

AstroChemical Newsletter #99

February 2024

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

ACA observation and chemical modeling of phosphorus nitride towards hot molecular cores G10.47+0.03 and G31.41+0.31

Arijit Manna, Sabyasachi Pal

Phosphorus (P) is one of the important elements for the formation of life and plays a crucial role in several biochemical processes. Recent spectral line surveys have confirmed the existence of P-bearing molecules, especially PN and PO, in the star-formation regions, but their formation mechanisms are poorly understood. The P-bearing molecule phosphorus nitride (PN) is detected in several star-forming regions, but this molecule has been poorly studied at high gas densities ($\geq 10^6 \text{ cm}^{-3}$) hot molecular cores. In this article, we present the detection of the rotational emission line of PN with transition $J = 3-2$ towards the hot molecular cores G10.47+0.03 and G31.41+0.31, using the Atacama Compact Array (ACA). The estimated column densities of PN for G10.47+0.03 and G31.41+0.31 using the local thermodynamic equilibrium (LTE) model are $(3.60 \pm 0.2) \times 10^{13} \text{ cm}^{-2}$ and $(9.10 \pm 0.1) \times 10^{12} \text{ cm}^{-2}$ with an excitation temperature of $150 \pm 25 \text{ K}$. The fractional abundance of PN relative to H_2 is 2.76×10^{-10} for G10.47+0.03 and 5.68×10^{-11} for G31.41+0.031. We compute the two-phase warm-up chemical model of PN to understand the chemical evolution in the environment of hot molecular cores. After chemical modelling, we claim that PN is created in the gas phase via the neutral-neutral reaction between PO and N in the warm-up stage. Similarly, PN is destroyed via the ion-neutral reaction between H_3O^+ and PN.

J. Astrophys. Astron 45, 3 (2024)

DOI: [10.1007/s12036-023-09989-x](https://doi.org/10.1007/s12036-023-09989-x)

Full-text URL: <https://arxiv.org/abs/2310.09514>

Vanadium oxide clusters in substellar atmospheres: A quantum chemical study

H. Lecoq-Molinos, D. Gobrecht, J.P. Sindel, Ch. Helling, L. Decin

We aim to understand the formation of cloud condensation nuclei in oxygen-rich substellar atmospheres by calculating fundamental properties of the energetically most favorable vanadium oxide molecules and clusters. A hierarchical optimization approach is applied in order to find the most favorable structures for clusters of $(\text{VO})_N$ and $(\text{VO}_2)_N$ for $N=1-10$, and $(\text{V}_2\text{O}_5)_N$ for $N=1-4$ and to calculate their thermodynamical potentials. The candidate geometries are initially optimized applying classical interatomic potentials and then refined at the B3LYP/cc-pVTZ level of theory to obtain accurate zero-point energies and thermochemical quantities. We present previously unreported vanadium oxide cluster structures as lowest-energy isomers. We report revised cluster energies and their thermochemical properties. Chemical equilibrium calculations are used to assess the impact of the updated and newly derived thermodynamic potentials on the gas-phase abundances of vanadium-bearing species. In chemical equilibrium, larger clusters from different stoichiometric families are found to be the most abundant vanadium-bearing species for temperatures below $\sim 1000 \text{ K}$, while molecular VO is the most abundant between $\sim 1000 \text{ K}$ and $\sim 2000 \text{ K}$. We determine the nucleation rates of each stoichiometric family for a given $(T_{\text{gas}}, p_{\text{gas}})$ profile of a brown dwarf using classical and non-classical nucleation theory. Small differences in the revised Gibbs free energies of the clusters have a large impact on the abundances of vanadium bearing species in chemical equilibrium at temperatures below $\sim 1000 \text{ K}$, which subsequently has an impact on the nucleation rates of each stoichiometric family. We find that with the revised and more accurate cluster data non-classical nucleation rates are up to 15 orders of magnitude higher than classical nucleation rates.

Accepted in A&A, 16 pages, 10 figures

Full-text URL: <https://arxiv.org/abs/2401.02784>

Stability of solid-state formamide under Ly α irradiation

T. Suhasaria, Th. Henning and V. Mennella

Formamide (NH_2CHO) plays a pivotal role as a crucial precursor to various prebiotic molecules, including sugars and nucleobases. To gain a deeper understanding of the chemical processes involving formamide formation in astrophysical settings, it becomes imperative to refine our comprehension through astrochemical models. These models necessitate not only the inclusion of pathways for formamide formation across diverse environments, but also the elucidation of mechanisms that lead to its degradation. Aims. The primary objective of this study is to scrutinize the influence of the underlying amorphous silicate substrate and the phase of formamide ice on the kinetics of its destruction and the resulting products upon exposure to Ly (121.6 nm) radiation at 16 K. Methods. To achieve this, we conducted an examination of the photodestruction of NH_2CHO ice, employing Fourier transform infrared spectroscopy. Results. Our findings reveal that, while the destruction rates of amorphous formamide ice remain consistent, regardless of the presence of an underlying amorphous olivine substrate, this substrate effectively reduces the formation of NH_3 , HNCO , and HCN within the ice following UV irradiation. On the other hand, contrary to common knowledge, crystalline formamide ice exhibits a considerably faster destruction rate, by an order of magnitude, than its amorphous counterpart under photo processing. Conclusions. In the interstellar medium, molecular ices often undergo phase changes depending on the environmental conditions. Our results indicate that crystalline formamide ice is more susceptible to rapid destruction than its amorphous counterpart, rendering it more elusive for detection within the lifetime of dense interstellar clouds. Furthermore, our findings emphasise the crucial significance of accounting for the influence of underlying dust grain surfaces in astrochemical models, as they have an effect on product formation during the degradation of molecular ices.

Accepted in Astronomy & Astrophysics

DOI: [10.1051/0004-6361/202348582](https://doi.org/10.1051/0004-6361/202348582)

Full-text URL: <https://arxiv.org/abs/2203.12390>

ATOMIUM: Molecular inventory of 17 oxygen-rich evolved stars observed with ALMA

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Context. The dusty winds of cool evolved stars are a major contributor of the newly synthesised material enriching the Galaxy and future generations of stars. However, the details of the physics and chemistry behind dust formation and wind launching have yet to be pinpointed. Recent spatially resolved observations show the importance of gaining a more comprehensive view of the circumstellar chemistry, but a comparative study of the intricate interplay between chemistry and physics is still difficult because observational details such as frequencies and angular resolutions are rarely comparable. **Aims.** Aiming to overcome these deficiencies, ATOMIUM is an ALMA Large Programme to study the physics and chemistry of the circumstellar envelopes of a diverse set of oxygen-rich evolved stars under homogeneous observing conditions at three angular resolutions between $\sim 0.02''$ – $1.4''$. Here we summarize the molecular inventory of these sources, and the correlations between stellar parameters and molecular content. **Methods.** Seventeen oxygen-rich or S-type asymptotic giant branch (AGB) and red supergiant (RSG) stars have been observed in several tunings with ALMA Band 6, targeting a range of molecules to probe the circumstellar envelope and especially the chemistry of dust formation close to the star. We systematically assigned the molecular carriers of the spectral lines and measured their spectroscopic parameters and the angular extent of the emission of each line from integrated intensity maps. **Results.** Across the ATOMIUM sample, we detect 291 transitions of 24 different molecules and their isotopologues. This includes several first detections in oxygen-rich AGB/RSG stars: PO $v = 1$, SO₂ $v_1 = 1$ and $v_2 = 2$, and several high energy H₂O transitions. We also find several first detections in S-type AGB stars: vibrationally excited HCN $v_2 = 2, 3$ and SiS $v = 4, 5, 6$, as well as first detections of the molecules SiC, AlCl, and AlF in W Aql. Overall, we find strong correlations between the following molecular pairs: CS and SiS, CS and AlF, NaCl and KCl, AlO and SO, SO₂ and SO, and SO₂ and H₂O; meaning both molecules tend to have more detected emission lines in the same sources. The measured isotopic ratios of Si and S are found to be consistent with previous measurements, except for an anomalously high ²⁹Si/³⁰Si ratio of 4 ± 1 in the RSG VX Sgr. **Conclusions.** This paper presents the overall molecular inventory and an initial analysis of the large ATOMIUM dataset, laying the groundwork for future work deriving molecular abundances and abundance profiles using radiative transfer modeling which will provide more rigorous tests for chemical models.

2024, Astronomy & Astrophysics, Volume 681, A50

DOI: [10.1051/0004-6361/202347632](https://doi.org/10.1051/0004-6361/202347632)

Full-text URL: <https://arxiv.org/abs/2312.03467>

Chemical tracers of a highly eccentric AGB–main-sequence star binary

T Danilovich, J Malfait, M Van de Sande, M Montargès, P Kervella, et al

Binary interactions have been proposed to explain a variety of circumstellar structures seen around evolved stars, including asymptotic giant branch (AGB) stars and planetary nebulae. Studies resolving the circumstellar envelopes of AGB stars have revealed spirals, disks and bipolar outflows, with shaping attributed to interactions with a companion. Here we use a combined chemical and dynamical analysis to reveal a highly eccentric and long-period orbit for W Aquilae, a binary system containing an AGB star and a main-sequence companion. Our results are based on anisotropic SiN emission, the detections of irregular NS and SiC emission towards the S-type star, and density structures observed in the CO emission. These features are all interpreted as having formed during periastron interactions. Our astrochemistry-based method can yield stringent constraints on the orbital parameters of long-period binaries containing AGB stars, and will be applicable to other systems.

Nature Astronomy, January 2024

DOI: [10.1038/s41550-023-02154-y](https://doi.org/10.1038/s41550-023-02154-y)

Full-text URL: <https://rdcu.be/du204>

Large-Scale Mapping Observations of DCN and DCO⁺ toward Orion KL

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We present emission maps of the DCN ($J=2-1$) and DCO⁺ ($J=2-1$) lines in the 2 mm band toward the Orion KL region obtained with the 2 mm receiver system named B4R installed on the Large Millimeter Telescope (LMT). The DCN emission shows a peak at the Orion KL hot core position, whereas no DCO⁺ emission has been detected there. The DCO⁺ emission shows enhancement at the west side of the hot core, which is well shielded from the UV radiation from OB massive stars in the Trapezium cluster. We have derived the abundance ratio of DCN/DCO⁺ at three representative positions where both species have been detected. The gas components with $V_{lsr} \sim 7.5$ – 8.7 km/s are associated with low abundance ratios of ~ 4 – 6 , whereas much higher abundance ratios (~ 22 – 30) are derived for the gas components with $V_{lsr} \sim 9.2$ – 11.6 km/s. We have compared the observed abundance ratio to our chemical models and found that the observed differences in the DCN/DCO⁺ abundance ratios are explained by different densities.

Accepted by The Astrophysical Journal

Full-text URL: <https://arxiv.org/abs/2401.06297>

A survey of molecular line emission towards Herbig Be star V645 Cyg

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We present a survey of molecular line emission towards the molecular cloud surrounding Herbig Be star V645 Cyg. The survey was performed with the 20-m Onsala space telescope at 3 and 4 mm. We detected emission lines of 33 molecules and their isotopologues from diatomic molecules to four COMs up to seven atoms. Using detected lines, we estimated molecular column densities and abundances relative to molecular hydrogen in local thermodynamic equilibrium (LTE) approximation for all molecules except for methanol, for which we obtained physical parameters using a non-LTE model. Moreover, in the basement of the non-LTE model of methanol line emission, we consider that there is a weak maser effect in the additional spectral component of 51–40 E methanol line at 84.521 GHz. We compared the molecular abundances with values found in several astrochemical templates: molecular clouds, hot cores, and photodissociation regions, and found that signatures of these different types can be found towards V645 Cyg. We also obtained maps of the cloud in several molecular emission lines. The peaks of CO and CH₃OH emission are shifted from the direction of the star, but the CS, HCO⁺, HNC, HCN,

and N₂H⁺ emission peaks are observed directly towards the star. Exploring the gas kinematics around V645 Cyg, we found that velocity structure in the ambient molecular cloud on the scale approx. 1.6–2.0 pc is not the same as within approx. 0.5 pc found previously by other authors.

Mon.Not.R.Astron.Soc., 2024., Vol. 528., P.108-121

DOI: [10.1093/mnras/stad3947](https://doi.org/10.1093/mnras/stad3947)

Full-text URL: <https://academic.oup.com/mnras/article/528/1/108/7492272>

Hunt for complex cyanides in protostellar ices with JWST: Tentative detection of CH₃CN and C₂H₅CN

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Nitrogen-bearing complex organic molecules have been commonly detected in the gas phase but not yet in interstellar ices. This has led to the long-standing question of whether these molecules form in the gas phase or in ices. James Webb Space Telescope (JWST) offers the sensitivity, spectral resolution, and wavelength coverage needed to detect them in ices and investigate whether their abundance ratios are similar in gas and ice. We report the first tentative detection of CH₃CN, C₂H₅CN, and the simple molecule, N₂O, based on the CN-stretch band in interstellar ices toward three (HOPS 153, HOPS 370, and IRAS 20126+4104) out of the five protostellar systems observed as part of the Investigating Protostellar Accretion (IPA) GO program with JWST-NIRSpec. We also provide upper limits for the two other sources with smaller luminosities in the sample. We detect OCN⁻ in the ices of all sources with typical CH₃CN/OCN⁻ ratios of around 1. Ice and gas column density ratios of the nitrogen-bearing species with respect to each other are better matched than those with respect to methanol, which are a factor of ~5 larger in the ices than the gas. We attribute the elevated ice column densities with respect to methanol to the difference in snowline locations of nitrogen-bearing molecules and of methanol, biasing the gas-phase observations toward fewer nitrogen-bearing molecules. Moreover, we find tentative evidence for enhancement of OCN⁻, CH₃CN, and C₂H₅CN in warmer ices, although formation of these molecules likely starts along with methanol in the cold prestellar phase. Future surveys combining NIRSpec and MIRI, and additional laboratory spectroscopic measurements of C₂H₅CN ice, are necessary for robust detection and conclusions on the formation history of complex cyanides.

Accepted for publication in A&A

Full-text URL: <https://arxiv.org/abs/2401.07901>

A deep search for large complex organic species toward IRAS16293-2422 B at 3 mm with ALMA

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Complex organic molecules (COMs) have been detected ubiquitously in protostellar systems. However, at shorter wavelengths (~0.8mm) it is more difficult to detect larger molecules than at longer wavelengths (~3mm) because of the increase of millimeter dust opacity, line confusion, and unfavorable partition function. We aim to search for large molecules (>8 atoms) in the ALMA Band 3 spectrum of IRAS 16293-2422 B. We search for more than 70 molecules and identify as many lines as possible in the spectrum. The spectral settings were set to specifically target three-carbon species such as propanol and glycerol. We identify lines of 31 molecules including many oxygen-bearing COMs such as CH₃OH and c-C₂H₄O and a few nitrogen- and sulfur-bearing ones such as HOCH₂CN and CH₃SH. The largest detected molecules are gGg-(CH₂OH)₂ and CH₃COCH₃. We do not detect glycerol or propanol but provide upper limits for them which are in line with previous laboratory and observational studies. The line density in Band 3 is only ~2.5 times lower in frequency space than in Band 7. From the detected lines in Band 3 at a ≥6σ level, ~25-30% of them could not be identified indicating the need for more laboratory data of rotational spectra. We find similar column densities and column density ratios of COMs (within a factor ~2) between Band 3 and Band 7. The effect of dust optical depth for IRAS 16293-2422 B at an off-source location on column densities and column density ratios is minimal. Moreover, for warm protostars, long wavelength spectra are not only crowded, but also take longer integration times to reach the same sensitivity limit. The 3mm search has not yet resulted in detection of larger and more complex molecules in warm sources. A full deep ALMA Band 2-3 (i.e., 3-4 mm) survey is needed to assess whether low frequency data have the potential to reveal more complex molecules in warm sources.

Accepted for publication in A&A

Full-text URL: <https://arxiv.org/abs/2401.04760>

Protonated acetylene in the z=0.89 molecular absorber toward PKS1830-211

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We report the first interstellar identification of protonated acetylene, C₂H₃⁺, a fundamental hydrocarbon, in the z=0.89 molecular absorber toward the gravitationally lensed quasar PKS1830-211. The molecular species is identified from clear absorption features corresponding to the 2_{12-1_01} (rest frequency 494.034 GHz) and 1_{11-0_00} (431.316 GHz) ground-state transitions of ortho and para forms of C₂H₃⁺, respectively, in ALMA spectra toward the southwestern image of PKS1830-211, where numerous molecules, including other hydrocarbons, have already been detected. From the simple assumption of local thermodynamic equilibrium (LTE) with cosmic microwave background photons and an ortho-to-para ratio of three, we estimate a total C₂H₃⁺ column density of 2 × 10¹² cm⁻² and an abundance of 10⁻¹⁰ compared to H₂. However, formation pumping could affect the population of metastable states, yielding a C₂H₃⁺ column density higher than the LTE value by a factor of a few. We explore possible routes to the formation of C₂H₃⁺, mainly connected to acetylene and methane, and find that the methane route is more likely in PDR environment. As one of the initial hydrocarbon building blocks, C₂H₃⁺ is thought to play an important role in astrochemistry, in particular in the formation of more complex organic molecules.

Accepted for publication in A&A

DOI: [10.1051/0004-6361/202348994](https://doi.org/10.1051/0004-6361/202348994)

Full-text URL: <https://arxiv.org/abs/2401.09975>

NEXT A Vision for the Future of Astrochemistry in the Interstellar Medium by 2050

Ryan C. Fortenberry

By 2050, many, but not nearly all, unattributed astronomical spectral features will be conclusively linked to molecular carriers (as opposed

to nearly none today in the visible and IR); amino acids will have been observed remotely beyond our solar system; the largest observatories ever constructed on the surface of the Earth or launched beyond it will be operational; high-throughput computation either from brute force or machine learning will provide unprecedented amounts of reference spectral and chemical reaction data; and the chemical fingerprints of the universe delivered by those of us who call ourselves astrochemists will provide astrophysicists with unprecedented resolution for determining how the stars evolve, planets form, and molecules that lead to life originate. Astrochemistry is a relatively young field, but with the entire universe as its playground, the discipline promises to persist as long as telescopic observations are made that require reference data and complementary chemical modeling. While the recent commissionings of the James Webb Space Telescope and Atacama Large Millimeter Array are ushering in the second “golden age” of astrochemistry (with the first being the radio telescopic boom period of the 1970s), this current period of discovery should facilitate unprecedented advances within the next 25 years. Astrochemistry forces the asking of hard questions beyond the physical conditions of our “pale blue dot”, and such questions require creative solutions that are influential beyond astrophysics. By 2050, more creative solutions will have been provided, but even more will be needed to answer the continuing question of our astrochemical ignorance.

ACS Phys. Chem Au 2024, 4, 1, 31–39

DOI: [10.1021/acsphyschemau.3c00043](https://doi.org/10.1021/acsphyschemau.3c00043)

Full-text URL: <https://pubs.acs.org/doi/10.1021/acsphyschemau.3c00043>

Decoding the molecular complexity of the solar-type protostar NGC 1333 IRAS 4A

Qutián-Lara Heidy M., Fantuzzi Felipe, Mason Nigel J., Boechat-Roberty Heloisa M.

The characterization of the molecular inventory of solar-type protostars is of crucial importance for a deep understanding of the chemical complexity underlying our cosmic origins. In this context, we present here the full millimetre line survey of the Class 0 protostellar object NGC 1333 IRAS 4A in the spectral bands at 3, 2, and 1.3 mm. In recognition of the powerful tool that unbiased spectral studies provide for investigating the chemistry and physics of star-forming regions, we provide a detailed description of the survey and the results of the analysis. We describe the identification of 1474 spectral lines belonging to 97 different molecular species, including complex organic molecules, which together cover the most ubiquitous chemical elements of life on Earth, namely carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulphur. The abundances obtained herein are compared with the Class 0 protostellar objects L483 and L1527, and selected molecular ratios are used as tracers of physicochemical properties of the sources. Particularly, the dominance of oxygen-bearing species and the presence of distinct excitation temperature regimes support the attribution of NGC 1333 IRAS 4A as a hot corino featuring three physical components with distinguished and diverse chemical composition.

MNRAS, 2024, 527, 4, 10294–10308

DOI: [10.1093/mnras/stad3873](https://doi.org/10.1093/mnras/stad3873)

Full-text URL: <https://academic.oup.com/mnras/article/527/4/10294/7478007>

CN and CCH azirine derivatives, possible precursors of prebiotic molecules: formation and spectroscopic parameters

P. Redondo, M. Sanz-Novato, C. Barrientos

N-heterocycles are of special relevance in astrobiology but at present no nitrogen-containing heterocycles have been detected in the interstellar medium (ISM). Thus far, the simplest N-heterocyclic compound, 2H-Azirine (c-C₂H₃N), has not been conclusively identified, despite being searched for. Recently, several cyano and ethynyl derivatives of unsaturated hydrocarbons have been discovered in the cold pre-stellar core Taurus Molecular Cloud 1 (TMC-1). The purpose of this work is to assess the feasibility of the possible formation of cyano and ethynyl derivatives of azirine (c-C₂H₂N-CN, c-C₂H₂N-CCH) under interstellar conditions and provide high-level theoretical spectroscopic parameters of the most relevant cyano- and ethynyl-azirine isomers to facilitate their experimental identification. Six isomers are located for each, cyano- and ethynyl-azirine derivatives, and their interconversion processes are studied. The reactions of 2H-azirine with the CN or CCH radicals in the gas phase are explored as possible formation routes of cyano and ethynyl azirine. We found that the formation processes of the most stable isomers, namely 3-cyano-2H-azirine, 2-cyano-2H-azirine, 3-ethynyl-2H-azirine, and 2-ethynyl-2H-azirine, are exothermic and barrier free. Thus, these compounds stand out as potential targets to be searched for in space. Based on the newly determined rotational spectroscopic parameters, which also account for ¹⁴N hyperfine splittings, we compile a line catalogue for each system up to 50 GHz as a preliminary and required step to characterize these molecules experimentally, whether in the laboratory or directly in the ISM.

2024, MNRAS, 527, 8670

DOI: [10.1093/mnras/stad3770](https://doi.org/10.1093/mnras/stad3770)

Full-text URL: <https://academic.oup.com/mnras/article/527/3/8659/7459928>

Announcements

The Astrochemistry Report Launch

The Astrochemistry Report launched on January 5, 2024 and owner & editor-in-chief Brielle Shope invites you to submit a contribution. The Astrochemistry Report shares current findings in the field of astrochemistry with the general public. Everyone is welcome - the curious-minded, the prospective student, to even the scholar of another field.

Research scientists in astrochemistry often share results with one another in academic journals, written at an expert level. These articles are full of jargon and assume prior knowledge. Such language is appropriate for learned researchers in the field but a complete whirlwind for someone who is just learning the ropes in the field or a casual onlooker. The Astrochemistry Report is a medium that can share these discoveries in terms easily understandable. Otherwise - if the community at large has no knowledge of the science completed - it might as well have never been done!

We live in an exciting time, when information can be spread instantly and globally. We hope that The Astrochemistry Report becomes a valuable resource to the general public and scholars across the globe: an avenue for graduate students, postdocs, and faculty to share their victories.

The owner & editor-in-chief is Brielle Shope, a fourth year graduate student at The University of Virginia. The current editorial team

includes Jessica Tennis and Ryan Fortenberry.

Please consider contributing an article and advertising this communications medium to your department/institution and friends and family. Articles can simply be 500-word lay summaries of your or another's recently published research.

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NASA Postdoctoral Program (NPP) Research Opportunity

Application Deadline: March 1, 2024 6:00:50 PM/18:00:59 US Eastern Time Zone (11:00:59 PM/23:00:59 UTC).

Description:

Our group studies the composition, evolution, as well as the physical and chemical properties of interstellar and planetary materials. More particularly, we focus on the evolution of astrophysical ices (on interstellar grains in dense molecular clouds, on grains in protoplanetary disks, in comets, or on the surface of icy worlds in our Solar System) and their interaction with energetic radiation (photons and energetic particles). We are particularly interested in how this leads to the formation of organic residues which contain a large variety of organic molecules including compounds of astrobiological interest. Such astrophysical ice analogs are produced in the laboratory under conditions that are realistically close to those expected in the interstellar and/or interplanetary medium (low temperatures, high vacuum), and analyzed using a range of analytical techniques which include infrared (IR) spectroscopy and microscopy, gas chromatography coupled to mass spectrometry (GC-MS), fluorescence microscopy, and X-ray absorption near-edge structure (XANES) spectroscopy. We also study the chemical and isotopic properties of the organic residues produced in our experiments, as well as the effects of energetic radiation on the composition and structure of these residues. The study of these materials provides us with qualitative and quantitative information to: (1) interpret astronomical observations; (2) interpret data taken from extraterrestrial samples (cosmic dust, meteorites, samples returned by spacecraft missions); (3) interpret data obtained by missions going to other Solar System objects; (4) help improve existing astrophysical and astrochemical models which need experimental inputs; and (5) guide instrument development for future missions. For more information on the Astrophysics & Astrochemistry Laboratory, visit our Web site at <http://www.astrochem.org>.

Location:
Ames Research Center, Moffet Field, California, USA

Field of Science:
Cosmochemistry, Astrochemistry

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Post-doc position: development of terahertz spectroscopy for atmospheric science (available until position is filled)

We expect to recruit a post-doc researcher for the STAR project co-funded by ANR (French National Research Agent) and ULCO (Université du Littoral Côte d'Opale, Dunkirk, France) starting in September 2024. Starting date may be negotiable in special case. This project focuses on the development of a continuous slit-jet expansion chamber coupled with various millimeter-wave / Terahertz spectrometers to study chemical reaction mechanism relevant to the atmosphere, climate and air quality.

Funding and Eligibility

The position is initially financed for 1 year and possible be extended depending on funding situation and performance. Candidates a PhD degree in physics, chemistry or relevant fields before the starting date of the position are welcome to apply. Indicative gross salary 2500€ monthly and can be negotiated based on the experience of the scholar.

How to apply:

Email with the subject "Postdoc application – ANR STAR" to luyao.zou@univ-littoral.fr, and include:

- * a cover letter
- * 1-2 pages summary of research activities
- * an up to date CV
- * name and email address of at least one referee who could write a recommendation letter.

You may also find more information about the project, the laboratory and requirements at: https://lpc.univ-littoral.fr/wp-content/uploads/2023/09/Postdoc_2024-sept_publicite.pdf

Equal Opportunity is University policy.

The application is open until the position is filled.

Multidisciplinary School of Astrochemistry

Astrochemistry has become a necessary tool for understanding the interstellar medium (ISM) of our Galaxy and external galaxies. Thanks to the development of large (sub-)millimeter telescopes and infrared space telescopes in the last decades, now we are aware of the existence of more than 300 molecules in interstellar and circumstellar regions, as well as of around 70 molecules in external galaxies. To unveil the physical and chemical properties of the underlying material is necessary to understand how this variety of molecules is formed in the gas and ice of such different environments. Laboratory experiments mimicking the conditions of the ISM and quantum chemical calculations are also key to determine the formation and destruction routes of the species identified in space. Only complex numerical simulations using high-performance computers can reproduce in a realistic way the physical and chemical evolution of interstellar matter during the formation of clouds, stars, and planets. In this regard, neural networks are becoming a common tool to afford the complex problems that astrochemists need to address.

"Multidisciplinary School of Astrochemistry" is designed to help PhD students and young post-docs to become familiarized with the

astrochemistry. Observations at mm and infrared wavelengths, molecular spectroscopy, dust properties, chemical models, laboratory experiments, numerical simulations and machine learning techniques, are included in our program. Although useful for astronomers of basically all fields, the school mainly focuses on star and planet formation, in order to understand how the precursors of life came to our planet.

For practical reasons the number of students is limited to 50. Students have the possibility to present a poster with their own work (not mandatory). At the end of the school, we will select the best own and give a symbolic poster-prize.

Registration opens on 1st of February (registration fee = 300 euros)

<https://cab.inta-csic.es/eventos/multidisciplinary-school-of-astrochemistry/>

EAS2024-S6: [1st Announcement] Symposium S6 "European Laboratory Astrophysics in the JWST era"

Symposium S6 "European Laboratory Astrophysics in the JWST era" <https://eas.unige.ch/EAS2024/session.jsp?id=S6> at the European Astronomical Society (EAS) annual meeting 2024

<https://eas.unige.ch/EAS2024/>,

PADOVA (ITALY) JULY 1-5, 2024

This symposium aims to foster new collaborations between experts in laboratory astrophysics and observational astrophysics. With the ground-breaking data from JWST, ALMA and the up-coming ELT, there is a strong need to establish productive links between the relevant communities.

The symposium will cover a variety of topics:

Ices, Tracers of astrochemistry, Molecular spectroscopy and reactivity, Protoplanetary discs and planets, Plasmas and dust in extreme environments as well as PAHs and fullerenes.

All interested researchers are invited to submit an abstract through the EAS website by March 4th:

https://eas.unige.ch/EAS_meeting/abstract_submission.jsp

Please note that meeting is planned to be a fully hybrid and on-line presentations will be possible except for invited speakers.

More information can be found on the session's webpage: <https://eas.unige.ch/EAS2024/session.jsp?id=S6>

Registration fee waivers and/or grants provided by EAS are also available on request: https://eas.unige.ch/EAS_meeting/grants.jsp

For any inquiries on the Symposium S6 please feel free to contact us.

Important dates:

- Very early bird registration deadline: *26 February 2024*
- *Abstract submission* deadline: *4 March 2024*
- Early bird registration deadline: *29 April 2024*
- Regular registration deadline: *30 June 2024*
- *Symposium S6 "European Laboratory Astrophysics in the JWST era": *1 - 2 July 2024*

The Scientific Organizing Committee

* Christine Joblin (Chair)

* Cristina Pizzarini (Co-Chair)

* Stephan Schlemmer (Co-Chair)

* Marcelino Agundez

* Nadia Balucani

* Olivier Berné

* Sandra Brünken

* Paola Caselli

* Emmanuel Dartois

* Franck Delahaye

* Jean-Hugues Fillion

* Thomas Henning

* Liv Hornaeker

* Cornelia Jäger

* Friedrich Kupka

* Martin McCoustra

* Vito Mennella

* Ewine van Dishoeck

* Henning Zettergren

EAS2024-S11 [Announcement]: Symposium S11 "Once upon a time... our astrochemical history"

Symposium S11 "Once upon a time... our astrochemical history" at the European Astronomical Society annual meeting 2024, to be held in Padova (Italy) from 1 to 5 July 2024.

This symposium aims to foster new collaborations between experts in astrochemical observations and modelling in order to draw a coherent picture of the origin and evolution of molecular complexity during the star formation process. We also aim to bring together the communities working on high and low mass star forming regions and protoplanetary discs to build an overall picture of star formation using astrochemistry.

All interested researchers are invited to submit an abstract through the EAS website by March 4th:

https://eas.unige.ch/EAS_meeting/abstract_submission.jsp

More information can be found on the session's webpage: https://eas.unige.ch/EAS_meeting/session.jsp?id=S11

Registration fee waivers and/or grants provided by EAS are also available on request: https://eas.unige.ch/EAS_meeting/grants.jsp

For any inquiries on the Symposium S11 please feel free to contact us.

Important dates:

- Very early bird registration deadline: 26 February 2024
- Abstract submission and fee waiver/grant requests deadline: 4 March 2024
- Early bird registration deadline: 29 April 2024
- Regular registration deadline: 30 June 2024
- Symposium S11 "Once upon a time... our astrochemical history": 3-4 July 2024

The Scientific Organizing Committee

Giovanni Sabatini (Chair)
Eleonora Bianchi (Co-Chair)
Catherine Walsh (Co-Chair)
Alice S. Booth
Stefano Bovino
Claudio Codella
Izaskun Jiménez-Serra
Linda Podio
Elena Redaelli
Dmitry Semenov
Benoît Tabone
Friedrich Wyrowski

New Graduate-Student-Organized Talks from the AstroCheminar Online Webinar Series

The ACS PHYS Astrochemistry Subdivision has been sponsoring a series of monthly AstroCheminars since Fall 2020. This year we have changed things up a bit and are sponsoring two types of events. We are co-sponsoring high profile Webinars with ACS, including a previous talk by Prof. Ewine van Dishoeck on JWST in November and an upcoming talk by Prof. Jose Cernicharo in April. We have turned over the organization of our other events to a committee of grad students. You can learn more about upcoming events and register for future webinars here: <http://astro.phys-acs.org/AstroCheminar.html>

The ACS PHYS Astrochemistry Subdivision welcomes new members. Members of the ACS PHYS Division can join the Subdivision free of any additional fee. The Astrochemistry Subdivision, which has recently celebrated its 10th anniversary, serves the world-wide community of astrochemists by hosting symposia at national ACS meetings and by hosting the monthly AstroCheminar series. We also bestow an annual award for the Outstanding Astrochemistry Dissertation from the previous three years. For more information about the Subdivision, visit: <http://astro.phys-acs.org>

PhD Position Carbon Chemistry on the Surfaces of the Galilean Ice Moons

In the group of Dr. Niels Ligterink at the Delft University of Technology (TU Delft, The Netherlands), a laboratory-based PhD project is available on the investigation of carbon chemistry on the heavily irradiated surfaces of the Galilean moons and unravel the endogenic and/or exogenic origin of these molecules. More info about the position and how to apply can be found here: [https://www.tudelft.nl/over-tu-delft/werken-bij-tu-delft/vacatures/details?](https://www.tudelft.nl/over-tu-delft/werken-bij-tu-delft/vacatures/details?jobId=16308&jobTitle=PhD%20Position%20Carbon%20Chemistry%20on%20the%20Surfaces%20of%20the%20Galilean%20Ice%20Moons)

[jobId=16308&jobTitle=PhD%20Position%20Carbon%20Chemistry%20on%20the%20Surfaces%20of%20the%20Galilean%20Ice%20Moons](https://www.tudelft.nl/over-tu-delft/werken-bij-tu-delft/vacatures/details?jobId=16308&jobTitle=PhD%20Position%20Carbon%20Chemistry%20on%20the%20Surfaces%20of%20the%20Galilean%20Ice%20Moons)
The deadline for applications is March 21st, 2024.