with IIT-Kanpur, helped us identify the excited states leading to dissociation and lifetimes of dicationic states. In the case of larger molecules, (SF₆, CCl₄, CH₄, alcohols) we observed a large number of dissociation pathways, and in a few cases, observed rearrangement of atoms within the molecule, leading to association between atoms spread across various sites within a molecule. Angular distributions of fragment ions have enabled us to estimate the geometry of precursor molecular ion, and deviations from the geometry of the ground neutral state, taking place during dissociative ionisation.

Besides the electron-impact work, we have done similar experiments using photons and ion beams as projectiles. These experiments have been done at the Centre for Advanced Technology, Indore, and at Inter-University Accelerator Centre, Delhi, respectively. My group was the first external user group to initiate and accomplish a project at the Indus-1 synchrotron, and also the first group in the country to perform gas-phase photoionisation experiments there. Photoionisation experiments brought out the effectiveness of the ion momentum imaging technique, highlighted by the determination of a molecular axis orientation dependence in photo-triple ionisation and fragmentation of CO₂, and establishing the dissociation pathways of SF₆³⁺.

As the next step in these investigations, we built an advanced version of the apparatus to detect, and determine the energies of, the electrons emitted in the ionisation

process, besides correlated ion momenta, giving us complete kinematics with shell-specificity in the dissociative ionisation process. The complexity of this experiment is far greater than that for ion analysis alone. These experiments enabled us to pinpoint shell excitations and their influence on the subsequent break-up patterns in dissociative photoionisation of molecules.

Current and Near Future

Aditya L1 Solar Mission My group at PRL is developing an instrument to fly on the 2018 solar mission of ISRO. The payload, called ASPEX, consists of two instruments. An ion spectrometer called SWIS (for Solar Wind Ion Spectrometer) designed to obtain simultaneous species, kinetic energy and direction information of solar wind particles (protons, alpha particles and other ions in the energy range 1–20 keV) and a Suprathermal Energy Particle Spectrometer (STEPS) which is a proton energy analyser. SWIS is based on an electrostatic energy analyser with a ramped field, a permanent magnetic mass analyser and a position-encoding detector. STEPS is based on stopping of protons in a silicon detector combined with pulse height analysis of the secondary charges.

A proof of principle demonstration of this instrument has been accomplished. A prototype of this instrument was designed and fabricated with assistance from the Space Applications Centre, Ahmedabad. A revised version of the spectrometer with improved performance is currently being fabricated and assembled. The electronic circuitry for detector readout and data processing is being developed at PRL.

A grant of Rs 12.30 cr has been sanctioned for the realisation of this payload by ISRO in Dec 2015. A proposal for setting up of a test facility for the qualifying model of the payload has been submitted to ISRO, under the RESPOND programme. I am the co-investigator for the SWIS payload, and a member of the Working Group of the mission.

Low energy ion–molecule collisions We are working on improving an earlier apparatus for studying energy-selective dissociative ionisation of molecules by a combination of electron spectroscopy and ion–momentum spectrometry. The apparatus is being developed at IISER and the experiments are planned at the Low Energy Ion Beam Facility at Inter-University accelerator Centre, Delhi (beam time sanctioned in Feb 2016). A similar series of experiments has been proposed with the SPARC project (Stored Particle Atomic Physics Research Collaboration) at the Gesellschaft für Schwerionenforschung, Darmstadt, Germany, under a DST/DAE–DFG joint programme. The main goal of this collaboration is to explore non-perturbative domains of scattering by performing kinematically complete dissociative ionisation experiments on molecules. The Delhi facility and the Darmstadt facility will provide complementary perturbative domains, on account of the different operating conditions and ion beam types in terms of the charge state, velocity and time structure and luminosities.

Positron Scattering A project for the investigation of positron and positronium scattering with molecules was proposed at IISER Pune. Electrons and positrons scatter

differently from atoms molecules because of the difference in their charge, and this is theoretically well understood with fair experimental evidence in support. Intriguingly, however, the positronium – which is a bound state of a positron and an electron – has been found to scatter from molecules *in a manner similar to electrons*. The reason for this is not understood. Since positron and positronium sources are scarce, verification and validation of experimental data is a hurdle, and experiments continue to show interesting features.

Advanced Undergraduate Experiments At IISER Pune I have begun a programme to develop laboratories for undergraduate teaching that encompass not only setting up interesting and challenging experiments to be done as part of the normal courses, but also re-building classic experiments that form the bedrock of modern science, for interpretation by undergraduate students as well as the general public.

Collaborations

- At the Indus-1 synchrotron in RRCAT, Indore, for studying photoionisation of atoms and molecules, in collaboration with Dr G S Lodha. The program was later expanded to perform momentum imaging of molecular fragmentation, in collaboration with Prof P C Deshmukh of IIT-Madras
- In collaboration with the group of Dr C P Safvan at the Inter-University Accelerator Centre, Delhi, we perform ion–molecule collision studies. We are making an attempt to attract more atomic/molecular physics users at the accelerator, and have conducted two workshop for this purpose.
- The programme on cluster formation by laser ablation was carried out in collaboration with the laser spectroscopy group at Institute for Plasma Research.
- In the past I have collaborated with Prof N Sathyamurthy (IIT Kanpur and IISER Mohali) and Dr Shamasundar (IISER Mohali) and Prof S V K Kumar (TIFR, Mumbai) on theoretical work concerning dissociation dynamics of molecular dications.
- Development of the Solar Wind Ion Spectrometer at PRL, Ahmedabad, is currently underway in collaboration with Space Applications Centre, Ahmedabad.

Thesis Supervision

At IISER Pune I have two int-PhD and one PhD students. During my tenure at PRL five candidates have obtained their Ph D degree under my supervision:

- Vandana Sharma (Ph D 2007, now Assistant Professor at IIT-Hyderabad)
- Rajesh Kushawaha (Ph D 2010, now Reader, PRL Ahmedabad)
- Arvind Saxena (Ph D 2014, now post-doc fellow POSTECH, Korea)

- Koushik Saha (Ph D 2014, now faculty member at PRL, Ahmedabad),
- Amrendra Pandey (Ph D 2015, now post-doc fellow at Raman Research Institute Bangalore).

Besides these candidates, S Sunil Kumar of IIT Madras worked with me in a collaborative project leading to his Ph D thesis in 2010, and is now post-doc fellow at Max-Planck-Institute for Nuclear Physics, Heidelberg, Germany.

Rajesh Kumar Singh, (Ph D 2002 from BHU), worked as a post-doctoral fellow with me and is now a faculty member at Institute of Plasma Research, Gandhinagar.

Teaching and Allied Experience

I have been teaching both laboratory and theory courses in the first two years of the BS-MS programme at IISER Pune.

I taught an elective course in Atomic Collisions and Spectra at IISER Mohali in Spring Semester 2012.

I taught at the graduate school course which all students joining PRL for Ph D have to undergo.

I taught at the Advanced B Sc programme of the Community Science Centre and the Gujarat Science Academy, Ahmedabad. I was member of the core group organising and planning this programme since 2005. It has been variously run as an year-long Sundays-only programme and as intensive, residential programme for a few weeks during the college vacations.

During my post doctoral stint in the University of Freiburg, Germany, I worked as Demonstrator for post-graduate laboratory courses (in German).

I co-directed a Department of Science and Technology sponsored training school on Atomic and Molecular Physics for Ph D students, and have taught in this and other SERC schools on atomic and molecular physics.

I work with *Eklavya*, an organisation based at Bhopal working on improving science curricula and teaching methods in schools. I have conducted teachers' workshops, and have been involved in the writing of learning-by-doing modules for high school science teachers and students being developed by that organisation. I am the primary author of the module on Heat and Temperature, and a contributor to modules on Motion, Nature of Matter, Light, and Electricity.

I am team member of the Connected Learning Initiatives (CLIX) project launched by the Tata Trusts, MIT and Tata Institute of Social Sciences last year. This is a multi-institution project that foresees the use of computers and the internet to enhance the learning experience of high school students. The project is in partnership with four state education boards: Chattisgarh, Rajasthan, Telangana and Mizoram, and is slated for a roll out in these states in August on a pilot scale.

At IISER Pune I have conducted several short programmes and given public talks for science popularisation and outreach aimed at students and the general public. These were under the aegis of different voluntary organisations as well as IISER Pune. I also co-organised a workshop on Science Education for students at IISER Pune.

Auxiliary Responsibilities

Academic

I have been a member on panels setting screening tests at the national level for Ph D and other higher education programmes for the last eight years (CSIR–NET and IIM–CAT).

I am on the Editorial Board of the e-journal *Physics Education* of the Indian Association of Physics Teachers.

I have refereed papers for *Journal of Chemical Physics*, and AIP Advances. I have reviewed several project proposals for DST-SERC and ISRO-Respond, BRNS and other research funding schemes from time to time. I have been an external examiner for several Ph D theses.

Organisation of Meetings, Training Programmes etc.

- Co-convener of XV National Conference of the Indian Society of Atomic and Molecular Physics, Dec 2004.
- Advanced BSc programme, Gujarat Science Academy and Vikram Sarabhai Community Science Centre, 2005 onwards.
- National Science Day: Open House, Quiz and Scholarship Examination of the Aruna Lal Foundation at PRL, every year from 2002 to 2008.
- DST-SERC school on Experimental Techniques in Atomic and Molecular Physics, Apr 2009.
- I have served on the executive committee of the Indian Society of Atomic and Molecular Physics for several terms.

Publications

- [1] Probing high-lying N_2^{++} and CO^{++} states via energy-selective fragment spectra
A. Pandey, K. Saha, B. Bapat, P. Kumar, S. B. Banerjee, K. P. Subramanian
Journal of Physics B **49** 135102 (2016)
- [2] Electron-impact dissociative double ionization of N_2 and CO : Dependence of transition probability on impact energy
A. Pandey, P. Kumar, S. B. Banerjee, K. P. Subramanian, and B. Bapat
Physical Review A **93** 042712 (2016)
- [3] State selective fragmentation kinematics of OCS^{2+} following $S(2p)$ Auger decay
K. Saha, S. B. Banerjee, B. Bapat
Chemical Physics Letters **607** 85–91 (2014)
- [4] Dissociation of OCS by high energy highly charged ion impact
Mridula Rani Jana, Pradip N. Ghosh, Biswajit Ray, Bhas Bapat, Rajesh Kumar Kushawaha, Koushik Saha, Ishwar A. Prajapati, C. P. Safvan
European Physical Journal D **68**:250 (2014)
- [5] Dissociation of OCS upon various $S(2p)$ Auger decay transitions
K. Saha, S. B. Banerjee and B. Bapat
Journal of Physics: Conference Series **488** 012020 (2014)
- [6] Effect of transmission losses on measured parameters in multi-ion coincidence momentum spectrometers
Amrendra Kumar Pandey and Bhas Bapat
International Journal of Mass Spectrometry **361C** 23 (2014)
- [7] Three body dissociation of CS_2^{2+} subsequent to various $S(2p)$ Auger transitions
K Saha, S B Banerjee and B Bapat,
Journal of Chemical Physics **139** 164309 (2013)
- [8] Charge Symmetric Dissociation of doubly-ionized N_2 and CO molecules
Amrendra Pandey, B. Bapat, K. R. Shamasundar,
Journal of Chemical Physics **140** 034319 (2014)
- [9] Dependence of ion kinetic energy and charge on cluster size in multi-photon ionisation of xenon clusters
Arvind Saxena, Prashant Kumar, S B Banerjee, K P Subramanian, B Bapat,
International Journal of Mass Spectrometry **357** 58 (2014)
- [10] A combined electron-ion spectrometer for studying the complete kinematics of molecular dissociation upon shell selective ionization
K. Saha, S. B. Banerjee, B. Bapat,
Review of Scientific Instruments **84** 073101 (2013)

- [11] Optical spectroscopy of carbon clusters produced in a hollow cathode source
Arvind Saxena, Prashant Kumar, S. B. Banerjee, K. P. Subramanian and B. Bapat,
Spectroscopy Letters DOI: 10.1080/00387010.2013.783872 (2013)
- [12] Ion-induced triple fragmentation of CO_2^{3+} into $\text{C}^+ + \text{O}^+ + \text{O}^+$
M. R. Jana, P. N. Ghosh, B. Bapat, R. K. Kushawaha, K. Saha, I. A. Prajapati, and
C. P. Safvan,
Physical Review A **84** 062715 (2011)
- [13] Similarities in Kinetic Energy Distributions of Associative Fragments during
Dissociative Ionization of Organic Molecules
Bhas Bapat and Rajesh K. Kushawaha,
Journal of the Korean Physical Society **59** 2905 (2011)
- [14] Triple F^+ ejection from SF_6 bombarded by swift ions
R K Kushawaha, S Sunil Kumar, M R Jana, I A Prajapati, C P Safvan and B Bapat,
Journal of Physics B **43** 205204 (2010)
- [15] Polarisation dependence in non-resonant photo-triple-ionisation of CO_2
R K Kushawaha, S Sunil Kumar, I A Prajapati, K P Subramanian and B Bapat,
Journal of Physics B **42** 105201 (2009)
- [16] Breakup of the SF_6^{3+} photoion revealed by momentum correlation between
fragments
S. Sunil Kumar and P. C. Deshmukh, R. K. Kushawaha, V. Sharma, I. A. Prajapati,
K. P. Subramanian, and B. Bapat,
Physical Review A **78** 062706 (2008)
- [17] Dissociative states of SF_4^{2+} probed by fragment momentum spectroscopy
B. Bapat, Vandana Sharma and S. V. K. Kumar,
Physical Review A **78** 042503 (2008)
- [18] Fragmentation dynamics of the methanol dication
R.K. Kushawaha and B. Bapat,
Chemical Physics Letters **463** 42–46 (2008)
- [19] Dissociative Double Ionization of CO_2 : Dynamics, Energy Levels and Lifetime
Vandana Sharma, B Bapat, Jagannath Mondal, M Hochlaf, Kousik Giri, and N
Sathyamurthy,
Journal of Physical Chemistry **111** 10205–10211 (2007)
- [20] Alteration of molecular symmetry during dissociative ionization
Vandana Sharma and Bhas Bapat,
Physical Review A **75** 040503R (2007)
- [21] Bent dissociative states of CO_2^{2+}
B Bapat and Vandana Sharma,
Journal of Physics B **40** 13–19 (2007)

- [22] Determination of active sites for H atom rearrangement in dissociative ionisation of ethanol
Vandana Sharma and B Bapat,
Journal of Chemical Physics J. Chem. Phys. **125** 044305 (2006)
- [23] Triply charged carbon-dioxide molecular ion: formation and fragmentation
R K Singh, G S Lodha, Vandana Sharma, I A Prajapati, K P Subramanian and B Bapat,
Physical Review A **74** 022708 (2006)
- [24] Mean kinetic energy of molecular fragment ions from time-of-flight and momentum analysis
B Bapat and V Sharma,
Int. Journal of Mass Spec. **251** 10–15 (2006)
- [25] An apparatus for studying momentum-resolved electron-impact dissociative and non-dissociative ionisation
V Sharma and B Bapat,
European Physical Journal D **37** 223–229 (2006)
- [26] First results from gas-phase photoionization experiments at Indus-1 B Bapat, R K Singh, K P Subramanian, G S Lodha,
Radiation Physics and Chemistry **74** 71–75 (2005)
- [27] Physics with highly-charged ions in an EBIT Source J R Crespo López-Urrutia, B. Bapat, I. Draganic, B. Feuerstein, D. Fischer, H. Lörch R. Moshhammer, J. Ullrich, R. Dubois, Y. Zou,
Hyperfine Interactions **146** 109-113 (2003)
- [28] Projectile-Charge Sign Dependence of Four-Particle Dynamics in Helium Double Ionization
D. Fischer, R. Moshhammer, A. Dorn, J. R. Crespo López-Urrutia, B. Feuerstein, C. Höhr, C. D. Schröter, S. Hagmann, H. Kollmus, R. Mann, B. Bapat, and J. Ullrich,
Physical Review Letters **90** 243201 (2003)
- [29] First results from the freiburg electron beam ion trap FreEBIT
López-Urrutia J R C, Bapat B, Draganic I, Werdich A, Ullrich J,
Physica Scripta **T92** 110–112 (2001)
- [30] First results from the Freiburg Electron Beam Ion Trap
J. R. Crespo López-Urrutia, B. Bapat, B. Feuerstein, A. Werdich, J. Ullrich,
Hyperfine Interactions **127** 97–501 (2000)
- [31] Double ionisation of helium in fast ion collisions: comparative study of model wavefunctions
S. Keller, B. Bapat, R. Moshhammer, R. Mann, J. Ullrich, R. M. Dreizler,
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B. Bapat, R. Moshhammer, S. Keller, R. Mann, J. Ullrich,
Journal of Physics B **33** 1437–1446 (2000)
- [33] Kinematically complete ion-atom collision experiments: Ionization of atoms in strong fields
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- [35] Atoms in extreme virtual fields of fast, highly charged ions
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- [44] The dynamics of the formation of S₂⁺ from CS₂ by electron impact
K. Nagesha, V. R. Marathe, E. Krishnakumar and Bhas Bapat,
Chemical Physics Letters **230** 283–289 (1994)
- [45] Dissociative Ionization of H₂ by fast fully stripped ions
E. Krishnakumar, Bhas Bapat, F. A. Rajgara and M. Krishnamurthy,
Journal of Physics B **27** L777–L784 (1994)
- [46] Capillary Array as an Effusive Molecular beam Source for High Resolution Recoil Ion Momentum Spectrometry
Bhas Bapat and E. Krishnakumar, *Zeitschrift für Physik D* **31** 1–4 (1994)