AstroChemical Newsletter #102

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You can access the full abstracts by clicking the paper titles. Submit your abstracts before the 25th of each month for inclusion in the following newsletter.

Abstracts

Observations of spiral and streamer on a candidate proto-brown dwarf

B. Riaz, D. Stamatellos, M. Machida

Spirals and streamers are the hallmarks of mass accretion during the early stages of star formation. We present the first observations of a large-scale spiral and a streamer towards a very young brown dwarf candidate in its early formation stages. These observations show, for the first time, the influence of external environment that results in asymmetric mass accretion via feeding filaments onto a candidate proto-brown dwarf in the making. The impact of the streamer has produced emission in warm carbon-chain species close to the candidate proto-brown dwarf. Two contrasting scenarios, a pseudo-disk twisted by core rotation and the collision of dense cores, can both explain these structures. The former argues for the presence of a strong magnetic field in brown dwarf formation while the latter suggests that a minimal magnetic field allows large-scale spirals and clumps to form far from the candidate proto-brown dwarf.

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Discovery of widespread non-metastable ammonia masers in the Milky Way

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We present the results of a search for ammonia maser emission in 119 Galactic high-mass star-forming regions (HMSFRs) known to host 22 GHz H2O maser emission. Our survey has led to the discovery of non-metastable NH3 inversion line masers toward 14 of these sources. This doubles the number of known non-metastable ammonia masers in our Galaxy, including nine new very high excitation (J,K) = (9,6) maser sources. These maser lines, including NH3 (5,4), (6,4), (6,5), (7,6), (8,6), (9,6), (9,8), (10,8), and (11,9), arise from energy levels of 342 K, 513 K, 465 K, 606 K, 834 K, 1090 K, 942 K, 1226 K, and 1449 K above the ground state. Additionally, we tentatively report a new metastable NH3 (3,3) maser in G048.49 and an NH3 (7,7) maser in G029.95. Our observations reveal that all of the newly detected NH3 maser lines exhibit either blueshifted or redshifted velocities with respect to the source systemic velocities. Among the non-metastable ammonia maser lines, larger velocity distributions, offset from the source systemic velocities, are found in the ortho-NH3 (K=3n) than in the para-NH3 (K≠3n) transitions.

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Discovery of thionylimide, HNSO, in space: the first N-, S- and O-bearing interstellar molecule

Miguel Sanz-Novo, Víctor M. Rivilla, Holger S. P. Müller, Izaskun Jiménez-Serra, Jesús Martín-Pintado, Laura Colzi, Shaoshan Zeng, Andrés Megías, Álvaro López-Gallifa, Antonio Martínez-Henares, Belén Tercero, Pablo de Vicente, David San Andrés, Sergio Martín, Miguel A. Requena-Torres

We present the first detection in space of thionylimide (HNSO) toward the Galactic Center molecular cloud G+0.693-0.027, thanks to the superb sensitivity of an ultradeep molecular line survey carried out with the Yebes 40m and IRAM 30m telescopes. This molecule is the first species detected in the interstellar medium containing, simultaneously, N, S and O. We have identified numerous Ka = 0, 1 and 2 transitions belonging to HNSO covering from Jup = 2 to Jup = 10, including several completely unblended features. We derive a molecular column density of N = (8 ± 1)e13 cm−2, yielding a fractional abundance relative to H2 of ~6e−10, which is about ~37 and ~4.8 times less abundant than SO and SO2, respectively. Although there are still many unknowns in the interstellar chemistry of NSO-bearing molecules, we propose that HNSO is likely formed through the reaction of the NSO radical and atomic H on the surface of icy grains, with alternative routes also deserving exploration. Finally, HNSO appears as a promising link between N- , S- and O- interstellar chemistry and its discovery paves the route to the detection of a new family of molecules in space.

Accepted in The Astrophysical Journal Letters
Full-text URL: https://arxiv.org/abs/2404.01044

First detection in space of the high-energy isomer of cyanomethanimine: H2CNCN

David San Andrés, Víctor M. Rivilla, Laura Colzi, Izaskun Jiménez-Serra, Jesús Martín-Pintado, Andrés Megías, Álvaro López-Gallifa, Antonio Martínez-Henares, Sarah Massalkhi, Shaoshan Zeng, Miguel Sanz-Novo, Belén Tercero, Pablo de Vicente, Sergio Martín, Miguel A. Requena-Torres, Germán Molpeceres, Juan García de la Concepción

We report the first detection in the interstellar medium of N-cyanomethanimine (H_2CNCN), the stable dimer of HCN of highest energy, and the most complex organic molecule identified in space containing the prebiotically relevant NCN backbone. We have identified a plethora of a-type rotational transitions with 3 ≤ Jup ≤ 11 and Ka ≤ 2 that belong to this species towards the Galactic Center G+0.693-0.027 molecular cloud, the only interstellar source showing the three cyanomethanimine isomers (including the Z- and E- isomers of C-cyanomethanimine, HNCHCN). We have derived a total column density for H_2CNCN of $(2.9\pm0.1)\times10^{12}$ cm^{-2}, which translates into a total molecular abundance with respect to H_2 of $(2.1\pm0.3)\times10^{-11}$. We have also revisited the previous detection of E- and Z-HNCHCN, and found a total C/N-cyanomethanimine abundance ratio of 31.8±1.8 and a Z/E-HNCHCN ratio of 4.5±0.2. While the latter can be explained on the basis of thermodynamic equilibrium, chemical kinetics are more likely responsible for the observed C/N-cyanomethanimine abundance ratio, where the gas-phase reaction between methanimine (CH_2NH) and the cyanogen radical (CN) arises as the primary formation route.

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FAUST XIII. Dusty cavity and molecular shock driven by IRS7B in the Corona Australis cluster

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The origin of the chemical diversity observed around low-mass protostars probably resides in the earliest history of these systems. We aim to investigate the impact of protostellar feedback on the chemistry and grain growth in the circumstellar medium of multiple stellar systems. In the context of the ALMA Large Program FAUST, we present high-resolution (50 au) observations of CH3OH, H2CO, and SiO and continuum emission at 1.3 mm and 3 mm towards the Corona Australis star cluster. Methanol emission reveals an arc-like structure at ~1800 au from the protostellar system IRS7B along the direction perpendicular to the major axis of the disc. The arc is located at the edge of two elongated continuum structures that define a cone emerging from IRS7B. The region inside the cone is probed by H2CO, while the eastern wall of the arc shows bright emission in SiO, a typical shock tracer. Taking into account the association with a previously detected radio jet imaged with JVLA at 6 cm, the molecular arc reveals for the first time a bow shock driven by IRS7B and a two-sided dust cavity opened by the mass-loss process. For each cavity wall, we derive an average H2 column density of ~7e21 cm−2, a mass of ~9e-3 M⊙, and a lower limit on the dust spectral index of 1.4. These observations provide the first evidence of a shock and a conical dust cavity opened by the jet driven by IRS7B, with important implications for the chemical enrichment and grain growth in the envelope of Solar System analogues.

A&A, 684, L12
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Chapter 1: The Astrobiology Primer 3.0

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Vincent, Jessica M. Weber, Maggie Meiqi Weng, Regina L. Wilpiszeki, and Amber Young

The Astrobiology Primer 3.0 (ABP3.0) is a concise introduction to the field of astrobiology for students and others who are new to the field of astrobiology. It provides an entry into the broader materials in this supplementary issue of Astrobiology and an overview of the investigations and driving hypotheses that make up this interdisciplinary field. The content of this chapter was adapted from the other 10 articles in this supplementary issue and thus represents the contribution of all the authors who worked on these introductory articles. The content of this chapter is not exhaustive and represents the topics that the authors found to be the most important and compelling in a dynamic and changing field.

The Astrobiology Primer 3.0. Astrobiology, 24(S1), S-4.
DOI: [10.1089/ast.2021.0129](https://doi.org/10.1089/ast.2021.0129)
Full-text URL: https://www.liebertpub.com/toc/ast/24/S1

Photocleavage of Aliphatic C-C Bonds in the Interstellar Medium

G. Tajuelo-Castilla, J.I. Mendieta-Moreno, M. Accolla, J.M. Sobrado, S. Canola, P. Jelínek, G.J. Ellis, J.A. Martín-Gago, G. Santoro

Ultraviolet (UV) processing in the interstellar medium (ISM) induces the dehydrogenation of hydrocarbons. Aliphatics, including alkanes, are present in different interstellar environments, being prevalently formed in evolved stars; thus, the dehydrogenation by UV photoprocessing of alkanes plays an important role in the chemistry of the ISM, leading to the formation of unsaturated hydrocarbons and eventually to aromatics, the latter ubiquitously detected in the ISM. Here, through combined experimental results and ab initio calculations, we show that UV absorption (mainly at the Lyα emission line of hydrogen at 121.6 nm) promotes an alkane to an excited Rydberg state from where it evolves toward fragmentation, inducing the formation of olefinic C=C bonds, which are necessary precursors of aromatic hydrocarbons. We show that the photochemistry of aliphatics in the ISM does not primarily produce direct hydrogen elimination but preferential C–C photocleavage. Our results provide an efficient synthetic route for the formation of unsaturated aliphatics, including propene and dienes, and suggest that aromatics could be formed in dark clouds by a bottom-up mechanism involving molecular fragments produced by UV photoprocessing of aliphatics.

2024 ApJ, 965, 184
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Full-text URL: https://arxiv.org/abs/2403.08452

Announcements

COST/DAN 2024 summer school on the astrochemistry of star & planet formation

First announcement: COST/DAN 2024 summer school on the astrochemistry of star & planet formation
When: 26-30 August 2024
Where: Groningen, The Netherlands
Registration Deadline: 15 May 2024

Contact email: nats2024@iac.es
Website: https://meetings.iac.es/nats2024/
We are very happy to announce that the 2024 COST/DAN summer school on the astrochemistry of star & planet formation will be held 26-30 August 2024 in Groningen, The Netherlands. Detailed information about the such as the programme, organising committees, registration, logistics, etc. can be found on the school's website.
The Astrochemistry Training School is organized by the COST Action NanoSpace (CA21126) in collaboration with the Dutch Astrochemistry Network (DAN). The main goal of the school is to provide PhD students and young researchers with specialised knowledge and training in the field of astrochemistry (e.g., theoretical and experimental tools). The programme will include sessions on astrophysical context, chemical processes in space, laboratory techniques, numerical models and theory, and the future of astrochemistry, as well as series of practical exercises and a participant poster session.
The school will be in person with attendance limited to 50-60 trainees and with priority given to PhD students and Young Researchers, who are strongly encouraged to participate. There is no registration fee and the NanoSpace COST Action will provide financial support (i.e. reimbursement after the event) for a significant number of participants (at least 20-30), with high priority to those with a primary affiliation at an institution located in an Inclusiveness Target Country (ITC) / Near Neighbour Country (NNC) participating in the COST Action. The information requested in the registration form will be used to select the final list of registered participants as well as those eligible for financial support, which will be notified in advance of the Training School (i.e., in the last week of May). The attendees are expected to arrange their own travel and accommodation following the instructions given by the organizing committee in due time.
Confirmed lecturers include:
Sergio Ioppolo, Aarhus University, Denmark
Thanja Lamberts, Leiden University, The Netherlands
Sandra Brünken, Radboud University, The Netherlands
Javier Goicoechea, Instituto de Física Fundamental (IFF-CSIC), Spain
Floris van der Tak, SRON, The Netherlands
Jacques le Bourlot, Observatoire de Paris, France
Maryvonne Gerin, French National Centre for Scientific Research (CNRS), France
Inga Kamp, University of Groningen, The Netherlands
Gerrit Groenenboom, Radboud University, The Netherlands
Alessandra Candian, University of Amsterdam, The Netherlands

Looking forward to meet you in Groningen!
The organizing committee:
Alessandra Candian (Amsterdam), Anibal García Hernández (Tenerife), Evelyne Roueff (Paris), Liv Hornekaer (Aarhus), Inga Kamp (Groningen), Ko-Ju Chuang (Leiden), Floris van der Tak (SRON)

Call for Papers: Special Issue in Honor of Harold Linnartz

On New Year's Eve, 2023, Harold Linnartz suddenly passed away at the age of 58. Harold was the head of the Astrophysics Laboratory of Leiden Observatory. He was a highly respected leader in the field of molecular astrophysics—specifically in the areas of molecular spectroscopy and its application to the carriers of the Diffuse Interstellar Bands, in the spectroscopy and reactions of low temperature solids as relevant to interstellar ices, and in the photochemistry of PAHs as they speak to the challenges of the AIBs.
With this Special Issue in ACS Earth and Space Chemistry, we want to honor Harold's

scientific legacy. We welcome articles on all aspects of molecular astrophysics; in particular, those that touch closely on Harold's scientific interests, which were very broad as, in his scientific career, he focused on unlocking the chemistry of the heavens in the broadest sense.
As a spectroscopist pur sang, shining light on molecules in space was one of his guiding principles. Fathoming the behavior of molecules under the extreme conditions of space was another. Topics that may be covered in the Special Issue may include, but are not limited to:
- Gas-phase spectroscopy
- Spectroscopy and dynamics of ices
- Photo physics of Polycyclic Aromatic Hydrocarbons and related compounds
- Astronomical observations involving molecules
- Modeling of astrophysical conditions, planets to galaxies

The deadline for submissions is January 1, 2025.
https://axial.acs.org/earth-space-and-environmental-chemistry/call-for-papers-special-issue-in-honor-of-harold-linnartz
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