

Dr. Dipen Sahu

CONTACT INFORMATION Ramanujan Fellow
AMOPH Division
Physical Research Laboratory
Thaltej campus, Ahmedabad, Gujarat, 380058
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Associated with:
Star-formation group
Academia Sinica Institute of Astronomy and Astrophysics
AS/NTU Astronomy-Mathematics Building,
No.1, Sec. 4, Roosevelt Rd,Taipei, Taiwan

RESEARCH INTERESTS mm-submm astronomy, physical and chemical evolution of low-mass star forming regions, astrochemical modeling, protoplanetary disk, star and planet formation

EDUCATION **University of Calcutta**, Kolkata, India

Ph.D., Astrochemistry (Theo. Phy.), *Degree* May 2017

- Thesis Topic: *Astrophysical processes leading to deuterium enrichment of the Interstellar Medium*
- Advisors: Dr.Ankan Das, Ph.D and Prof. Sandip K. Chakrabarti, Ph.D

Post M.Sc Project., S N Bose National Centre for Basic Sciences, 2012

- The formation of Protostar by a two dimensional hydrodynamic Code

University of Calcutta, Kolkata, India

M.Sc., Pure Physics July 2011

- *Mention: First Class*

University of Calcutta, Kolkata, India

B.Sc., Physics honours June 2009

- *Mention: First Class*

RESEARCH EXPERIENCE **Ramanujan Fellow** August 2022 - present
Physical Research Laboratory, Ahmedabad, India
Post-Doctoral Fellow April 2019 - July 2022
Academia Sinica Institute of Astronomy and Astrophysics, Taiwan
Post-Doctoral Fellow Dec. 2018 - April 2019
Indian Institute of Astrophysics, India
Visiting Post-Doctoral Fellow Aug. 2018 to mid-Nov
Department of Astronomy and Astrophysics,
Tata Institute of Fundamental Research, India
Post-Doctoral Fellow July 2016 to July 2018
Atomic, molecular and optical physics division,
Physical Research Laboratory
Ph. D. student Feb 2012 to June 2016
Division of Astrochemistry and Astrobiology
Indian Centre for Space Physics (Affiliated to University of Calcutta), India,

HONORS, AWARDS
AND FELLOWSHIPS

- Ramanujan Fellowship, 2022: Ramanujan Fellowship is meant for brilliant Indian scientists and engineers from outside India to take up scientific research positions in India, Department of Science of Technology, Govt. of India
 - AS-Fellow award, 2021. It is a competitive and honorary postdoctoral award by Academia Sinica(AS), with only one award for each stream (AS is the top national research academy of Taiwan, Global Top 200, 18th in Reuters World's Most Innovative Research Institutions of 2019).
 - 'Leids Kerkhoven-Bosscha Fonds' (LKBF) grant to collaborate and work at one of the Dutch astronomical institutes- Kapteyn Institute, Groningen, 2021.
 - Member of the ALMA Regional Center (ARC), Taiwan node (2019 -2022 .
 - Member of International Science Development (ISDT) Team of TMT.
 - Invited Visitor Scientist, Laboratoire d'astrophysique de Bordeaux, France, 2018.
 - ASIAA-visitor award, Academia Sinica Institute of Astronomy, Taiwan, 2018
 - ASIAA-visitor Award, Academia Sinica Institute of Astronomy, Taiwan, 2017.
 - Young-Visitor Award, Korea Astronomy and Space Science Institute (KASI), South Korea, 2016.
 - Young-Visitor Award, Korea Astronomy and Space Science Institute (KASI), South Korea, 2015.
 - Post-Doctoral Fellowship, Indian Institute of Astrophysics, India.
 - Post-Doctoral Fellowship, Physical Research Laboratory, India.
 - Senior Research Fellowship, Ministry of Earth Science (MoES), India.
 - Junior Research Fellowship, Indian Space Research Organization(ISRO) Respond project.
 - UST, Korea and GUAS/SOKENDAI, Japan grant to attend UST-GUAS radio astronomy winter school, Jeju Island, South Korea, 2015.
 - The Open University, UK grant to attend European Astronomical Society conference (EWASS/EAS-2018), Liverpool, UK, 2018.
 - The Committee on Space Research (COSPAR) Grant to attend the COSPAR Assembly, Pasadena, USA, 2018.
 - Qualified National Eligibility Test (NET-December, 2012) .
 - Qualified TIFR (GS-2012).
 - Qualified IIA (December, 2011).
 - Qualified BARC (2011).
 - Qualified GATE-2011, 2013.
- (Note: These are national level & highly competitive test in India)

REFEREED
JOURNAL
PUBLICATIONS

1. **“Shock processing of amorphous carbon nanodust”**, Roy, A., Singh, S. V., Ambresh, M., Sahu, D., Meka, J. K., Ramachandran, R., Samarth, P., Pavithraa, S., Jayaram, V., Hill, H., Cami, J., Rajasekhar, B. N., Janardhan, P., Bhardwaj, A., Mason, N. J., & Sivaraman, B., *Advances in Space Research*,70,2571, (2022).
2. **“Phenol in High-mass Star-forming Regions”**, Ghosh, R., Sil, M., Kumar Mondal, S., Gorai, P., Sahu, D., Kumar Kushwaha, R., Sivaraman, B., & Das, A., *Research in Astronomy and Astrophysics*,22,065021, (2022).
3. **“ALMA Survey of Orion Planck Galactic Cold Clumps (ALMASOP): How Do Dense Core Properties Affect the Multiplicity of Protostars?”**, Luo, Q.-yi ., Liu, T., Tatematsu, K., Liu, S.-Y., Li, P. S., di Francesco, J., Johnstone, D., Goldsmith, P. F., Dutta, S., Hirano, N., Lee, C.-F., Li, D., Kim, K.-T., Won Lee, C., Lee, J.-E., Liu, X.-chuan ., Juvela, M., He, J., Qin, S.-L., Liu, H.-L., Eden, D., Kwon, W., Sahu, D., Li, S., Xu, F.-W., Zhang, S.-ju ., Hsu, S.-Y., Bronfman, L., Sanhueza, P., Pelkonen, V.-M., Zhou, J.-wen ., Liu, R., Gu, Q.-lao ., Wu, Y.-fang ., Mai, X.-feng ., Falgarone, E., & Shen, Z.-Q., *The Astrophysical Journal*,931,158, (2022).

4. **“ALMA Survey of Orion Planck Galactic Cold Clumps (ALMASOP): Evidence for a Molecular Jet Launched at an Unprecedented Early Phase of Protostellar Evolution”**, Dutta, S., Lee, C.-F., Hirano, N., Liu, T., Johnstone, D., Liu, S.-Y., Tatematsu, K., Goldsmith, P. F., Sahu, D., Evans, N. J., Sanhueza, P., Kwon, W., Qin, S.-L., Samal, M. R., Zhang, Q., Kim, K.-T., Shang, H., Lee, C. W., Moraghan, A., Jhan, K.-S., Li, S., Lee, J.-E., Traficante, A., Juvela, M., Bronfman, L., Eden, D., Soam, A., He, J., Liu, H.-li., Kuan, Y.-J., Pelkonen, V.-M., Luo, Q., Yi, H.-W., & Hsu, S.-Y., *The Astrophysical Journal*,931,130, (2022).
5. **“Nobeyama Survey of Inward Motions toward Cores in Orion Identified by SCUBA-2”**, Tatematsu, K., Yeh, Y.-T., Hirano, N., Liu, S.-Y., Liu, T., Dutta, S., Sahu, D., Evans, N. J., Juvela, M., Yi, H.-W., Lee, J.-E., Sanhueza, P., Li, S., Eden, D., Kim, G., Lee, C.-F., Wu, Y., Kim, K.-T., Tóth, L. V., Choi, M., Kang, M., Thompson, M. A., Fuller, G. A., Li, D., Wang, K., Sakai, T., Kandori, R., Hsu, S.-Y., Chiong, C.-C., & “Almasop” Collaboration, *The Astrophysical Journal*,931,33, (2022).
6. **“ALMA Survey of Orion Planck Galactic Cold Clumps (ALMASOP): Deriving Inclination Angle and Velocity of the Protostellar Jets from Their SiO Knots”**, Jhan, K.-S., Lee, C.-F., Johnstone, D., Liu, T., Liu, S.-Y., Hirano, N., Tatematsu, K., Dutta, S., Moraghan, A., Shang, H., Lee, J.-E., Li, S., Liu, C.-F., Hsu, S.-Y., Kwon, W., Sahu, D., Liu, X.-C., Kim, K.-T., Luo, Q., Qin, S.-L., Sanhueza, P., Bronfman, L., Qizhou, Z., Eden, D., Traficante, A., Lee, C. W., & Almasop Team, *The Astrophysical Journal*,931,L5, (2022).
7. **“ALMA Survey of Orion Planck Galactic Cold Clumps (ALMASOP): A Hot Corino Survey toward Protostellar Cores in the Orion Cloud”**, Hsu, S.-Y., Liu, S.-Y., Liu, T., Sahu, D., Lee, C.-F., Tatematsu, K., Kim, K.-T., Hirano, N., Yang, Y.-L., Johnstone, D., Liu, H., Juvela, M., Bronfman, L., Chen, H.-R. V., Dutta, S., Eden, D. J., Jhan, K.-S., Kuan, Y.-J., Lee, C. W., Lee, J.-E., Li, S., Liu, C.-F., Qin, S.-L., Sanhueza, P., Shang, H., Soam, A., Traficante, A., & Zhou, J., *The Astrophysical Journal*,927,218, (2022).
8. **“ALMA Survey of Orion Planck Galactic Cold Clumps (ALMASOP): Detection of a Dense SiO Jet in the Evolved Protostellar Phase”**, Dutta, S., Lee, C.-F., Johnstone, D., Liu, T., Hirano, N., Liu, S.-Y., Lee, J.-E., Shang, H., Tatematsu, K., Kim, K.-T., Sahu, D., Sanhueza, P., di Francesco, J., Jhan, K.-S., Lee, C. W., Kwon, W., Li, S., Bronfman, L., Liu, H.-L., Traficante, A., Kuan, Y.-J., Hsu, S.-Y., Moraghan, A., Liu, C.-F., Eden, D., Soam, A., Luo, Q., & (Almasop Team), *The Astrophysical Journal*,925,11, (2022).
9. **“The JCMT Transient Survey: Four-year Summary of Monitoring the Submillimeter Variability of Protostars”**, Lee, Y.-H., Johnstone, D., Lee, J.-E., Herczeg, G., Mairs, S., Contreras-Peña, C., Hatchell, J., Naylor, T., Bell, G. S., Bourke, T. L., Broughton, C., Francis, L., Gupta, A., Harsono, D., Liu, S.-Y., Park, G., Plovie, S., Moriarty-Schieven, G. H., Scholz, A., Sharma, T., Teixeira, P. S., Wang, Y.-T., Aikawa, Y., Bower, G. C., Vivien Chen, H.-R., Bae, J., Baek, G., Chapman, S., Ping Chen, W., Du, F., Dutta, S., Forbrich, J., Guo, Z., Inutsuka, S.-ichiro., Kang, M., Kirk, H., Kuan, Y.-J., Kwon, W., Lai, S.-P., Lalchand, B., Lane, J. M. M., Lee, C.-F., Liu, T., Morata, O., Pearson, S., Pon, A., Sahu, D., Shang, H., Stamatellos, D., Tang, S.-Y., Xu, Z., Yoo, H., & Rawlings, J. M. C., *The Astrophysical Journal*,920,119, (2021).
10. **“Planck Galactic Cold Clumps at High Galactic Latitude-a Study with CO Lines”**, Xu, F., Wu, Y., Liu, T., Liu, X., Zhang, C., Esimbek, J., Qin, S.-L.,

- Li, D., Wang, K., Yuan, J., Meng, F., Zhang, T., Eden, D., Tatematsu, K., Evans, N. J., Goldsmith, P. F., Zhang, Q., Henkel, C., Yi, H.-W., Lee, J.-E., Saajasto, M., Kim, G., Juvela, M., Sahu, D., Hsu, S.-Y., Liu, S.-Y., Dutta, S., Lee, C.-F., Zhang, C.-P., Xu, Y., & Ju, B., *The Astrophysical Journal*, 920, 103, (2021).
11. **“Molecular Cloud Cores with High Deuterium Fractions: Nobeyama Mapping Survey”**, Tatematsu, K., Kim, G., Liu, T., Evans, N. J., Yi, H.-W., Lee, J.-E., Wu, Y., Hirano, N., Liu, S.-Y., Dutta, S., Sahu, D., Sanhueza, P., Kim, K.-T., Juvela, M., Tóth, L. V., Fehér, O., He, J., Ge, J., Feng, S., Choi, M., Kang, M., Thompson, M. A., Fuller, G. A., Li, D., Ristorcelli, I., Wang, K., di Francesco, J., Eden, D., Ohashi, S., Kandori, R., Vastel, C., Hirota, T., Sakai, T., Lu, X., Nguyễn Lu’O’Ng, Q., Shinnaga, H., Kim, J., Scope Collaboration, & Jcmt Large Program, *The Astrophysical Journal Supplement Series*, 256, 25, (2021).
 12. **“Identification of Methyl Isocyanate and Other Complex Organic Molecules in a Hot Molecular Core, G31.41+0.31”**, Gorai, P., Das, A., Shimonishi, T., Sahu, D., Mondal, S. K., Bhat, B., & Chakrabarti, S. K., *The Astrophysical Journal Letter*, 907, 108, (2021).
 13. **“ALMA Survey of Orion Planck Galactic Cold Clumps (ALMASOP): Detection of Extremely High-density Compact Structure of Prestellar Cores and Multiple Substructures Within”**, Sahu, D., Liu, S.-Y., Liu, T., Evans, N. J., Hirano, N., Tatematsu, K., Lee, C.-F., Kim, K.-T., Dutta, S., Alina, D., Bronfman, L., Cunningham, M., Eden, D. J., Garay, G., Goldsmith, P. F., He, J., Hsu, S.-Y., Jhan, K.-S., Johnstone, D., Juvela, M., Kim, G., Kuan, Y.-J., Kwon, W., Lee, C. W., Lee, J.-E., Li, D., Li, P. S., Li, S., Luo, Q.-Y., Montillaud, J., Moraghan, A., Pelkonen, V.-M., Qin, S.-L., Ristorcelli, I., Sanhueza, P., Shang, H., Shen, Z.-Q., Soam, A., Wu, Y., Zhang, Q., & Zhou, J., *The Astrophysical Journal*, 907, L15, (2021).
 14. **“ALMA Survey of Orion Planck Galactic Cold Clumps (ALMASOP). II. Survey Overview: A First Look at 1.3 mm Continuum Maps and Molecular Outflows”**, Dutta, S., Lee, C.-F., Liu, T., Hirano, N., Liu, S.-Y., Tatematsu, K., Kim, K.-T., Shang, H., Sahu, D., Kim, G., Moraghan, A., Jhan, K.-S., Hsu, S.-Y., Evans, N. J., Johnstone, D., Ward-Thompson, D., Kuan, Y.-J., Lee, C. W., Lee, J.-E., Traficante, A., Juvela, M., Vastel, C., Zhang, Q., Sanhueza, P., Soam, A., Kwon, W., Bronfman, L., Eden, D., Goldsmith, P. F., He, J., Wu, Y., Pelkonen, V.-M., Qin, S.-L., Li, S., & Li, D., *The Astrophysical Journal Supplement Series*, 251, 20, (2020).
 15. **“ALMA Survey of Orion Planck Galactic Cold Clumps (ALMASOP). I. Detection of New Hot Corinos with the ACA”**, Hsu, S.-Y., Liu, S.-Y., Liu, T., Sahu, D., Hirano, N., Lee, C.-F., Tatematsu, K., Kim, G., Juvela, M., Sanhueza, P., He, J., Johnstone, D., Qin, S.-L., Bronfman, L., Chen, H.-R. V., Dutta, S., Eden, D. J., Jhan, K.-S., Kim, K.-T., Kuan, Y.-J., Kwon, W., Lee, C. W., Lee, J.-E., Moraghan, A., Rawlings, M. G., Shang, H., Soam, A., Thompson, M. A., Traficante, A., Wu, Y., Yang, Y.-L., & Zhang, Q., *The Astrophysical Journal*, 898, 107, (2020).
 16. **“Constraints of the Formation and Abundances of Methyl Carbamate, a Glycine Isomer, in Hot Corinos”**, Sahu, D., Liu, S.-Y., Das, A., Garai, P., & Wakelam, V., *The Astrophysical Journal*, 899, 65, (2020).
 17. **“Corrigendum to ”Deuterium Enrichment of the Interstellar Medium” [New Astronomy, Volume 35, p. 53-70]”**, Das, A., Majumdar, L., Chakrabarti, S. K., & Sahu, D., *New Astronomy*, 70, 64, (2019).

18. **“Implications of a Hot Atmosphere/Corino from ALMA Observations toward NGC 1333 IRAS 4A1”**, Sahu, D., Liu, S.-Y., Su, Y.-N., Li, Z.-Y., Lee, C.-F., Hirano, N., & Takakuwa, S., *The Astrophysical Journal*,872,196, (2019).
19. **“Chemical Diagnostics of the Massive Star Cluster-forming Cloud G33.92+0.11. II. HDCS and DCN”**, Minh, Y. C., Liu, H. B., Galvań-Madrid, R., Sahu, D., He, J., & Hasegawa, T., *The Astrophysical Journal*,864,102, (2018).
20. **“Deuterated formaldehyde in the low-mass protostar HH212”**, Sahu, D., Minh, Y. C., Lee, C.-F., Liu, S.-Y., Das, A., Chakrabarti, S. K., & Sivaraman, B., *Monthly Notices of the Royal Astronomical Society*,475,5322, (2018).
21. **“SH stretching vibration of propanethiol ice—a signature for its identification in the interstellar icy mantles”**, Pavithraa, S., Sahu, D., Seth, G., Lo, J.-I., Raja Sekhar, B. N., Cheng, B.-M., Das, A., Mason, N. J., & Sivaraman, B., *Astrophysics and Space Science*,362,126, (2017).
22. **“Adsorption energies of H and H₂: a quantum-chemical study”**, Sil, M., Gorai, P., Das, A., Sahu, D., & Chakrabarti, S. K., *European Physical Journal D*,71,45, (2017).
23. **“Deuterium enrichment of the interstellar grain mantle”**, Das, A., Sahu, D., Majumdar, L., & Chakrabarti, S. K., *Monthly Notices of the Royal Astronomical Society*,455,540, (2016).
24. **“Monte Carlo simulation to investigate the formation of molecular hydrogen and its deuterated forms”**, Sahu, D., Das, A., Majumdar, L., & Chakrabarti, S. K., *New Astronomy*,38,23, (2015).
25. **“Methyl Acetate and Its Singly Deuterated Isotopomers in the Interstellar Medium”**, Das, A., Majumdar, L., Sahu, D., Gorai, P., Sivaraman, B., & Chakrabarti, S. K., *The Astrophysical Journal*,808,21, (2015).
26. **“Deuterium enrichment of the interstellar medium”**, Das, A., Majumdar, L., Chakrabarti, S. K., & Sahu, D., *New Astronomy*,35,53, (2015).

REVIEW ARTICLE • ‘Anatomy of Orion Molecular Clouds—The Astrochemistry Perspective/Approach’, by **Dipen Sahu**, Sheng-Yuan Liu and Tie Liu, a invited review article, published in *Frontiers in Astronomy and Space Sciences journal* 8:672893 (astrochemistry section, peer reviewed journal).

OTHER ARTICLES • Wrote a **chapter** “Role of Interstellar Molecules on Evolution of Cosmic Deuteration: An ALMA Observation as a Case in Point” in the book ‘Exploring the Universe: From Near Space to Extra-Galactic’, Springer, 2018, Pages 477-489.

• Jointly wrote an article with Shih-Ying Hsu, Sheng-Yuan Liu based on our work on complex organic molecules in hot-corino and prebiotic molecules. The article is accepted and published by Ministry of Science and Technology (MoST, Taiwan) in *Natural sciences news letter*, Volume 32, Issue 4, November, 2020 (in Taiwanese Mandarin language, [link](#)).

SUBMITTED PAPERS

1. ‘Modeling the density profiles of highly dense and centrally condensed prestellar cores from multiscale – single dish to interferometric (ALMA) observations’, Sahu et al. 2022, submitted to *Astrophysical Journal*.

PAPERS IN
PREPARATION
/ARXIV

1. ‘N-Graphene Synthesized in Astrochemical Ices’ KK Rahul, M Ambresh, D Sahu, JK Meka, S-L Chou, Y-J Wu, D Gupta, A Das, J-I Lo, B-M Cheng, BN Sekhar, A Bhardwaj, H Hill, P Janardhan, NJ Mason, B Sivaraman. arXiv preprint arXiv:2008.10011, in communication with ApJ

CONFERENCE
PROCEEDINGS

1. D. Sahu, C.-F. Lee, S.-Y. Liu, N. Hirano, Y.-N. Su, S. Takakuwa, and Z.-Y. Li, “A special case of COMs absorption towards NGC 1333 IRAS 4A1; implications of a Hot Atmosphere/Corino?”, in 43rd cospar scientific assembly. held 28 january- 4 february, Vol. 43 (Jan. 2021), p. 1997.8
2. D. Sahu, A. Das, V. Wakelam, P. Gorai, and S.-Y. Liu, “A glycine isomer, methyl carbamate towards hot corino objects?”, in 43rd cospar scientific assembly. held 28 january - 4 february, Vol. 43 (Jan. 2021), p. 1909
3. D. Sahu, A. Das, and C.-F. Lee, “Complex molecules and deuteration in a pristine jet-disk system, HH212”, in 42nd cospar scientific assembly, Vol. 42 (July 2018), F3.5-15–18
4. M. Sil, P. Gorai, A. Das, D. Sahu, and S. K. Chakrabarti, “Binding energy a key to defining interstellar volatile species”, in 42nd cospar scientific assembly, Vol. 42 (July 2018), B1.3-17–18
5. D. Sahu, Y. C. Minh, C.-F. Lee, S.-Y. Liu, A. Das, S. K. Chakrabarti, and B.Sivaraman, “Deuteration in the outflows of a low mass protostar system HH212: An ALMA observation of deuterated formaldehyde”, in 42nd cospar scientific assembly, Vol. 42 (July 2018), F3.2-23–1
6. A. Das, P. Gorai, D. Sahu, and S. K. Chakrabarti, “Deuteration of the Interstellar medium”, in 42nd cospar scientific assembly, Vol. 42 (July 2018), F3.5-14–1
7. D. Sahu, Y. C. Minh, and S. K. Chakrabarti, “Deuterated formaldehyde in HH212: physics and chemistry of a typical protostar”, in 41st cospar scientific assembly, Vol. 41 (July 2016), F3.1-62–16
8. P. Gorai, A. Das, L. Majumdar, D. Sahu, B. Sivaraman, and S. K. Chakrabarti, “Search for Deuterated methyl acetate in the ISM”, in 41st cospar scientific assembly, Vol. 41 (July 2016), F3.1-14–16
9. A. Das, D. Sahu, L. Majumdar, and S. K. Chakrabarti, “Deuterium enrichment of interstellar dusts”, in 41st cospar scientific assembly, Vol. 41 (July 2016), F3.1-6–16
10. D. Sahu, A. Das, and S. K. Chakrabarti, “Study the Formation of H₂, HD and D₂ under Various Interstellar Conditions”, in 41st cospar scientific assembly, Vol. 41 (July 2016), F3.1-29–16
11. A. Das, S. K. Chakrabarti, L. Majumdar, and D. Sahu, “Chemical composition of interstellar dust”, in 40th cospar scientific assembly, Vol. 40 (Jan. 2014), B0.5-4–14
12. D. Sahu, A. Das, S. K. Chakrabarti, and L. Majumdar, “Explaining the deuterium fractionation of Water: Modelling and observations”, in 40th cospar scientific assembly, Vol. 40 (Jan. 2014), B0.5-9–1
13. A. Das, L. Majumdar, D. Sahu, and S. K. Chakrabarti, “Co-relation of the degree of Ionization of a molecular cloud with the depletion of the neutral species on the interstellar dust”, in 40th cospar scientific assembly, Vol. 40 (Jan. 2014), F3.2-13–14

14. [D. Sahu](#), A. Das, S. K. Chakrabarti, and L. Majumdar, “Effective formation of simple molecules like H₂, D₂, HD on grain surfaces and various consequences”, in 40th cospar scientific assembly, Vol. 40 (Jan. 2014), F3.2-38–14
15. [D. Sahu](#), A. Das, L. Majumdar, and S. K. Chakrabarti, “Role of ambipolar diffusion towards the chemical evolution of molecular cloud”, in First international conference on chemical evolution of star forming region and origin of life:astrochem2012, Vol. 1543, edited by S. K. Chakrabarti, K. Acharyya, and A. Das, American Institute of Physics Conference Series (June 2013), pp. 236–24

RESEARCH
HIGHLIGHTS

- [Research highlighted \(press release\) based on Sahu et al. 2021 by these international observatories:](#)
 - ‘**ALMA reveals the very seeds of stars in the forming**’ by ALMA-Japan, National Observatory of Japan(NAOJ)
 - ‘**JCMT and ALMA: Hunting for stellar nurseries in Orion**’ by East Asian Observatory (JCMT- Hawaii, USA) and Shanghai Astronomical Observatory, China
 - ‘**ALMA reveals the very seeds of stars in the forming for the first time**’ Academia Sinica Institute of Astronomy and Astrophysics, Taiwan [\[link\]](#)
- Research highlighted by Phys.org is a (UK-based science, research and technology news aggregator) with a title ‘**Deuterated formaldehyde detected in protostar HH 112**’ based on Sahu et al. 2018. Sahu et al. 2018 was the first-ever article from India based on astrochemistry with ALMA.

SIGNIFICANT
RESEARCH
ACHIEVEMENTS

- To date, it is not known how multiple systems are born from a prestellar core and how a prestellar core looks just before the formation of protostars. For the first time, we have reported detection of centrally dense core (at a scale of 1000 au) and earliest signatures of protostar multiplicity (Sahu et al. 2021, ApJL). For more than three decades, researchers are studying the physical structure of prestellar cores. However, our results have unveiled a new class of prestellar cores (see the news release articles).
- In Sahu et al. (2019, ApJ), for the first time we have shown how optically thick emission can hide/affects source physical (e.g., magnetic field, density) and chemical properties (presence of complex organic molecules). Astronomy and Astrochemistry community now started realizing the role of opacity in (sub)millimeter domain (see cited papers)
- Prebiotic molecules in the interstellar medium may play an important role in the origin of life. Glycine, the simplest amino acid, is a prebiotic molecule detected in meteorites. However, it is yet to be detected in the ISM. Sahu et al. (ApJ, 2020) reported the tentative presence of a glycine isomer, methyl carbamate, toward protostars (hot corinos).

PROFESSIONAL
AND COMMUNITY
SERVICES

Organization of workshop and presentation

- As a part of scientific organizing committee we are organizing an international conference on ‘Dust-Ice-Gas Astrochemistry’, 17-18 November, 2022.
- Jointly with ARC (ALMA Regional Center) in Taiwan (One of the East Asian node) we organized ‘ALMA Imaging Workshop during September 1-2, 2020 at ASIAA, Taiwan.
Presented/teach: ‘Basic image analysis’ with CASA.

Event/conference chair

- Chair of ALMA Regional Centre (ARC) Taiwan node bi-weekly meeting, from October 2020 onward.
- Session chair in the conference/workshop ‘Workshop for Protoplanetary Disks and Exoplanets’, during Dec. 17-18, 2019, ASIAA, Taiwan.

Quality assurance of ALMA data

- ALMA data-sets undergo a series of quality assurance (QA) processes. The QA2 stage is an assurance that the observations have achieved the characteristics requested in the proposal. As a member of the ALMA observatory, we check (QA2) and release data notes to PIs after carefully inspecting the data.
- As a member of the ALMA regional center, I served the ALMA users by replying via the international helpdesk platform.

Referee for publications in peer-review journals

- External Reviewer for Astrophysical Journal, AAS Publication
- Review Editor of Frontiers in Astronomy and Space Sciences, for topics related to mm-submm astronomy and astrochemistry.
- Guest Editor of Frontiers in Astronomy and Space Sciences.

Reviewer of observing proposals

- Served as a reviewer of ALMA observing proposal
- Served as reviewer of JCMT observing proposal.

MAJOR
OBSERVING
PROPOSALS AS PI
AND CO-PI

- ***ALMA cycle-8 main call:** ‘Unveiling the kinematics of a highly dense prestellar core with substructures at 1000 au scale’, PI:**Dipen Sahu**, CoIs: Naomi Hirano, Shih-Ying Hsu, Kee-Tae Kim, Chin-Fei Lee, Shanghuo Li, Sheng-Yuan Liu, Tie Liu, Anthony Moraghan, Hsien Shang, Ken’ichi Tatematsu
- **NOEMA-observatory, 2020:** ‘Census of Complex Organic Molecules in YSOs toward Cepheus Flare’, PI: Shih-Ying Hsu, CoIs: Sheng-Yuan Liu, **Dipen Sahu**, Yao-Lun Yang
- ***NOEMA-observatory, 2020:** ‘The earliest phase of a multiple stellar system? Unveiling the kinematics and sub-structures in the dense prestellar ‘kernel’ at a scale of 1000 AU’, Science PI: **Dipen Sahu**, PI: Yuxin Lin CoIs: Sheng-Yuan Liu, Tie Liu, Naomi Hirano, Chin-Fei Lee, Ken’ichi Tatematsu, Shih-Ying Hsu, Somnath Dutta, Shanghuo li, Kee-Tae Kim, Anthony Moraghan
- ***SMA-observatory, 2020:** ‘Stability of centrally dense prestellar cores at a scale of 2000 AU’, PI: **Dipen Sahu**, CoIs: K.Tatematsu, Sheng-Yuan Liu, Tie Liu, Naomi hirano, kai-syun jhan, Chin-Fei Lee, Somnath Dutta, Shih-Ying Hsu, Anthony Moraghan, Sienny Shang, kee-tae kim, Gwanjeong Kim
- **NRO-45m observatory, 2020:** ‘The kinematic study of 37 cores embedded in Planck Galactic Clumps in the Orion’, PI: Gwanjeong Kim, CoIs: K.Tatematsu, Sheng-Yuan Liu, Tie Liu, **Dipen Sahu**, Naomi hirano, kai-syun jhan, Chin-Fei Lee, Somnath Dutta, Shih-Ying Hsu, Anthony Moraghan, Sienny Shang, kee-tae kim
- **SMA-observatory, 2019:** ‘Magnetic fields in the central regions of prestellar cores’, PI: Naomi Hirano, CoIs: Sheng-Yuan Liu , **Dipen Sahu** , Tie Liu , Kai-Syun Jhan , Somnath Dutta, Chin-fei Lee, Shih-Ying Hsu, Anthony Moraghan, Sienny Shang, Ken’ichi Tatematsu, Ramprasad Rao, Pak Shihg Li (UC Berkeley), Kee-Tae Kim
- **ALMA (ACA)-observatory, 2019:** ‘Ortho-H₂D⁺ in the cores close to the onset

of star formation’, PI: Naomi Hirano, CoIs: Sheng-Yuan Liu, Tie Liu, **Dipen Sahu** et al. 2019

- **JCMT large program, 2019:** ‘Submillimeter Polarization And Chemistry in Earliest star formation (SPACE)’, PI: Tie Liu, CoIs: Kee-Tae Kim, Sheng-Yuan Liu, Ken’ichi Tatematsu, David Eden, James Di Francesco, Naomi Hirano, Derek Ward-Thompson, **Dipen Sahu** and members mostly from ALMASOP team
- ***SMT- Arizona Radio Observatory:** December, 2017; ‘Gas Phase vs Grain Phase Chemistry: Formaldehyde and Deuterium Enrichment in the Prestellar Core L1544’, P.Is S.Y Liu, **D. Sahu**

INTERNATIONAL
PROJECTS AND
COLLABORATION

- A key member of a large observing project and collaborative science project- ALMA (**ALMA Survey of Orion Planck galactic cold clumps: ALMASOP**). The team consists of members from reputed institutes all over the World.
- Team member of a big research project - ‘**The JCMT Transient Survey.**’ It consists of more than 70 scientists all over the World with multiple science projects from ‘transient’ studies to ‘disk chemistry’/‘astrochemistry’.
- ‘Unveiling the physical structure and chemical composition of hot molecular cores by observation and astrochemical model’ this is only one project in astronomy and space science division sanctioned by India-Japan (DST-Japan Society for the Promotion of Science) funding authorities in the year 2019-2020. PI from India is Dr. Ankan Das, ICSP and PI from Japan is Dr. Takashi Shimonishi (Tohoku University). I am one of the Co-PIs and participants of the proposal.
- Member of International Science Development (ISDT) Team of TMT, Formation of Stars and Planets section, proposal title: ‘The role of disk-astrochemistry in understanding planet formation and exoplanet atmosphere’.
- P.I. for a proposal for participation in SKA-1 (Square Kilometer Array telescope) stage as a member of Department of Space institutions.

RESEARCH
EXPERTISE&
SKILLS

Research interests

- Astrochemistry modeling and observation
- Chemical evolution in Low-mass star forming region
- Protoplanetary disk chemistry and its connection with planet’s chemical compositions
- Deuterium enrichment in the Interstellar medium
- Molecular line transitions as tracers of physical conditions in molecular clouds

Skills

- Astrochemical modeling, Gas-grain modeling
- mm-submm observations
- Radiative transfer
- Synthetic line spectra
- Observing simulations

Technical

- Astrochemical modeling using KIDA databases and codes
- Simple hydrodynamics (e.g H.F. Shu’s model) to study time dependent chemistry in molecular clouds

- Monte-Carlo simulation for mono-layer grain chemistry
- CASA software for ALMA data analysis, Basic AIPS
- CASSIS for line-analysis and radiative transfer, Basic RADEX
- Fortran and Python for programming and plotting
- other software used: Xmgrace (plotting), SRIM/TRIM (for studying ion-matter interaction etc.)
- Linux as working environment, Latex for scientific writing

- ACADEMIC VISITS
- Visited Laboratoire d'astrophysique de Bordeaux from 17th Nov -1st Dec. 2018 for a collaborative work with Dr Valentine Wakelam and astrochemistry group.
 - Visited Academia Sinica Institute of Astronomy and Astrophysics from 1st Sept - 27th Oct. 2017 for a collaborative work on searching complex molecules using ALMA data
 - Visited Indian Institute of Sciences from 24th March- 9th April'17 (IISc, India) for a collaborative work on spectral line analysis of GMRT data.
 - Young Visitor, Korea Astronomy and Space Science Institute, Daejeon, South Korea. 12th June - 27th June 2016.
 - Young Visitor, Korea Astronomy and Space Science Institute, Daejeon, South Korea. 4th Oct.- 4th Nov. 2015.

- INVITED TALKS
- 'Unveiling the physical evolution of molecular cores and our chemical heritage through a multidisciplinary approach', National Astronomical Observatory of Japan(NAOJ), 13th March, 2021
 - 'The earliest stage of stellar-multiples? -millimeter studies on evolution of molecular cores', National Taiwan Normal University Colloquium, 23rd Feb., 2021
 - 'The apparent chemical diversity and physical structure of the IRAS 4A proto-binary system', CICO-VICO Fall 2020 Workshop, jointly organized by Chalmers University and University of Virginia, 14th-16th December.
 - 'Physical and chemical evolution of molecular clouds down to protoplanetary disk and our chemical origin', Chalmers University of Technology colloquium, 25th November, 2020
 - 'From Hot-corinos to our chemical heritage; the case of NGC1333 IRAS 4A', Astrochemistry Discussion (a reputed International online platform of astrochemist all over the World), 7th October, 2020
 - 'Interstellar Molecules, evolution of Sun-like stars and our chemical origin', Indian Center for Space Physics, Kolkata, India, 7th February, 2020
 - A pristine protostellar jet-disk system: HH212, and chemical complexity in it, Astrochemistry in the THz domain, Chennai, India 30-31st Oct. 2017

- CONTRIBUTED TALKS
- 'Astro-physical/chemical connection of early planetary atmospheres: Phosphine in Venus as a case ', Venus-Science conference, organized by Department of Space (PRL), Online Conference: 29-30 September 2022.
 - 'Estimating the density profile of a highly dense prestellar core with compact structure (1000s au) in OMC from multi-scale observations', East Asian ALMA conference, National Astronomical Observatory of Japan (NAOJ) (virtual); 18th-21th Jan., 2022,
 - 'Detection of extremely high density compact structure of prestellar cores and multiple substructures within', East Asian ALMA workshop organized by KASI, Korea; 17th-19th Feb., 2021
 - 'A Glycine isomer, methyl carbamate towards hot corion objects', 43rd COSPAR Assembly, 28th Jan. - 4th Feb, 2021
 - 'Implications of a Hot Atmosphere/Corino from ALMA Observations toward NGC

1333 IRAS 4A1' Astrochemical Frontiers Conference - Quarantine Edition, June 15 - 19, 2020; Sponsored by IAU Commission H2 Steering Committee: E. Bergin (President), P. Caselli (Vice-President), J. Jorgensen (Secretary), & Y. Aikawa, M. Cunningham, W. Geppert, K. Öberg, T. Millar (Ex-officio).

- 'Constraints of the formation and abundances of methyl carbamate, a glycine isomer, in hot corinos', The Astronomical Society of Republic of China (Taiwan) Meeting, ASIAA, Taipei, 3-4 September, 2020.
- Deuteration in the outflows of low-mass protostar system, HH212: An ALMA observation of deuterated formaldehyde, COSPAR-2018, 14-22th July 2018, Pasadena, USA.
- Complex molecules and deuteration in a pristine jet-disk system HH212, COSPAR-2018, 14-22th July 2018, Pasadena, USA.
- Tracing the low-mass star formation; complex molecules and hot-corino, EXPUNIV-2018, 14-17th Nov 2018, SNBNCBS, Kolkata, India.
- The Molecular Universe: study by means of modeling, experiment and observation, 4th April, 2017, Department of Physics, IISc, India.
- Developing a 2D hydrodynamic code to study the formation of proto-star and the Chemical evolution of cloud, International work.shop on chemical evolution and origin of life, 21-23 rd march, 2013, IIT Roorke , india
- Formation of H₂ , D₂ and HD on interstellar dust, Light Scattering technique and application to astronomy and other areas, 19-21st Nov, 2013, S N Bose National Centre for Basic Sciences, Kolkata, India.

POSTER

- 'A special case of COMs absorption towards NGC 1333 IRAS 4A1; implications of a hot atmosphere/corino?', 43rd COSPAR Assembly, 28th Jan. - 4th Feb, 2021.
- 'Prestellar cores and fragmentation in the Orion molecular clouds'; East-Asian ALMA Science Workshop 2019/2020, ASIAA, Taipei, Taiwan, February 19-21, 2020.
- 'Millimeter astronomy; the role of ISM molecules in understanding the physics and chemistry of low mass star-forming regions', XXXVIII Astronomical Society India meeting, IISER Tirupati, 13-17 Feb, 2020
- 'Gas phase complex organic molecules as a tracer of hot-corino; ALMA Observations toward NGC 1333 IRAS 4A1 as a case study', The Astronomical Society of Republic of China (Taiwan) Meeting, National Museum of Natural Science, Taichung, May 17 19, 2019.
- Complex Organic molecules from prestellar core to protostar; the case of L1544, HH212 and IRAS 4A, EWASS-2018, 3-6 April, 2018, Liverpool, UK.
- Methyl Acetate and its singly deuterated isotopomers in the interstellar medium, IDMC, 15-18 Dec, 2014, Tezpur University, Assam.
- Role of ambipolar diffusion towards the chemical evolution of molecular cloud , ASTROCHEM 2012, 10-13 July, 2012, S N Bose National Centre for Basic Sciences, Kolkata, India.

TEACHING & OUTREACH

Student research project:

- Supervising Mr. Khang Nguyen from University of Birmingham, UK for a summer student project (ASIAA, 2021) -'Unveiling the co-evity of embedded protostar multiplets from multiscale observations (ALMA) and molecular signatures'

Teaching experience:

- Teaches part of 'solar system studies' to the students for Post-Graduate Course in Space Science conducted under the auspices of Center for Space Science and Technology Education in Asia and the Pacific (CSSTEAP), 2017, ISRO campus.

Outreach:

- Demonstrated ‘Molecular transitions in space and Astrochemistry’ through video, model and poster during Nation Science Day 2017 to a gathering of people for two days in PRL, India.
- Took part in ‘Balloon flight’ projects for sending payloads, conducted by Indian centre for Space Physics (ICSP, India), 2012

REFERENCES

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