

Curriculum Vitae

Dr. Rahul Kumar Kushwaha

Postdoctoral Scholar

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Date of Birth: January 16th, 1994

Positions/Employment

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|-------------------|---|
| 03/2023 - | Postdoctoral Scholar Jet Propulsion Laboratory, California Institute of Technology Pasadena, CA, USA |
| 10/2021 – 03/2023 | Postdoctoral Fellow Institute for Nuclear Research (ATOMKI), Debrecen, Hungary |
| 09/2020 – 10/2021 | Postdoctoral Fellow Physical Research Laboratory (PRL), Ahmedabad, India |

Education

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|-------------------|---|
| 07/2015 – 08/2020 | PhD (Experimental Astrochemistry) Physical Research Laboratory (PRL), Ahmedabad, India <i>affiliated to</i> Mohanlal Sukhadia University (MLSU), Udaipur, Rajasthan, India |
| 07/2013 – 07/2015 | Master of Science (Physics, University 1st Rank) University of Allahabad, Prayagraj, India |
| 07/2010 – 07/2013 | Batchelor of Science (Physics, Chemistry & Mathematics) University of Allahabad, Prayagraj, India |

Recognition and awards

- **DST-DFG** award to attend **69th Lindau Nobel Laureates Meeting** (Physics), (June 30th, 2019 – July 5th, 2019), Lindau, Germany and visit various premier research institutes in Germany from July 6th, 2019 – July 12th, 2019.
- Junior/Senior Research Fellowship 2015 – 2020, PRL, Department of Space, India.
- Junior Research Fellowship 2016, CSIR-UGC, India.

Research Experience

ATOMKI, Debrecen, Hungary

- Performed experiments on high-energy (keV - MeV) ion irradiation and thermal processing of molecular ices relevant to astrobiological/astrochemical interest and probing using infrared spectroscopy and mass spectrometry at Ice Chamber for Astrophysics & Astrochemistry (ICA) at Tandetron ion facility, ATOMKI, Debrecen.
- Part of a team for development and installation of a low temperature set-up for astrochemistry experiments at electron cyclotron resonance ion source (ECRIS) at ATOMKI, Debrecen as EUROPLANET 2024 RI facility.
- Test and installation of evaporator with the astrochemistry set up depositing the molecules with low vapour pressure such as PAHs, Sulphur powder etc.
- A systematic study of electron irradiation of Titan's ice analogues (*in progress*).

Physical Research laboratory, Ahmedabad, India

- Development of a set-up for Low-Temperature Astrochemistry Instrument at Physical Research Laboratory (PRL), Ahmedabad, India, to synthesize the molecular ice under astrochemical condition and probe them using infrared (IR) spectroscopy.
- A series of experiments using the IR setup (*at PRL, Ahmedabad*) on astrochemical ices to understand the morphology and chemical evolution.
- Vacuum Ultraviolet Spectroscopy of astrochemical ices (pure ice and energetic photon irradiated matrix) in the group and independently at *National Synchrotron Radiation Research Center (NSRRC), Taiwan* at various granted beam-time.
- Photo-irradiation and thermal processing of pure/mixed/layered astrochemical ices to study synthesis of new molecules, change of ice morphology, formation of residue.

- Imaging and elemental analysis of residue from irradiated ice for its physical structure using HR-TEM and FE-SEM.
- Commissioning of a set-up for Quadrupole Mass Spectrometer (1 - 5000 Da) (*at PRL, Ahmedabad, India*) to analyse the processing of molecules/ices via intense shock, electron irradiation, or from other energetic sources.

University of Allahabad, Allahabad, India

- Polarization of electric field vector due to the applied magnetic field
- Theoretical and experimental analysis of Second-harmonic generation (SHG) in asymmetric crystal (Lithium niobate)
- Experimental use of Nd-Yag laser and its application to verify SHG

Accepted proposals

- Europlanet2024 Research Infrastructure grant for a trans-national visit to perform experiments at Ion chamber for Astrophysics/Astrochemistry - ICA, Hungary (2020)

Programming Language

- Basic of the Python
- Data plotting in Origin software

Other Interests

1. Educating and motivating young students in villages and remote area through a Science Fair (<https://unitedscienceforum.org/members>)
2. Volunteer for National Science Days and Open House in our research institute to motivate younger students towards science.
3. Reaching out to schools in the villages and remote areas to popularise science (Science Express) with models and hands-on experiments

Conferences & Workshops

1. Europlanet Science Congress (EPSC), 2022, Granada, Spain.
2. Chemistry and Physics at Low Temperature (CPLT), 2022, Visegrád, Hungary.
3. Europlanet Science Congress (EPSC), 2021, Virtual Meeting.
4. Europlanet Science Congress (EPSC), 2020, Virtual Meeting.

5. Spectroscopy and Dynamics of Molecules and Clusters (SDMC), 2020, Rajasthan, India.
6. Indian Planetary Science Conference (IPSC), 2020, PRL, Ahmedabad
7. International Conference on Infrared Astronomy and Astrophysical Dust (IRAAD), 2019, IUCAA, Pune.
8. National Conference on Atomic and Molecular Physics 2019, IIT – Kanpur, India
9. National Symposium on Space Science 2019, Pune University, IUCAA, NCRA, Pune, India
10. International Workshop on Atomic and Molecular Collision 2018, Udaipur, India
11. Asian International Symposium on Atomic and Molecular Physics (AISAMP) 2018, TIFR & IIT- B, Mumbai, India
12. Exploring the Universe: Near-Earth Space Science to Extra-Galactic Astronomy (EXPUNIV) 2018, SNBNCBS, Kolkata, India
13. National Conferences on Advances in Spectroscopy: Molecules to Materials (NCASMM) 2018 (*Best oral presentation award*), IITRAM, Ahmedabad India
14. Young Astronomers' Meet 2018 (Organizer) PRL, Ahmedabad, India
15. Young Astronomers' Meet 2017 (Participant) IUCAA-Pune, India
16. Optical astronomy using large telescopes (School – 2017), IUCAA-Pune, India
17. ASTROSAT Users' Proposal Workshop 2016, IUCAA-Pune, India

Publications

1. Radiolytic Cyanide and Cyanate Formation in Astrophysical Ice Analogues, K. K. Rahul, P. Herczku, D. V. Mifsud, S. T. S. Kovács, B. Sulik, R. Rácz, G. Lakatos, P. A. Hailey, Z. Kaňuchová, S. Biri, S. Ioppolo, R. W. McCullough, N. J. Mason and Z. Juhász (***Under preparation***)
2. Residue from vacuum ultraviolet irradiation of benzene ices: Insights into the physical structure of astrophysical dust. **K K Rahul**, E Shivakarthik, J K Meka, A Das, V Chandrasekaran, B N Rajasekhar, J -I Lo, B -M Cheng, P Janardhan, A Bhardwaj, N J Mason, B Sivaraman, *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, **231**, 117797, 2020
(Appeared on the cover page of 65th issue of the AstroPAHs Newsletter, Leiden Observatory, Netherlands).
3. Infrared attenuation due to phase changes from amorphous to crystalline observed in astrochemical propargyl ether ices, **K K Rahul**, J K Meka, S Pavithraa, P Gorai, A Das, J -

- I Lo, B N Rajasekhar, B -M Cheng, P Janardhan, A Bhardwaj, B Sivaraman, *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, **224**, 117393, 2020.
4. Bombardment of CO Ice by Cosmic Rays. I. Experimental Insights into the Microphysics of Molecule Destruction and Sputtering, Alexei V. Ivlev, Barbara M. Giuliano, Zoltán Juhász, Péter Herczku, Béla Sulik, Duncan V. Mifsud, Sándor T. S. Kovács, **K. K. Rahul**, Richárd Rácz, Sándor Biri, István Rajta, István Vajda, Nigel J. Mason, Sergio Ioppolo, and Paola Caselli, *The Astrophysical Journal*, **944**, 181, 2023.
 5. Sulfur Ion Implantations Into Condensed CO₂ : Implications for Europa, D. V. Mifsud, Z. Kaňuchová, P. Herczku, Z. Juhász, S. T. S. Kovács, G. Lakatos, K. K. Rahul, R. Rácz, B. Sulik, S. Biri, I. Rajta, I. Vajda, S. Ioppolo, R. W. McCullough, N. J. Mason, *Geophysical Research Letters*, **49**, e2022GL100698, 2022.
 6. Energetic electron irradiations of amorphous and crystalline sulphur-bearing astrochemical ices, Duncan V. Mifsud, Péter Herczku, Richárd Rácz, **K. K. Rahul**, Sándor T. S. Kovács, Zoltán Juhász, Béla Sulik, Sándor Biri, Robert W. McCullough, Zuzana Kaňuchová, Sergio Ioppolo, Perry A. Hailey and Nigel J. Mason, *Frontiers in Chemistry*, 10:1003163, 2022.
 7. Ozone production in electron irradiated CO₂:O₂ ices. D V Mifsud, Z Kaňuchová, S Ioppolo, P Herczku, A Traspas Muiña, B Sulik, **K K Rahul**, P A Hailey, N J Mason, Z Juhász, *Physical Chemistry Chemical Physics*, **22**, 24, 2022.
 8. Vacuum ultraviolet photo-absorption spectra of an in-situ synthesized peptide precursor: hydroxylamine on a cold astrochemical dust analogue. R Thombre, D Gupta, S Pavithraa, J -I Lo, S -L Chou, Y -J Wu, **K K Rahul**, B -M Cheng, H Hill, A Bhardwaj, B N Raja Sekhar, N J Mason, B Sivaraman, *The European Journal D*, **76**, 2022.
 9. Vacuum ultraviolet photoabsorption spectra of icy isoprene and its oligomers. R Ramachandran, S Pavithraa, J K Meka, **K K Rahul**, J -I Lo, S -L Chou, B -M Cheng, B N Rajasekhar, A Bhardwaj, N J Mason, B Sivaraman, *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, **268**, 120586, 2022.
 10. Phenol in High-mass Star-forming Regions. R Ghosh, M, S K Mondal, P Gorai, D Sahu, **R K Kushwaha**, B Sivaraman and A Das, *Research in Astronomy and Astrophysics*, **22**, 065021, 2022
 11. Mid-IR and VUV spectroscopic characterisation of thermally processed and electron irradiated CO₂ astrophysical ice analogues. D V Mifsud, Z Kaňuchová, S Ioppolo, P

Herczku, A Traspas Muiña, T A Field, P A Hailey, Z Juhász, S T S Kovács, N J Mason, R W McCullough, S Pavithraa, **K K Rahul**, B Paripás, B Sulik, S -L, Chou, J -I Lo, A Das, B -M Cheng, B N Rajasekhar, A Bhardwaj, B Sivaraman, *Journal of Molecular Spectroscopy*, **385**, 111599, 2022

12. Sticking of dust/ micrometeorite particles on to ices at high impact velocities - Implications for astrochemical ice enrichment. E Shivakarhik, J K Meka, Harish, V S Surendra, **K K Rahul**, R Thombre, H Hill, S Vijayan, B Sivaramana, *Planetary and Space Science*, **104972**, 2020.

13. Vacuum Ultraviolet Photoabsorption of Prime Ice Analogues of Pluto and Charon. S Pavithraa, J -I Lo, **K Rahul**, B -M Cheng, N J Mason, B Sivaraman, *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, **190**, 2018.

Presented at Conferences

1. Astrochemistry Experimental Setup at Atomki-ECRIS: A Europlanet Facility, **Kushwaha, R. K.**, Rácz, R., Kovács, S. T. S., Herczku, P., Sulik, B., Juhász, Z., Biri, S., Mifsud, D. V., Ioppolo, S., Kanuchová, Z., Field, T. A., Hailey, P., McCullough, R., and Mason, N. J., EPSC 2022, Granada, Spain, 18–23 Sep 2022, *EPSC2022-1019*, 2022.
2. Graphene in Titan. **Kushwaha, R. K.**, A Mallya, D Sahu, J K Meka, S -L Chou, Y -J Wu, D Gupta, A Das, J -I Lo, B -M Cheng, B N Rajasekhar, A Bhardwaj, H Hill, J Padmanabhan, N J Mason, B Sivaraman. *EPSC2021-480*, 2021.
3. Biomarker on Callisto **Kushwaha, R. K.**, J-I Lo, B M Cheng, B N Rajasekhar, N J Mason, B Sivaraman. *EPSC2020-1005*, 2020.