SUBRATA CHAKRABORTY

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RESEARCH EXPERTISE:

I am a physicist by education and a laboratory astrophysicist by training. Through experimental simulation studies, my goal is to understand the formation and evolution of our solar system, the distribution, and evolution of volatiles in different planetary bodies and their connection to the origin of life.

EDUCATION

2004 **Physical Research Laboratory & Gujarat University** Ahmedabad, India
- Ph.D. in PHYSICS

Dissertation: "Anomalous fractionation of oxygen isotopes in photochemical reactions"
Advisor: Prof. S. K. Bhattacharya

1996 **Jadavpur University** Kolkata, India
- Master of Science (MSc) in PHYSICS
- Minor in ELECTRONICS

Dissertation: "Design and fabrication of a Multi-Channel Analyzer for radioactive counting"
Advisor: Dr. M. Trivedi

1993 **Katwa College, The University of Burdwan** Burdwan, India
- Bachelor of Science (BSc) in PHYSICS
- Minor in Mathematics and Chemistry

2017- 18 **University of California, San Diego Extension** San Diego, USA
- **Executive Certification** in "Effective leadership and teamwork in the workplace"

Leadership and teamwork as experienced in a professional setting were explored in an expansive manner through a deep understanding of who I am: my desires, motivations, strengths and weaknesses and how to orient myself in Organizational Behavior, Organizational Psychology, and Organizational Development.

o "***Project Management for the Collaborative workplace"***

The course covered the basics of Project Management. It also covered a great detail about project management in a collaborative framework.

o ***Practicum: "IdeaWave Market Research Project"***

Performed a market research study to investigate the reasons behind low faculty engagement in the IdeaWave crowdsourcing tool compared to the other groups (student and staff). Developed a research-based marketing plan and recommendations for the improvement.

APPOINTMENTS

- Project Scientist, Department of Chemistry and Biochemistry, University of California, La Jolla, CA, USA, July 2018– Present.
- Temporary Lecturer in Physics, University of California, San Diego, La Jolla, CA, USA. Summer 2018.
- Associate Project Scientist, Department of Chemistry and Biochemistry, University of California, San Diego, CA, USA, 2014 – June 2018.
- Assistant Project Scientist, Department of Chemistry and Biochemistry, University of California, San Diego, CA, USA, 2009 – 14.
- Postdoctoral Researcher, Department of Chemistry and Biochemistry, University of California, San Diego, CA, USA, 2008 – 09.
- Academic Faculty (as Reader in *Planetary Science and Exploration Program, PLANEX)*, Physical Research Laboratory, Ahmedabad, India, 2007 – 08.
- Postdoctoral Researcher, Department of Chemistry and Biochemistry, University of California, San Diego, CA, USA, 2003 – 07.

- Postdoctoral Researcher, Planetary and Geosciences Division, Physical Research Laboratory, Ahmedabad, India, 2002 – 03.
- Project Associate, Planetary and Geosciences Division, Physical Research Laboratory, Ahmedabad, India, 1996 – 98.

GRANTS

EXTERNAL FUNDING

Co-Investigator (Science), 2005 - 2010

NASA Funded Grant: Determination of solar wind oxygen and sulfur isotopic composition from CVD Diamond and SiC/ Fz-silicon wafers from the concentrator of the Genesis return mission and other collection surfaces by Isotope Ratio Mass Spectrometry (NNH08ZDA001N-SRLIDAP, $482,698)

Principal Investigator 2007 – Present

Advanced Light Source (LBNL), Berkeley

Project: VUV photodissociation of CO, N_2, and Sulfur-containing molecules

Co-Investigator (Science), 2007 - 2010

NASA Funded Grant: Origin of Meteoritic Oxygen Isotopic Anomalies: Experimental Testing of Chemical and Self Shielding Mechanisms (NNX07AJ81G, $228,000)

Co-Investigator (Science), 2009 - 2014

NASA Funded Grant: Multi-isotope study of oxygen and sulfur from meteorite samples and laboratory experiments run to understand the formation and evolution of early solar system (NNH08ZDA001N-COS, $405,011)

Co-Principal Investigator/ Science-PI, 2010 - 2014

NASA Funded Grant: Determination of photochemical isotopic fractionation factors in oxygen and nitrogen in the VUV photodissociation of carbon monoxide, N_2 and other nitrogen bearing species and their relevance to meteoritic observations (NNH09ZDA001N-SSO, $334,927)

Co-Principal Investigator/ Science-PI, 2012

NASA Funded Grant: Determination of Solar Wind oxygen and Sulfur Isotopic Composition from SiC Wafers from the Concentrator of the Genesis Discovery Mission by Stable Isotope Ratio Mass Spectrometry with Laser Fluorination (NNH11ZDA001N-LARS, $100,000)

Co-Principal Investigator/ Science-PI, 2014-2017

NASA Funded Grant: Understanding the formation and evolution of the early solar system: A multi-isotope study of oxygen and sulfur from laboratory-based experiments and meteorite samples (NNH13ZDA001N-COS, $330,000)

Collaborator, 2010-2015

NSF Funded Project: He-Ne-Ar-N2-CO2 Isotope Characterization of the East Africa Rift System (Award # 1019489)

Co-PI/ Science-PI, 2015-2018

NASA Funded Grant: Determination of photochemical isotopic fractionation factors in nitrogen and carbon in the VUV/ UV photodissociation of N_2, and other nitrogen bearing species, and carbon monoxide and their relevance to meteoritic observations (Emerging Worlds, $400,000)

Co-PI/ Science-PI, 2015-2019

NASA Funded Grant: Determination of Solar Wind oxygen and Sulfur Isotopic Composition from SiC Wafers from the Concentrator of the Genesis Discovery Mission by Stable Isotope Ratio Mass Spectrometry with Laser Fluorination (LARS, $225,000)

Co-PI/ Science-PI, 2019-2022 (Pending)

NASA Funded Grant: Determination of Solar Wind oxygen and Sulfur Isotopic Composition from SiC Wafers from the Concentrator of the Genesis Discovery Mission by Stable Isotope Ratio Mass Spectrometry with Laser Fluorination (LARS, $431,902)

Co-PI/ Science-PI, 2019-2022 (Pending)

NSF Funded Grant: Development of Synchrotron-based THz and Mid-IR Spectrometer for In-situ Determination of Isotopic Fractionation in VUV Photodissociation of Molecules of Astrophysical Interest (NSF FastLane, $783,121)

RESEARCH EXPERIENCE
09 – Present

Project Scientist
University of California, San Diego, La Jolla, California

• Science-Principal investigator of multiple NASA funded research projects, resulting in more than 10 first author research publications including **3 in Science Magazine** and **3 in the Proceedings of the National Academy of Sciences (PNAS)**.

• Wrote over 10 research grant proposals resulting in being awarded over **$2.2 M** research funds through NASA solicitations.

• Project management of the NASA Genesis mission's UCSD assignment which is to determine and analyze the composition of the sun and 5 other NASA funded projects to study the chemical evolution of our solar system.

Managed a budget of $2.2 M, communicated finance and policy to campus grant office, recruited research assistants, data interpretation, reporting to the funding agency and in technical conferences, publishing in peer-reviewed journals, managed data and developed accessibility protocol to comply with the funding agency.

• Designed, prototyped, tested, arranged for the manufacturer, and deployed 3 complicated devices designed to do the following tasks:

- Designed and partly fabricated an instrument to extract embedded solar wind particles in the Genesis (spacecraft) collector using an UV laser.
- Designed and fabricated an integrated liquid nitrogen (LN2) cryostat and a chemical vapor deposition (CVD) unit to study the surface oxidation reactions possible in the astrophysical environment. The design of this apparatus was very conceptual where cooling of a substrate surface at LN2 temperature and operating a heater at 1600 C to evaporate rock samples inside a small vacuum chamber at the same time was needed. The biggest problem was that the high-temperature heater was heating the wall of the chamber and affecting the vacuum. This issue was solved by designing a water-flow cooling system. To know the lattice structure of the deposited thin film and the transformed mineral phases after oxidation, I inserted a TEM grid on top of the cold collection plate and performed TEM analysis afterward. To know the stoichiometry and I performed SEM/EDX analysis to image the minerals as well as the composition using an environment SEM, where the samples were directly loaded on SEM sample holder with double-sided tape.
- Designed and fabricated a 'coupling unit' to introduce vacuum-UV light from an ultra-low vacuum synchrotron (Advanced Light Source, ALS) beamline into a gas-filled reaction chamber. The coupling was designed with a three-stage 'differential pumping' units internally connected through small apertures, thus the gas from high-pressure sides gradually gets pumped off in each stage and achieve high-vacuum where connected to the beamline. The apertures are aligned to introduce the photons inside the chamber.

• Design 8 Original Standard Operating Procedures (SOPs) and safety protocols, implemented strategic safety protocols, trained employees to follow and reduce risk, waste, and costs

• Designed and executed the following innovative experiments to simulate the condition of the solar nebula to understand the physics and chemistry of the solar system:

- High-temperature gas-phase oxidation of silicates in nebular condition to understand the oxygen isotopes in the meteorites. The major problem was to create silicon in the vapor phase. That problem was solved by adopting continuous laser ablation of the silicon substrate to create a steady-state gas-phase concentration inside a small vacuum chamber. Initially, the results are hard to understand and puzzling. To solve this, I have mathematically simulated the reactions by developing a Matlab code and was able to decipher different reaction channels. The results are published in **Science**, and we showed for the first time that symmetry dependent recombination reactions could produce meteorite-like mass-independent oxygen isotopic composition and a probable reaction in the solar nebula.
- Simulation of the photochemical environment in the outer solar nebula to study the photochemical evolution of nitrogen using the vacuum-UV photons from ALS

synchrotron. The results have implications for Titan's and other planetary bodies and the formation of organic materials and are published in the **Proceedings of the National Academy of Sciences**. The major technical issue of this study was to capture the photochemically produced atomic nitrogen. The solution I have adopted is to mix hydrogen with the initial N_2 gas. The product atomic-N, reacted with H_2 and produced ammonia and was cryogenically collected. The next problem was to measure the N-isotopic composition in NH_3 of the sub-micromole amount. This problem was tackled by producing break-seals for each sample separately with pre-conditioned CuO and later used high-temperature decomposition to liberate N_2. Since the photon absorption cross section of N_2 at the VUV wavelengths are known, a Matlab based simulation code was developed to calculate the isotopic composition of the product nitrogen. These simulated values were in stark difference from the measured one and provided the most important clue to the chemical physics community about the lack of understanding of the photodissociation process.

- Simulated the photochemical environment in the inner solar nebula to study the photochemical evolution of sulfur-bearing gas-H_2S using the vacuum-UV photons from ALS synchrotron. The other major issue was to collect the H_2S photolysis product, elemental sulfur. The experiments were performed with a chamber liner made from thick ultra-high purity Al-foil and the elemental sulfur was deposited on the foil and later treated the entire liner as a sample. The results are published in the **Proceedings of the National Academy of Sciences**, which show that the photochemically derived sulfur from H_2S in the inner nebula was incorporated into the silicate phase and accreted as meteorite parent body.
- Collected aerosol samples of a jet-exhaust from several locations on the runway to understand the isotopic composition of primary jet emission and its spatial and temporal evolution and the impact of synthetic fuels on commercial aircraft engine during "**Alternative Aviation Fuel Experiment (AAFEX)**" campaign. The major problem from aerosol sample collection standpoint was to stabilize the high-volume filter units (made of aluminum) against the thrust of the jet exhaust. We solved this problem on-spot by adapting several modifications of the samplers using materials from the home improvement store, also we placed the samplers strategically to avoid the maximum thrust.

• Mentored students, advised laboratory research associates for the smooth running of the projects.

• High-impact research publications resulted in extensive national and international media coverage, including radio interview and news articles.

2003 – 08 ***Postdoctoral Researcher***

University of California, San Diego La Jolla, CA

• Science-Principal Investigator of NASA funded research projects, resulted in high impact research publication in **Science Magazine** and was extensively covered by the national and international media, including newspaper interview and news articles.

• Written research grants resulted in over **$ 750K** research funds through NASA solicitations.

• Designed and executed experiments to simulate the photochemical environment of the early solar nebula inside a reaction chamber to study the oxygen isotopic composition from CO (major O-bearing gas in the nebula) photodissociation. The results are published in the journal **Science**, which show the isotopic composition of the photochemically derived oxygen from CO.

• Project management, starting from planning to recruiting undergraduate research assistants to execution, data interpretation, reporting to the funding agency and in technical conferences through oral and poster presentations, and finally publishing in peer-reviewed journals.

1998 – 03 ***Research Fellow***

Physical Research Laboratory, Ahmedabad, India

• Published 5 first author research articles in peer-reviewed journals.

• I undertook a research problem to measure triple-isotopes of oxygen to understand the photochemical processes. To make this possible under limited resources I have converted an old dual collector mass-spectrometer to a triple collector one (suitable to measure all three isotopes of O_2) with a bigger magnet. Designed a magnet positioning system to easily adjust the position of the magnet to get the perfectly focused beam. This extensive and innovative mass-spectrometric work resulted in 'Best Thesis of the Year Award, 2003' from the Indian Society for Mass-spectrometry (ISMAS).

1996 – 98 ***Project Associate***
Physical Research Laboratory, Ahmedabad, India
• Assigned to a job to design and fabricate an ultra-low background gamma counter to quantify low-level radioactivity in fresh fall meteorites. Two detectors were used inside a lead-shield in anti-coincidence to filter the actual signal from the sample from the background. The challenge was to build a mechanism to lift one of the detectors (~60 lbs.) during changing the samples. I built a pulley system made from a certain kind of hard plastic with zero-background (had to test each material before using) and finally, it was a success.

TEACHING EXPERIENCE

Temporary Lecturer in Physics
20018-Present University of California, San Diego, La Jolla, CA, USA
Taught undergraduate physics courses

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2007-08 Reader, Planetary Science and Exploration Program, Physical Research Laboratory, India
• "Principles of stable isotopes and their applications in nature" (12 post-MS students): contributed to curriculum development.
• "Instrumentation techniques: Remote sensing in planetary science" (12 post-MS students): contributed to curriculum development.

2010 'Camp Ciencia' at the Institute of Americas, University of California, San Diego
• "Basics of planetary science and the applications of isotopes" (a group of 50 international high school students from Latin America): 2-day workshop.

1995-96 Physics private tutor
• Tutored high school students and coached high school students for national level qualifying exams.

AWARDS

• **David A. Shirley Award, Advanced Light Source (ALS, Berkeley), 2011.**
This award is given to one individual every year for Outstanding Scientific Achievement at the Advanced Light Source (Synchrotron).
The award is given for "the design and execution of the most important and difficult experiment relevant to understanding the origin and evolution of the solar system".

• **NASA Group Achievement Award, NASA, 2010**.
For outstanding achievement in establishing the impact of synthetic fuels on commercial aircraft engine and auxiliary power unit performance and pollutant emissions in "Alternative Aviation Fuel Experiment (AAFEX)".

• **Nominated for the Young Scientist Award, Indian National Science Academy (INSA), 2004, 2007**.
At the most, five young scientists (under the age of 35) from Earth and Planetary Science stream are nominated each year for this yearly award.

• **Best Thesis Award, Indian Society for Mass-spectrometry, 2003**.
This award is given to a person each year who is fresh Ph.D. and used mass-spectrometer as a tool to perform his/her research during the society's annual meeting.

• **Research Scholarship, Physical Research Laboratory, India, 1998.**

Five to ten master students are given this scholarship each year based on national level is written test and personal interview. Physical Research Laboratory (Dept. of Space, Government of India), Ahmedabad, India conducts this test.

- **National Merit Scholarship, Human Resource Development, Government of India, 1993**
  Given to one meritorious student per college throughout India based on their grade in their bachelor (honors) exam.

SKILLS AND QUALIFICATIONS

Science • Research • Data collection, analysis, and interpretation • Outstanding written communications- journal articles, reports, grants

Teaching • Undergraduate courses (large class size) • Graduate courses (small class size) • Undergraduate research faculty mentor

Technical • Mass-spectrometry • Vacuum systems and technologies • Gas and liquid chromatography • Designing and fabricating complex experimental apparatus • VUV/UV/IR laser and light sources • Cryogenic systems • UV/VIS/IR Spectroscopy • SEM, TEM imaging

Leadership and Mentoring • Leadership in workplace • Team building and teamwork • Teaching and training • Mentoring, advising and consulting

Business • Project management • Oral communication • Risk management • Conflict resolution • Large-scale event planning and execution

Computing • Software Packages: MS Office, SigmaPlot, Photoshop, Coral Draw, easily learn new programs • Computer languages: Fortran, C, HTML • Numerical simulation (modeling): MATLAB and R

Languages • English (native fluency), Bengali (native fluency), Hindi (near-native fluency)

SERVICE/ LEADERSHIP

- Member, Advisory Committee on Sustainability at University of California, San Diego (https://pda.ucsd.edu/about/campus-reps.html), 2017- 2019.
  This committee advises a set of recommendations to the office of the Chancellor to better prepare the campus for sustainable future. I represent the post-doctoral scholars and their viewpoints on this particular issue.
- Scientific Consultant- San Onofre Nuclear Waste Management, Samuel Lawrence Foundation, 2018.
  San Onofre Nuclear Power Generating Station is being decommissioned. About 3500 million pounds of highly radioactive nuclear waste is being buried in the plant area which is 108 feet from the Pacific Ocean. Naturally, the common people are concerned over it as there is about 8.5 people lives in the vicinity of 50 miles of the plant. The foundation approached me to scientifically examine the risk involved in the process with an open mind. I will present the analysis in WM International Conference in Phoenix (March 2019).
- Co-Chair, Lunar and Planetary Science Conference (LPSC), Houston, TX, March 2010, March 2016.
- Co-convener, 22nd V. M. Goldschmidt Conference, Montréal, Canada, 24-29 June 2012 **(**Carbon-iron-sulfur partitioning in modern and ancient sediments: Global sulfur cycle and diagenetic pathways: Session 16C).
- Member, Scientific and Local Committee, a Third international symposium on isotopomers (ISI 2006), San Diego, CA, USA.
- Referee, Science Magazine; Nature; Nature Geosciences; Nature Reports; Proceedings of National Academy of Sciences; Astronomy and Astrophysics; Geochimica et Cosmochimica Acta; Meteoritics and Planetary Science; Journal of Geophysical Research-Atmospheres; Deep Sea Research-II; Rapid Communication of Mass-spectrometry; Atmospheric and Ocean Sciences, Earth and Planetary Science Letters, Planetary Space Science.
- Judge, Stephen E, Dwornik Award by Lunar and Planetary Institute, 2009-present. Judging graduate and undergraduate students based on their oral and poster presentations.
- Judge, Best student presentation award, 22nd V. M. Goldschmidt Conference, Montréal, Canada, 24-29 June 2012.

- Treasurer, biennially **elected member** of the executive committee of a non-profit, charitable organization- SAIKAT, serving Indian community in southern California, 2014-2017.
  Oversaw an annual budget of $75K. Undertook drastic measures to set this 30-years old organization in a financially sustainable path that included fundraising resulted in significant growth of the reserve fund (50% increase during my tenure).
- Student representative and spoke person of Research Scholars, Physical Research Laboratory, Ahmedabad, India, 1998-2003.
  Solved decade-long issues related to student hostel accommodations, basic necessities (e.g., to make washing machine facility available to the students), reducing the student hostel's electricity bill by re-defining as residential use (worked with the city electric supply office).
- **Elected** student representative of the class, Jadavpur University, Kolkata, India, 1995-96.
  Worked with the administration to set student-friendly exam schedule, successfully pursued the administration to cover the medical expenses of an accident victim from our class. Successfully pursued the local congressman for additional help for the victim's family.
- **US House Rep. Mike Levin's Task Force Member:** Member of the Task Force founded by the US House Representative (California 49th District), Mike Levin.
  I was invited to join this task force to provide technical input to the committee in support of legislative effort to handle the nuclear waste problem in Southern California and elsewhere.

OUTREACH

Mentoring undergraduate students through active participation in Faculty Mentor Program (FMP) of University of California, San Diego, 2009-present.

- Mentoring Undergraduate Students at UCSD:
  [1] Avery Green- Physics
  [2] Petia Yanchulova- Physics
  [3] Christine Quintana- Physics
  [4] Josh Aguilar- Physics
  [5] Haiyang Kehoe- Physics
  [6] Zak Owens- Physics
  [7] Tien L. Pham- Chemical Engineering
  [8] Erick Alvarado- Chemical Engineering
  [9] Deborah Gardner- Physics/ Chemical Engineering (Marine, Veteran)
  [10] Christopher Immekus- A Physics/ Chemical Engineering (Navy, Veteran)
  [11] Gabriele Di-fiore- Chemical Engineering
  [12] Yangyang Dai- Chemical Engineering
  [13] Mohammed Almahdawi- Chemical Engineering
  [14] Catalina Verduzco- Chemical Engineering
  [15] Yu Tan- Chemical Engineering
  [16] Dong G Kim- Chemical Engineering
  [17] Jonathan Tang- Chemical Engineering
  [18] Jacqueline Jabuca- Physics/ Environmental Science
  [19] Trinh Nguyen- Chemical Engineering
  [20] Christian Boothby- Chemistry
  [21] Dagoberto Valdes- Chemistry
  [22] Gabriella Welten- Chemistry
- Mentoring Masters/ Doctoral Student at UCSD:
  [1] Ryan Davis- M**entored** MS/Doctoral student from Prof. Thiemens Lab. He worked closely with me to learn the experimental techniques involved with the gas-phase photochemical experiments at Advanced Light Source synchrotron facility. I was also provided him scientific and technical advice for the development of CRDS-based spectrometer for isotopic ratio analysis of carbon dioxide.

PROFESSIONAL ASSOCIATIONS

- Member, Science Team of NASA's Genesis Discovery Mission (http://genesismission.jpl.nasa.gov/people/index.html), 2004 - Present.
- American Geophysical Union (AGU).
- Geochemical Society.
- Meteoritical Society (MetSoc).
- Indian Society for Mass Spectrometry (ISMAS)- Life Member, Bhaba Atomic Research Center, Mumbai, India (http://www.ismas.org).

PUBLICATIONS

- **Articles in Peer-Reviewed Journals**

[1] **Chakraborty, S.,** Bruce Rude, M. Ahmed, and M. H. Thiemens, Carbon and oxygen isotopic fractionations in the products of low-temperature VUV photodissociation of carbon monoxide, ***Chemical Physics* 514**, 78, 2018.

[2] Ray, D., R. R. Mahajan, A.D. Shukla, T. K. Goswami and **S. Chakraborty**, Petrology, classifications, noble gases and cosmogenic records of Kamargaon (L6) meteorite: the latest fall in India, ***Meteoritics, and Planetary Sc.***, (doi: 10.1111/maps.12875) 2017.

[3] **Chakraborty, S.,** Bruce Rude, T. Jackson, M. Ahmed, and M. H. Thiemens, Nitrogen isotopic fractionations in the low temperature (80K) vacuum ultraviolet photodissociation of N_2, ***J. Chem. Phys.* 145**, 114302, 2016.

[4] **Chakraborty, S.,** T. L. Jackson, B. H. Muskatel, Musahid Ahmed, R.D. Levine and M. H. Thiemens, Nitrogen Isotopic Fractionation in VUV Photodissociation of N_2: Implications for the Early Solar System, ***Proc. National Academy of Sciences,* 111**, 14704-14709, 2014.

[5] Thiemens, M.H., **S. Chakraborty** and T.L. Jackson, Decadal $\Delta^{17}O$ Record of Tropospheric CO_2: Verification of a Stratospheric Component in the Troposphere, ***Journal of Geophysical Research***, 119 (10), 6221–6229, 2014.

[6] **Chakraborty, S**., P. Yanchulova, and M. H. Thiemens, Mass-independent oxygen isotopic partitioning during gas phase SiO_2 formation, ***Science,*** 342, 463, 2013.

[7] **Chakraborty S.**, T. L. Jackson, M. Ahmed, and M.H. Thiemens, Anomalous isotope effect in VUV photodissociation of Hydrogen Sulfide: Implications for chondrule and chondrite isotopic data, ***Proc. National Academy of Sciences***, 110, 44, 17650-17655, 2013.

[8] **Chakraborty, S.,** R. Davis, M. Ahmed, T. L. Jackson and M. H. Thiemens, Oxygen isotope fractionation in the vacuum ultraviolet photodissociation of carbon monoxide: wavelength, pressure and temperature dependency, ***J. Chem. Physics***, 137, 024309, 2012.

[9] Thiemens, M. H., **S. Chakraborty** and G. Dominguez, The physical chemistry of mass-independent isotope effects and their observation in nature, ***Annual Review of Physical Chemistry***, *63, 155-177*, 2012.

[10] Burnett, D. S., and **Genesis Science Team**[1], Solar composition from the Genesis discovery Mission, ***Proceedings of National Academy of Sciences,*** *108, 19147-19151*, 2011.

[11] **Chakraborty, S**., M. Ahmed, T. L. Jackson and M. H. Thiemens, Response to the comment on "Experimental test of isotope self-shielding in vacuum ultraviolet photodissociation of CO", ***Science***, *324, 1516*, 2009.

[12] **Chakraborty, S**., M. Ahmed, T. L. Jackson and M. H. Thiemens, Experimental test of isotope self-shielding in vacuum ultraviolet photodissociation of CO, ***Science***, *321, 1328-1331*, 2008.

[13] Kimura, Y., J. A. Nuth, **S. Chakraborty** and M. H. Thiemens, Non-Mass-Dependent Oxygen Isotopic Fractionation in Smokes Produced in an Electrical Discharge, ***Meteoritics & Planetary Science***, *42*, 1429-1439, 2007.

[14] **S. Chakraborty,** and S.K. Bhattacharya, Experimental investigation of oxygen isotope exchange between CO_2 and $O(^1D)$ and its relevance to the stratosphere, ***J. Geophys. Res.***, *108*(D23), 4724, doi:10.1029/2002JD002915, ACH 5-1-15, 2003.

[15] Bhattacharya, S. K., **S. Chakraborty**, J. Savarino, and M. H. Thiemens, Reply to comment by D. Krankowsky et al. on "Low-pressure dependency of the isotopic enrichment in ozone:

[1] **S. Chakraborty** is a Genesis Science team member since 2004 [http://www.pnas.org/content/suppl/2011/05/06/1014877108.DCSupplemental/pnas.1014877108_SI.pdf]

Stratospheric implications" by S. K. Bhattacharya et al., ***J. Geophys. Res.***, *108*(D16), 4504, doi:10.1029/2003JD003482, ACH 9-1-3, 2003.

[16] Supriyo Chakraborty, and **S. Chakraborty,** Isotopic fractionation of the O_3-nitric oxide reaction, ***Current Science***, *85(8)*, 2003, 1210-1212, 2003.

[17] **Chakraborty, S.,** and S.K. Bhattacharya Reply to 'Comment on 'Oxygen Isotopic Anomaly in Surface Induced Ozone Dissociation' [*Chem. Phys. Lett.*, *369 (2003)* 662]', ***Chem. Phys. Lett.***, *379*, 592 –594, 2003.

[18] **Chakraborty, S**., and S.K. Bhattacharya, Mass Independent Isotopic Fractionation: Recent Development, ***Current Science***, *84* (6), 766-774, 2003.

[19] **Chakraborty, S.**, and S.K. Bhattacharya, Oxygen Isotopic Anomaly in Surface Induced Ozone Dissociation, ***Chem. Phys. Lett.***, *369*, 662-667, 2003. [Erratum: *Chem. Phys. Lett.*, *371*, 229-230, 2003].

[20] **Chakraborty, S**., and S.K. Bhattacharya, Oxygen Isotopic Fractionation During UV and Visible Light Photo-Dissociation of Ozone, ***J. Chem. Phys.***, *118*, 2164-2172, 2003.

[21] Bhattacharya, S.K., **S. Chakraborty**, J. Savarino, and M.H. Thiemens, Low-pressure dependency of the isotopic enrichment in ozone: Stratospheric implications, ***J. Geophys. Res.***, *107*(D23), 4675, doi:10.1029/2002JD002508, ACH 4-1-10, 2002.

- **Articles under review/revision**

[22] Sæmundur A. Halldórsson, David R. Hilton, **Subrata Chakraborty**, Paolo Scarsi, Tsegeye Abebe, Jens Hopp, the Widespread occurrence of recycled volatiles in the sub-continental lithospheric mantle of the East African Rift system - Evidence from the He-Ar-CO_2-N_2-O systematics of mantle xenoliths (Under Revision in ***J. of Petrology***), 2017.

[23] D. Ray, R.R. Mahajan, A.D. Shukla, T.K. Goswami and **S. Chakraborty**, Petrology, classification, noble gases and cosmogenic records of Komar Gaon meteorite, Meteoritics & Planetary Science (Under Review).

[24] **Chakraborty, S.**, Tom English, ES&H Risk Estimation from "Interim Storage" of SNF at the Beach: The San Onofre NPP, WM Symposia 2019, March 3-7, Phoenix, AZ (Under Review).

- **Article in a book (peer-reviewed)**

[25] Semenov Dmitry, **Subrata Chakraborty** and Mark H. Thiemens**,** Chemical evolution of the solar nebula in Protoplanetary Dust the astrochemical and astrochemical perspectives *(Book Chapter# 4)* (Editors: **Dániel Apai,** Dante Lauretta), Cambridge University Press *ISBN: 978-0-521-51772-0*, 2010.

- **Articles under preparation (for peer-reviewed journal)**

[26] **Chakraborty, S**., T. Jackson, Bruce Rude, M. Ahmed, and M. H. Thiemens, Meteoritic organic like sulfur isotopic composition from VUV photodissociation of SO_2: Constrain on organic formation in the solar nebula, ***Science, 2019 (In Preparation***).

[27] **Chakraborty, S.,** Understanding Titan's Atmospheric Isotope Inventory through Laboratory Photolysis Experiments using Vacuum Ultraviolet Photons from Advanced Light Source Synchrotron, ***ApJ Letters***, 2019 (In Preparation).

[28] **Chakraborty, S,** with Thiemens Group, Isotope signature of primary Sulfate formation in jet engine exhaust in control experiments and in LAX airport (In preparation).

[29] **Chakraborty, S**. and M. H. Thiemens, Design and testing of newly build laser ablation system capable of measuring triple-oxygen isotopes in nano-mole level (In Preparation for ***Rapid Comm. Mass Spectrometry***).

[30] Nunn, M., **S. Chakraborty** and M. H. Thiemens, Oxygen Isotopic Effects of Ion-Molecule Reactions and Implications on Interstellar Molecular Cloud Chemistry (under preparation for ***Astrophysical Journal Letters***).

- **Articles (full) in conference proceedings (non-peer-reviewed)**

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[6] **Chakraborty S.**, Christopher Immekus, and M. H. Thiemens Investigating Formation and Evolution of Titan's Atmosphere through its Isotopic Inventory and New Photochemical Studies, Lunar Planetary Science Conference XXXVIII, Houston, 20-24 March 2017.

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PRESENTATIONS

- "Mineral Formation and Growth with Anomalous Oxygen Isotopic Composition on Siliceous Dust Surfaces**"**, Lunar Planetary Science Conference XXXXI, Houston, 19-23 March 2018.
- "Photochemistry of volatiles in the solar nebula", 80th Annual Meeting of The Meteoritical Society, Santa Fe, New Mexico, 24-28 July 2017.
- **"**New Constraints of the petrogenesis of Piplia Kalan meteorite**"**, 80th Annual Meeting of The Meteoritical Society, Santa Fe, New Mexico, 24-28 July 2017.
- **"**Investigating Formation and Evolution of Titan's Atmosphere through its Isotopic Inventory and New Photochemical Studies**"**, Lunar Planetary Science Conference XXXVIII, Houston, 20-24 March 2017.
- "Investigating Formation and Evolution of Titan's Atmosphere through its Isotopic Inventory and New Photochemical Studies", Lunar Planetary Science Conference XXXVIII, Houston, TX, 20-24 March 2017.
- "Sulfur Isotopic Fractionation During Vacuum Ultraviolet Photolysis of SO_2: Implication for Meteorites and Early Earth", AGU Fall Meeting, San Francisco, 12-16 December 2016.
- "New experimental evidence of silicate formation with meteorite like oxygen isotopes on a dust surface analog", Lunar Planetary Science Conference XXXVII, Houston, 21-25 March 2016.
- "Low Temperature (80K) Vacuum Ultraviolet Photodissociation of Nitrogen: Isotopic Fractionations and Significance for Solar Nebular Chemistry", Lunar Planetary Science Conference XXXVI, Houston, 16-20 March 2015.
- "Solar Wind and Solar Nebula through Light Stable Isotopes", Genesis Earth Return, 10th Anniversary Meeting, JPL, Pasadena, 7-9 October 2014.
- "Synthesis of ^{15}N Enriched NH_3 Through N_2 Photolysis: Relevance to N-Enriched Meteoritic Organics", V. M. Goldschmidt Conference, Sacramento, CA 8-13 June 2014.
- "Mass independent oxygen isotopic composition in laboratory synthesized silicates via gas-phase and surface assisted reactions: Cosmochemical implications", Lunar Planetary Science Conference XXXIV, Houston, 18-22 March 2013.
- "Oxygen Isotope Saga of the Early Solar System", Washington University at St. Louis, Physics Department St. Louis, MO, 17th February 2013 (Invited).
- "Mass-independent sulfur isotopic fractionation in VUV photodissociation of H_2S: implications for meteorite data", 42nd V. M. Goldschmidt Conference, Montreal, Canada, 24-29 June 2012.
- "Laboratory observation of mass-independent oxygen isotopic composition in solid silicates through gas phase reaction**:** Cosmochemical Implications", Lunar Planetary Science Conference XXXIII, Houston, 19-23 March 2012.
- "Simulating early solar system condition using ALS synchrotron", LBNL Berkeley, 4th October 2011 (Invited: Shirley A. David Award Talk).
- "Anomalous isotope effect in VUV photodissociation of Hydrogen Sulfide: Implications for chondrule and chondrite isotopic data", Lunar Planetary Science Conference XXXII, Houston, 7-11 March 2011.
- "Oxygen isotope effect dominated by VUV photodissociation dynamics of CO: Implications for nebular CO Photolysis", 73rd Meteoritical Society Meeting, New York, 26-30 July 2010.
- "Wavelength-dependent oxygen isotopic fractionation in the VUV photodissociation of CO: An early solar system perspective", Lunar Planetary Science Conference XXXI, Houston, 1-5 March 2010.
- "Accidental predissociation: A special case of photo-induce isotope fractionation effect and possible occurrence in nature", AGU Fall Meeting, San Francisco, 14-18 Dec 2009.
- "Oxygen isotopic fractionation in vacuum ultraviolet photodissociation of CO: Lack of self-shielding and relevance to the early solar system", Lunar Planetary Science Conference XXXX, Houston, 23-27 March 2009.

- "Vacuum ultraviolet photodissociation of carbon monoxide: Relevance for meteorite oxygen isotopes", Advanced Light Source Users Meeting, Berkeley, 13-15 October 2008 (Invited lecture as a part of '2007 Science Highlight of ALS').
- "Multi oxygen isotopes for environmental and solar system studies", Advanced Light Source Users Meeting Workshop, Berkeley, 13-15 October 2008.
- "First experimental test of self-shielding in VUV photodissociation of CO: Relevance for meteorite oxygen isotopes", 4th International Symposium on Isotopomers, Odaiba (Tokyo), Japan, 4-9 Oct. 2008.
- "Experimental test of isotope self-shielding in VUV photodissociation of CO", Lunar Planetary Science Conference XXXIX, Houston, 9-13 March 2008.
- "A laboratory observation of mass-independent oxygen isotopic fractionation in the gas phase: Cosmological Implications", Diamond Jubilee Conference: Terrestrial Planets: Evolution through Time, PRL, Ahmedabad, 22-25 January 2008.
- "Wavelength-dependent isotopic fractionation in CO photolysis: Experimental findings relevant to the solar nebula", Lunar Planetary Science Conference XXXVIII, Houston, 12-16 March 2007.
- "Oxygen isotopes in the solar system: Recent experimental observations", ISI2006 conference, La Jolla, J CA, USA, 27-31 August 2006.
- "Isotopic Fractionation Associated with Photochemistry of CO: Experimental Findings Relevant to the Solar Nebula", Lunar Planetary Science Conference XXXVII, Houston, 13-17 March 2006.
- "Evaluation of CO Self-Shielding as a Possible Mechanism for Anomalous Oxygen Isotopic Composition of Early Solar System Materials", Lunar Planetary Science Conference XXXVI, Houston, 14-18 March 2005.
- "Oxygen Isotopic Exchange Between CO_2 and $O(^1D)$: A Laboratory Investigation", ISI2003 conference, 2003, Italy, Nov 4 to 7, 2003 (Invited speaker).
- "Mass independent oxygen isotopic fractionation during UV photo-dissociation of ozone", ISMAS-SJS-2003 symposium, *National Institute of Oceanography*, Goa, January 27-31, 2003.
- "Oxygen isotopic anomaly in surface assisted ozone dissociation", 1st ISI-2001 symposium, Yokohama, Japan. 23-26 July 2001.
- "Oxygen isotope enrichment in ozone formed by UV photolysis", 9th ISMAS Workshop on Mass Spectrometry, *National Institute of Oceanography*, Goa, December 12-16, 2000.

POPULAR ACCOUNT OF RESEARCH

- **KPBS Radio Morning Edition and KPBS Television Evening Edition:** Broadcasted interview regarding problems in San Onofre Nuclear Power Plant Decommissioning on 2nd Jan, 2019. (Audio: https://www.kpbs.org/news/2019/jan/02/scientific-analysis-suggests-additional-problems-s/ Video: https://www.youtube.com/watch?v=sxEStPE1vzQ&t=36s)

- Discovery of the anomalous fraction in oxygen isotopes and its implication for solar system (published in Science, 2008) was widely covered by the popular media:

o Telegraph India (Interview: Know How Story: The Oxygen Puzzle, 15th Sept 2008 Issue). o The Guardian Newspapers (United Kingdom) o University of California News Room. o University of California, San Diego News Center o Light Sources News o NASA Research News o NASA Earth Observatory News o Berkeley Lab News Feature o Fox News o National Geosciences News: Iran o Sunday Newscape Magazine o Eureka Alert o Physics Org News o Innovations Report o Universe Sciences o Science Daily Report o Imperial Valley Press o Google-Sina o Malaysia Sun o Space Daily Report o Herald Globe News o UK-Space News Deed o Science Technology Online o Only Perception (Japanese) o KISTI (Korean) o Afghanistan Sun o New Kerala News o One India News o Khabar Express o Indian SciTech News o Yahoo News.

- Discovery of the anomalous fraction of sulfur isotopes during photochemistry of H_2S (PNAS, 2013) led to the popular article:

Advanced light source (ALS) Feature (February 2013): Searching for the Solar System's Chemical Recipe; Berkeley Lab News (Vol 340, 2013): Studying the Solar System's Chemical Recipe.

- Discovery of meteorite-like oxygen isotopic distribution through nebula-like chemical reaction (Science, 2013) led to the following popular articles:

  "Scientists Solve Mystery of Odd Patterns of Oxygen in Solar System's Earliest Rocks"─ UC, San Diego News (Oct 24, 2013, http://ucsdnews.ucsd.edu/pressrelease/scientists_solve_mystery_of_odd_patterns_of_oxygen_in_solar_systems_earlies).

  Featured in "Triton", a UC San Diego Alumni Publication (May 2014).

  Nature World News.

  Radio Interview with Voice of Russia US (http://sputniknews.com/voiceofrussia_us/2013_11_02/Solving-an-oxygen-conundrum-3261/).

- Discovery of the unprecedented fraction of nitrogen isotopes by photodissociation of N_2 (PNAS, 2014) led to the following popular articles:

  "Nitrogen Fingerprint in Biomolecules and Extraterrestrial Objects Could Be From Early Sun" "─ **UC, San Diego News** (Sept 29, 2014, http://ucsdnews.ucsd.edu/pressrelease/nitrogen_fingerprint_in_biomolecules_and_extraterrestrial_objects_coul1).

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