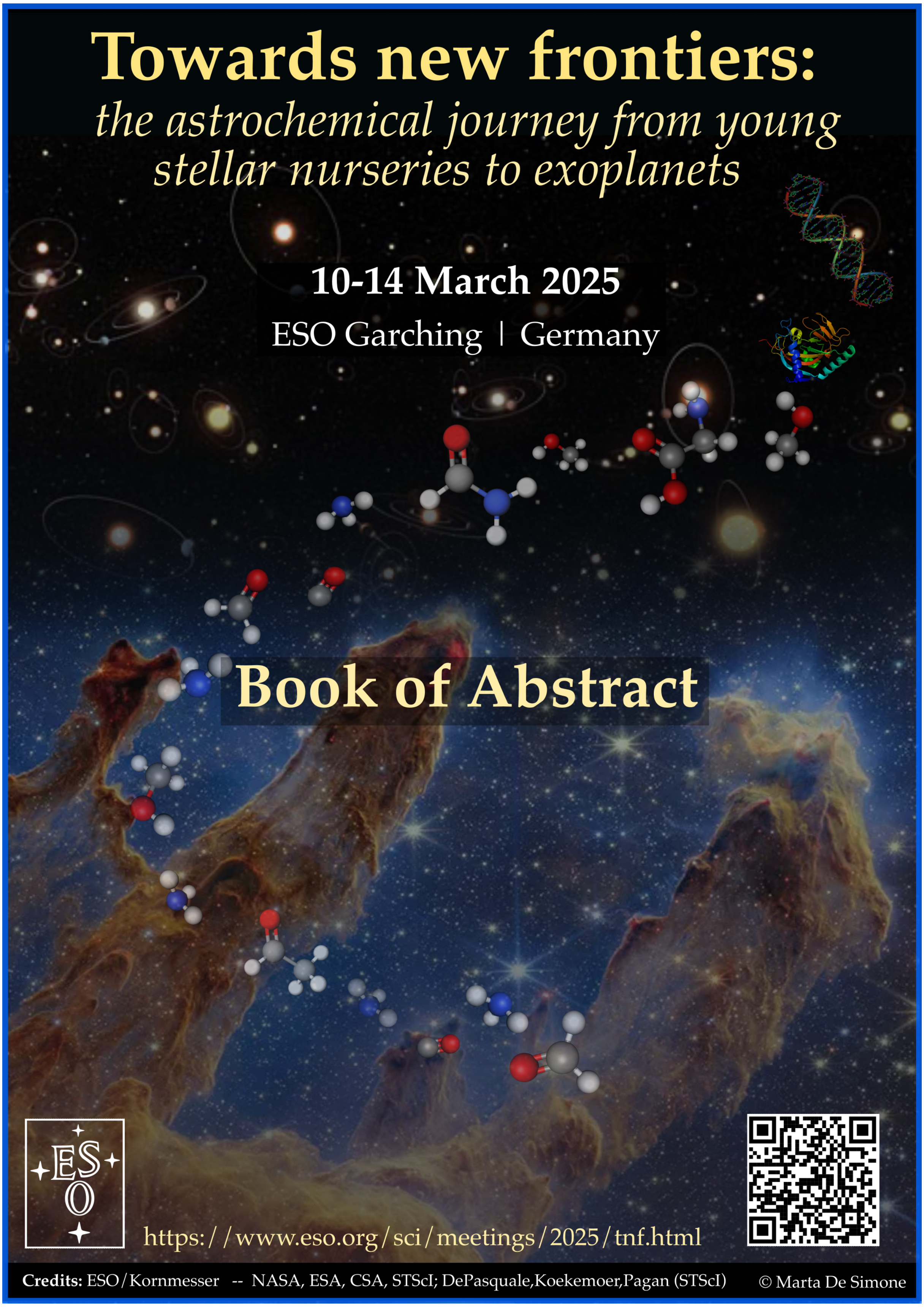
Towards new frontiers:
the astrochemical journey from young stellar nurseries to exoplanets
10-14 March 2025
ESO Garching | Germany
Book of Abstract
ESO
https://www.eso.org/sci/meetings/2025/tnf.html
Credits: ESO/Kornmesser -- NASA, ESA, CSA, STScI; DePasquale,Koekemoer,Pagan (STScI)
© Marta De Simone

Contents

Program

Monday 10th March 2025

Chair: Pooneh Nazari

Time	Type	Title	Speaker
12:30		REGISTRATION	
13:45		Introduction	LOC/SOC
14:00	Invited	Overview of the complex chemistry in starless and prestellar cores	Samantha Scibelli
14:30	Contributed	Chemical diversity of prestellar cores in Orion B	Helena Mazurek
14:45	Contributed	The Distribution of Complex Organic Molecules in Barnard 5	Tadeus Carl
15:00	Contributed	Formation of OCS in interstellar ices	Rafael Martin Domenech
15:15	Contributed	How Chemical Complexity Flourishes on Dust Grains: CH_3SH Formation in Cold Molecular Clouds	Franciele Kruczkiewicz
15:30		Coffee Break	
16:15	Contributed	The Physical and Chemical Evolution of Starless and Prestellar Cores	Yancy Shirley
16:30	Contributed	A study of the 13C and 15N fractionation in low-mass starless cores	Sigurd Jensen
16:45	Contributed	Forming deuterated methanol (and other COMs) in pre-stellar core conditions	Wiebke Riedel
17:00	Contributed	Chemical signatures of a prestellar cluster in the Galactic Center	Laura Colzi
17:15		Poster Session 1 - flash talks	

Tuesday 11st March 2025

Chair: Laura Colzi

Time	Type	Title	Speaker
09:00	Invited	From icy cocktails to hot rocks: JWST's constraints on planetary building blocks	Melissa McClure
09:30	Contributed	First Cospatial Mapping of H2O, CO2 and CO Ices Across a Molecular Cloud with JWST NIRCam WFSS	Zak Smith
09:45	Contributed	Toward the detection of the sulphur reservoir(s) in the JWST era ?	Angele Taillard
10:00	Contributed	From clouds to comets: Tracing the molecular journey of interstellar ices with JWST	Katerina Slavicinska
10:15		Coffee Break	
11:00		Break-out Session	
12:30		Lunch Break	
13:45	Invited	Streamers and winds: shaping the chemistry of protostellar disks	Linda Podio
14:15	Contributed	The ALMA-FAUST revolution: Hunting large-grains factories in protostellar outflow cavities	Giovanni Sabatini
14:30	Contributed	Protostellar outflow shocked regions: astrochemical laboratories at our disposal - The case of L1157	Juliette Robuschi
14:45	Contributed	A new outflow from the Class 0/I binary system [BHB2007]11 revealed by ALMA	Antonio Martinez-Henares
15:00	Contributed	The [D/H] abundance derived from protostellar outflows across the Galactic disk measured with JWST	Logan Francis
15:15	Contributed	The shocking arrival of a streamer toward a protostar in Perseus	Maria Teresa Valdivia Mena
15:30		Coffee Break	

Chair: TBD

16:15	Invited	Molecular richness in protostars: a paradise for astrochemists	Ana Lopez-Sepulcre
16:45	Contributed	Probing the evolution of oxygen-bearing complex organic molecules (O-COMs) from ice to gas	Yuan Chen
17:00	Contributed	A New Mechanism for Forming Hot Corinos: Shocks from Binary Interactions	Munan Gong
17:15	Contributed	Sagittarius B2(N), a gold mine to investigate the formation of complex organic molecules	Arnaurd Belloche
17:30	Contributed	The Pathway to Prebiotic Chemistry: molecular precursors from space	Victor Rivilla
17:45	Contributed	JOYS+ study of solid state 12C/13C isotope ratios in protostellar envelopes with JWST	Nashanty Brunken

Wednesday 12th March 2025

Chair: Sigurd Sigersen Jensen

Time	**Type**	**Title**	**Speaker**
09:00	Invited	Towards new frontiers through the ALMA Wideband Sensitivity Upgrade (WSU)	Anna Miotello
09:30	Contributed	Molecular evolution throughout planetary system formation: from molecular clouds to comets	Alvaro Lopez-Gallifa
09:45	Contributed	Hot cores in the outer Galaxy: impact of metallicity on the formation of complex organic molecules	Youxin Wang
10:00	Contributed	Origin and fate of interstellar S-bearing molecules: insights from observations and experiments	Julia Santos
10:15		Coffee Break	
11:00		Break-out Session	
12:30		Lunch Break	
13:45		Poster Session 2 - flash talks	

Chair: Alexander Cridland

14:00	Invited	The chemistry of protoplanetary disks	Romane Le Gal
14:30	Contributed	A fish out of water: unique observations of water in planet-forming disks	Margot Leemker
14:45	Contributed	Understanding JWST results: What thermochemical models tell us about the cold H2O content in disks	Marissa Vlasblom
15:00	Contributed	Chemical differentiation within a binary Class II disk system	Beatrice Kulterer
15:15	Contributed	Correlation in the emission of carbon-bearing species with dynamical state of protoplanetary disks	Felipe Alarcon
15:30		Coffee Break	
		Free & social afternoon	

Thursday 13th March 2025

Chair:Alexander Cridland

Time	Type	Title	Speaker
09:00	Invited	Future perspective with cm observations, ngVLA and SKA	Izaskun Jiménez-Serra
09:30	Contributed	Chasing O-bearing Organics in protoplanetary disks: Early results from DECO ALMA Large Program	Claudio Hernandez-Vera
09:45	Contributed	Constraining the physics of protoplanetary disks within Earth-like orbits: The warm molecular disk	Cade Bürgy
10:00	Contributed	A multi-molecular perspective: chemical complexity as a probe of the 2D physical structure of disks	Viviana Pezzotta
10:15		Coffee Break	
11:00		Break-out Session	
12:30		Lunch Break	

Time	Type	Title	Speaker
13:45		Poster Session 3 - flash talks	

Chair: Beatrice Kulterer

14:00	Invited	Chemical Characterisation of Solar System Bodies through in-situ Space Probes	Nozair Khawaja
14:30	Contributed	Exploring the Galilean moon volatile composition with SWI on JUICE	Eva Wirström
14:45	Contributed	The chemical diversity of chondrules from their formation in protoplanetary envelopes	Ali-Dib Mohamad
15:00	Contributed	Experimental ice simulations for the interpretation of ice and organics observations in the Solar System	Guillermo Muñoz Caro
15:15	Contributed	Adsorption of water on olivine and the origin of Earth's water	Luca Vattuone
15:30		Coffee Break	
16:15		Poster Session 4 - flash talks	
16:30	Invited	TBS: the chemistry of exoplanets (atmospheres)	Luis Welbanks
17:00	Contributed	Radial variations in nitrogen, carbon, and hydrogen fractionation in the PDS 70 planet-hosting disk	Luna Rampinelli
17:15	Contributed	Volatile composition of the HD 169142 disk and its embedded planet	Luke Keyte
17:30	Contributed	Quantifying the C/O ratio in the planet-forming environments around very low-mass stars	Javiera Díaz-Berríos
17:45	Contributed	Gas dynamics and chemistry around an embedded planet	Alex Cridland

Friday 14th March 2025

Chair: Beatrice Kulterer

Time	Type	Title	Speaker
09:00	Invited	Small planet atmospheres from the ground: state-of-the-art and future perspectives	Enric Pallé
09:30	Contributed	Probing Mini-Neptune Atmospheres: the case of K2-18b	Gareb Enoc Fernandez Rodriguez
09:45	Contributed	Characterizing Earth-like Exoplanets: Insights from Earthshine Observations	Giulia Roccetti
10:00		Coffee Break	
10:45		Break-out Session	
12:00		Plenary Session & final remarks	
13:00		Lunch Break	

Poster Session 1:
Hanga Andras-Letanovszky - Organic Deuteration in Starless Cores
Katharina Giers - Deuteration of Carbon Chains in L1544
David San Andrés - Chemical Complexity in G+0.693 and G+0.633
Milou Temmink - JWST-MIRI H_2O Emission in Millimeter-Compact Disks
Laura Schöller - Probing Sulfur Chemistry in Starless Cores
Maxime Valeille-Manet - Forces Preventing Gravitational Collapse in High-Mass Prestellar Cores

Poster Session 2:
Lennart Böhm - HCl in Massive Star-Forming Regions
Akash Gupta - Chemical Evolution in High-Mass Star-Forming Regions
David Haasler - Phosphorus Carriers in Star-Forming Regions
Le N. Tram - Chemical Modeling of Protostellar Cores
Lucas Volpe - Characterization of Young Stellar Clusters
Miguel Sanz-Novo - New Discoveries in G+0.693-0.027

Poster Session 3:
Coralie Foucher - Radial & Vertical Structure of an Edge-on Protoplanetary Disk
Lucy Evans - Thermal & Non-Thermal Desorption of Methanol in HD 100546
Clara Ross - Wideband Chemical Survey of Planet Formation with SMA
Alessandro Soave - Hunting for Methanol in a Water-Rich Planet-Forming Disk
Luigi Zallio - Extracting physical properties of barely-resolved protoplanetary disks using visibilities
Erika Alquicira - Molecular emission from a protostellar jet-disk wind interaction

Poster Session 4:
Lizxandra Flores-Rivera - UV Processing of Icy Pebbles in Disks
Giulia Ricciardi - CO Observations of the Faintest Planet-Forming Disks
Ester Nascimento - Chemical Abundances of M Dwarf Host Stars
Karolina Plakitina - Machine Learning for Molecular Emission Analysis
Adibah Nur Zainol Abidin - Raman Spectra of Lab-Produced Organic Matter
Luigi Zallio - Extracting protoplanetary gas disk properties: the perspective from ALMA DECO Large Program

Scientific Organising Committee (SOC)

Marta De Simone (ESO, Germany; Chair)

Pooneh Nazari (ESO, Germany)

Elizabeth Artur de la Villarmois (ESO, Chile)

Eleonora Bianchi (INAF - Osservatorio Astrofisico di Arcetri, Italy)

Elena Redaelli (Max Planck Institute for Extraterrestrial Physics, Germany)

Jes JÃÿrgensen (Niels Bohr Institute, Denmark)

Matteo Brogi (University of Turin, Italy)

Charlotte Vastel (IRAP, UniversitÃľ de Toulouse, France)

Catherine Walsh (University of Leeds, UK)

Stephanie Cazaux (Delft University of Technology, Leiden Observatory, The Netherlands)

Local Organising Committee (LOC)

Marta De Simone (ESO, Germany; Chair)

Pooneh Nazari (ESO, Germany)

Elizabeth Artur de la Villarmois (ESO, Chile)

Eleonora Bianchi (INAF - Osservatorio Astrofisico di Arcetri, Italy)

Elena Redaelli (ESO, Germany)

Denisa Tako (ESO, Germany)

Luigi Zallio (ESO, Germany)

Maria Teresa Valdivia Mena (ESO, Germany)

Giulia Ricciardi (ESO, Germany)

Elena Viscardi (ESO, Germany)

Claudia Toci (ESO, Germany)

Giulia Roccetti (ESO, Germany)

Lennart BÃűhm (ESO, Germany)

Abstracts

Overview of the complex chemistry in starless and prestellar cores

Monday 10th March 2025 14:00

Samantha Scibelli

National Radio Astronomy Observatory

sscibell@nrao.edu

Invited Talk

Historically depicted as 'voids' or 'obscuring bodies' in the visible night sky, starless and prestellar cores are now defined as singular 'units' of star formation. These objects are budding chemical laboratories filled with molecular gas and dust, most often probed by submillimeter and infrared facilities, that set the initial conditions important for understanding the later stages of star and planet formation (e.g., protostars, disks, and comets). In this review, I will summarize what we know about the increasing chemical complexity found in this early stage, specifically those molecules that are precursors to more biologically relevant species such as amino acids, DNA, and RNA. The growing prevalence and abundance of complex molecules in starless and prestellar cores, both in the gas-phase and ices, suggests at least some of their chemical composition is inherited to the later evolutionary stages. As we look to the future, there is much more work to do in order to expand our understanding of the evolution, spatial distribution, ice composition, etc., of starless and prestellar cores, with facilities like ALMA and JWST as well as ongoing chemical modeling efforts and laboratory studies.

Chemical diversity of prestellar cores in Orion B

Monday 10th March 2025 14:30

Helena Mazurek

Paris Observatory

helena.mazurek@obspm.fr

Contributed Talk

The densest and coldest regions of molecular clouds, though seemingly inactive, often contain prestellar cores that exhibit emission of various chemical species indicative of star formation processes. The Orion B molecular cloud is a laboratory of different environments, from UV-illuminated to cold and shielded, which directly contributes to the diversity of sources forming there. In this talk, I will present the results of an analysis based on the observations of the ORION-B observational programme performed with the IRAM 30m telescope (Pety et al., 2017; Einig et al., 2023). A sample of pre-stellar cores and protostars was selected based on the Herschel catalogue (Konyves et al., 2020), and their molecular line emission was characterised for selected species, including four CO isotopologues, organic compounds such as H_2CO and CH_3OH, nitrogen-bearing species like N_2H^+ and HNC, and deuterated species including DCO^+ and DNC. The abundances measured in the local thermodynamic equilibrium (LTE) scenario will be presented, as well as those measured for a selected number of cores using a non-LTE multilayer model (Segal et al., 2024). General trends indicate a strong diversity of sources and chemical species, as evidenced by CO depletion and environmental dependence as traced by dust temperatures. These results along with their interpretations will be presented during the talk.

The Distribution of Complex Organic Molecules in Barnard 5

Monday 10th March 2025 14:45

Tadeus Carl

Chalmers University

tadeus.carl@chalmers.se

Contributed Talk

We present an observational study aiming to set constraints on the formation mechanisms of complex organic molecules (COMs) in cold and dense molecular cloud sources. The so-called methanol hotspot in B5 (B5-Hotspot) is an ideal testbed for this purpose. It is a cold (~ 9.5 K) and dense ($\sim 6.8 \times 10^{-4}$ cm^{-3}) source, characterized by high abundances of gas phase CH_3OH ($\sim 5.4 \times 10^{-9}$) and H_2O ($\sim 2.8 \times 10^{-9}$) w.r.t. H_2. In addition, the larger COMs CH_3CHO, CH_3OCHO, and CH_3OCH_3 are identified with abundances around 10-10. It is known from mappings that the abundance of CH_3OH is peaking at B5-Hotspot, while larger COMs have been studied only with pointings towards this position. However, it is largely undetermined what mechanism is causing the efficient release of methanol and water. In our study, we made pointed observations with the IRAM 30m and Onsala 20m telescopes towards two positions close to B5-Hotspot: one position with a lower AV at the edge of the B5 ridge and one position with a higher AV, i.e., the dense core B5-East 189. We targeted the same COMs identified at B5-Hotspot and find that abundances of larger COMs are peaking together with methanol at B5-Hotspot. We argue that this can be explained most easily if these COMs are formed alongside methanol at the surface of dust grains and released by the same efficient desorption mechanism. It requires chemical modelling to test if the observed COM abundance patterns could also be produced by the gas phase formation of COMs.

Formation of OCS in interstellar ices

Monday 10th March 2025 15:00

Rafael Martin Domenech

Centro de Astrobiología

rmartin@cab.inta-csic.es

Contributed Talk

The high sensitivity and spectral resolution offered by the JWST have allowed us to expand the search for new species, both in the gas and the solid phases. The S-bearing species are of particular interest due to its relevance in the star-formation process (Fuente et al. 2023) and the origin of life (Leustek 2002, Francioso et al. 2020). Unfortunately, current observations cannot account for the expected sulfur abundance in star-forming regions (Laas & Caselli 2019). The missing sulfur is expected to be locked in the solid phase (Millar & Herbst 1990). However, JWST observations of ice mantles in dense molecular clouds have only been able to detect OCS (McClure et al. 2023) and, tentatively, SO_2 (Rocha et al. 2024), with abundances that only account for <5% of the cosmic sulfur abundance. Understanding how this reservoir of sulfur in interstellar ices is built is of vital importance to constrain the evolution of the sulfur chemistry during star-formation. In the case of OCS, in situ formation on the grain surface through the CO+S and/or CS+O pathways needs to be invoked (Boogert et al. 2022). We present laboratory experiments comparing the relative contribution of these two pathways to the OCS formation in interstellar ices. We found that the CS+O pathway is 3-6 times more efficient, depending on the ice temperature. In addition, a significant fraction of the initial S in our experiments seemed to form sulfur chains, that could contain part of the missing sulfur in the ISM.

How Chemical Complexity Flourishes on Dust Grains: CH_3SH Formation in Cold Molecular Clouds

Monday 10th March 2025 15:15

Franciele Kruczkiewicz

Leiden University

kruczkiewicz@strw.leidenuniv.nl

Contributed Talk

The molecular makeup of the Interstellar Medium (ISM) holds the key to tracing the pathways that lead to star- and planet-forming regions, including our own. In dense molecular clouds, chemical complexity flourishes on the surfaces of cold dust grains, which act as catalytic sites that enable the formation of icy mantles containing molecules like water (H_2O), methane (CH_4), and ammonia (NH_3), as well as interstellar Complex Organic Molecules (iCOMs). However, the precise formation mechanisms for iCOMs, particularly sulfur-bearing carriers in the solid state, remain elusive. In this study, we experimentally investigate the role of atomic carbon in driving solid-state reactions forming S-bearing iCOMs, uncovering new potential pathways for molecular complexity in the ISM. Using the SURFRESIDE3 setup, interstellar ice analogues are grown on a cold (10 K) gold-plated substrate within an ultra-high vacuum (UHV) chamber ($P_{base} = 10^{-10}$ mbar) by the co-deposition atomic (H/D, C) and molecular species (H_2S, H_2). The ices are monitored via reflection absorption infrared spectroscopy (RAIRS), and analyzed with a quadrupole mass spectrometer (QMS) during temperature-programmed desorption (TPD) measurements. I will discuss the formation pathways of CH_3SH and H_2CS in prestellar cores and the implications their formation routes have on deuteration ratios and gas-phase abundances found at later stages of star formation.

The Physical and Chemical Evolution of Starless and Prestellar Cores

Monday 10th March 2025 16:15

Yancy Shirley

University of Arizona

yshirley@arizona.edu

Contributed Talk

Starless and prestellar core are the earliest stage of star and planet formation where the initial physical and chemical conditions of the future protoplanetary disk are set. In this talk, I shall synthesize a series of projects to understand starless and prestellar core evolution by studying the complete core population of the B10 region of the Taurus Molecular Cloud, a pristine environment only containing starless and prestellar cores embedded within filamentary structure with minimal feedback from protostars. Using 3D radiative transfer modeling of (sub)millimeter continuum emission, we have constructed physical models of the cores. Mapping observations of dense gas tracers (i.e. pNH_3), analyzed with a new multi-velocity component Bayesian decomposition, probe the viral stability and kinematics of the filaments and cores. We characterize the chemical evolution of the cores with surveys of deuteration in dense gas tracers (DNC, N_2D^+, NH_2D) and organic molecules (CH_2DOH, HDCO, pD_2CO) along with gas depletion in $C^{18}O$. By combing the information from these different surveys, we constrain the physical and chemical evolution, including evidence for differential evolution rates, of this population of starless and prestellar cores and compare our results with MHD models of core evolution.

A study of the ^{13}C and ^{15}N fractionation in low-mass starless cores

Monday 10th March 2025 16:30

Sigurd Jensen

Max-Planck-Institute for Extraterrestrial Physics

sigurdsj@mpe.mpg.de

Contributed Talk

The nitrogen isotopic ratio ^{14}N/^{15}N can provide crucial insights into the chemical evolution during star and planet formation (e.g., Ceccarelli+2014). The ^{14}N/^{15}N ratio is often determined assuming a constant ^{12}C/^{13}C ratio (double isotope method). However, this assumption has been challenged by recent astrochemical models of carbon fractionation which show a significant variation in carbon fractionation in starless cores at different chemical ages and physical conditions (Colzi+2020, Sipilä+2023). I will present IRAM 30m observations of HCN, H^{13}CN, and HC^{15}N toward 6 low-mass starless cores (Jensen+2024). The ^{12}C/^{13}C and ^{14}N/^{15}N ratios for HCN are derived using the double isotope method and directly through 1D line-radiative transfer modeling of the emission lines. The results imply that a fixed ^{12}C/^{13}C ratio is a poor assumption for starless cores and reveal a substantial difference between the nitrogen fractionation ratio in HCN derived using direct and indirect methods. This can strongly affect the interpretation of the chemical processing in fractionation studies and questions the reliability of the double isotope method.

Forming deuterated methanol (and other COMs) in pre-stellar core conditions

Monday 10th March 2025 16:45

Wiebke Riedel

Max-Planck-Institute for Extraterrestrial Physics

riedel@mpe.mpg.de

Contributed Talk

The extremely cold (=10K) environment of pre-stellar cores are ideal physical conditions for the isotopic fractionation of hydrogen. It was previously believed that these conditions would restrict the degree of chemical complexity to simpler molecular species. However, there is recent observational evidence (e.g: Jiménez-Serra+2016) that even complex organic molecules (COMs) form in these dark and cold environments. I updated a gas-grain chemical code capable of deuterium chemistry (Sipilä+2015a, Sipilä+2019b) by various mechanisms essential to study the formation of methanol and larger COMs on the surface of icy dust grains. This includes multiple mechanisms for nondiffusive chemistry. Using the improved code, I performed several 1D simulations of the pre-stellar core L1544 and derived column density profiles for methanol and its deuterated isotopologues. I will show that on one hand, when applying a single collision reaction probability (Hasegawa+1992), an increase in the reaction rate is needed to attain observed methanol levels. On the other hand, when applying reaction-diffusion competition (Chang+2007), reactions proceeding by thermal diffusion is enough to reach observed levels. I find that, in contrast to other COMs, the introduced nondiffusive mechanisms play only a secondary role in the formation and deuteration of methanol. In more recent efforts, I am focusing on models for the heavier COMs with the aim to make first predictions about their D/H ratios.

Chemical signatures of a prestellar cluster in the Galactic Center

Monday 10th March 2025 17:00

Laura Colzi

Centro de Astrobiología (CAB), CSIC-INTA

lcolzi@cab.inta-csic.es

Contributed Talk

The Central Molecular Zone (CMZ) contains most of the mass of our Galaxy, but its star formation rate is one order of magnitude lower than in the Galactic disk. This is likely related to the fact that the bulk of the gas in the CMZ is in a warm (100 K) and turbulent phase with little material in the prestellar phase. I will present D/H ratios of HCN, HNC, HCO^+, and N_2H^+ obtained towards the CMZ molecular cloud G+0.693-0.027 (Colzi et al. 2022). These observations clearly show, for the first time, the presence of a colder, denser and narrow component, with a line width of about 9 km s^{-1}, in addition to the warm, less dense, and turbulent broad component with a line width of about 20 km s^{-1}. For this new component D/H ratios higher than 1×10^{-4} and excitation temperatures of 7 K for all molecules have been found, suggesting kinetic temperatures lower than 30 K and H_2 densities higher than 5×10^4 cm^{-3}. This new method indicates that the degree of deuteration of different molecules, such as N_2H^+ and HCO^+, and their line profiles, can be used to reveal the different gas components in the line of sight to the CMZ. Then, I will present HC_3N excitation-derived gas densities and temperatures of the gas components towards the same source, using multiple transitions coupled with spatially resolved HC_3N images of the source. This approach allows us to identify denser gas that possibly is on the verge of gravitational collapse and that will host future protostars in the CMZ (Colzi et al. 2024).

From icy cocktails to hot rocks: JWST's constraints on planetary building blocks

Tuesday 11th March 2025 09:00

Melissa McClure

Leiden Observatory, Leiden University

mcclure@strw.leidenuniv.nl

Invited Talk

Volatile elements, like C, H, O, N, and S, are critical to the detectability of planetary atmospheres and the origins of life as we know it. These elements are mostly carried by icy dust grains that may have been transferred to Earth from the cold outer regions of the Solar protoplanetary disk. The total amount and variety of ices inherited this way is an open question. Additionally, the chemical complexity achieved by the ices is unclear; interstellar complex organic molecules (COMs, >6 atoms, including C) are seen in the gas phase of dense clouds and in cometary ices, but whether they form as ices or not is hotly debated. Furthermore, the degree to which solids are thermally processed during their journey from clouds to the planet forming regions of disks is unknown. These questions are critical to understanding planetary habitability and the rise of life, and they could allow us to use the atmospheric composition of giant planets to trace their formation zones in protoplanetary disks. I will present initial results from several JWST programs, including the ERS program Ice Age (http://jwst-iceage.org/), revealing the diversity of icy chemistry found in dark regions of molecular clouds and the distribution and bulk composition of ice and gas in protostars and disks. We see early chemical pathways to complex ices and CO_2 in the cloud while the distribution of CO ice in the protoplanetary disk, suggests that it is trapped in the CO_2 ice matrix on the dust grains. Further evidence for widespread CO_2 ice trapping is seen in observations of protostars and edge-on protoplanetary disks, along with heating to the point of silicate sublimation. These results provide additional complications in the community's efforts to connect exoplanets' atmospheric compositions with their formation histories.

First Cospatial Mapping of H_2O, CO_2 and CO Ices Across a Molecular Cloud with JWST NIRCam WFSS

Tuesday 11th March 2025 09:30

Zak Smith

Leiden Observatory

zsmith@strw.leidenuniv.nl

Contributed Talk

In the coldest regions of molecular clouds, carbon and oxygen are incorporated into icy dust grains. Ices play an essential role in star and planet formation where they set the initial chemical composition for future protoplanetary disks and chemical complexity. Despite this, ice's sequential formation is poorly constrained. Infrared spectroscopy probes ice chemistry, but previous telescopes observed insufficient sightlines to map a single cloud. JWST NIRCam Wide-Field Slitless Spectroscopy (WFSS) provides an excellent opportunity to do this. I present the first cospatial <1000AU-scale maps of H_2O, CO_2 and CO ice over the central region of the Chamaeleon I molecular cloud, using 44 sightlines along with the novel data reduction pipeline written to make WFSS a viable observing option. These observations show that ice species correlations, at densities ten times larger than previous work, suggest additional CO_2 ice formation in CO ice for the densest sightlines. This large statistical sampling within a single cloud represents a step-change in constraining ice chemistry, eliminating averaging over clouds with different intrinsic chemical environments. This dataset adds a wealth of chemically-consistent observational constraints that can now be applied to pre-stellar phase astrochemical models. Mapping opens the door to probing gas-grain exchanges, snowlines, chemical evolution in the densest regions, and drawing conclusions on the impact of ice chemistry on wider astrophysics.

Toward the detection of the sulphur reservoir(s) in the JWST era ?

Tuesday 11th March 2025 09:45

Angèle Taillard

Centro de Astrobiologia, CSIC-INTA

angele.taillard@cab.inta-csic.es

Contributed Talk

The abundances of sulphur species in the gas-phase observed in star-forming regions represent only a tiny fraction (<1 %) of the cosmic sulphur abundance. The majority of sulphur in the interstellar medium (ISM) is expected to be in solid form, either in an ice mantle or in (semi-)refractory form. The search for solid-phase sulphur in the ISM has not yet been successful: only OCS has been unambiguously detected, with attempts to detect H_2S and SO_2. The column density estimates for these two species only represent <5 % of the cosmic abundance of sulphur. This leaves around 90% of this species hidden in a form that has not yet been detected. Current chemical models have difficulty implementing sulphur chemistry with other elements, despite recent efforts to improve the prescriptions on chemical networks. Models predict that a large fraction of the volatile sulphur species in dense cores are found in ice mantles. Recent observations also suggest that sulphur depletion and composition of sulphur species in the ices are strongly affected by the dynamics and chemical history of the cloud. We will present a tool for generating synthetic ice spectra, based on the JWST instrumentation, based on a simple approximation of laboratory spectra to predict NIRSpec and MIRI observations. We study the feasibility of detecting sulphur species (in particular H_2S, CS_2, SO_2 and S_8) in ice and to understand which physico-chemical environments would enable such reservoirs to be obtained in ice.

From clouds to comets: Tracing the molecular journey of interstellar ices with JWST

Tuesday 11th March 2025 10:00

Katerina Slavicinska

Leiden Observatory

slavicinska@strw.leidenuniv.nl

Contributed Talk

In the cold dense interstellar clouds from which stellar systems are born, a variety of solid-state molecules form on the surfaces of dust grains, resulting in the growth of ice layers comprising species like H_2O, CO_2, NH_3, CH_3OH, and possibly even complex organic molecules. However, it is uncertain to what degree these primordial ices are preserved during the various stages of star formation and subsequently inherited by the icy bodies that form in the cold outer protoplanetary disk. In this talk, I will discuss how new infrared spectra from the recently launched JWST can be utilized to investigate the chemical link between interstellar ices and comets via two interstellar ice detections: HDO and NH_4SH. The detection of HDO ice enables comparisons between the D/H ratio of interstellar water ice and D/H ratios measured in the gas phase in protostellar envelopes, protoplanetary disks, and comets, and their similarities suggest a considerable degree of interstellar ice inheritance. NH_4SH salt was recently abundantly detected in the dust grains of comet 67P, so its possible presence and high abundance in interstellar ices not only introduces a new candidate sulfur sink for the early stages of star formation, but also strengthens the proposed chemical link between interstellar and cometary matter. These ice detections indicate that the chemical origins of a significant portion of cometary matter can be traced as far back as the pre- and protostellar epochs.

Streamers and winds: shaping the chemistry of protostellar disks

Tuesday 11th March 2025 13:45

Linda Podio

INAF - Osservatorio Astrofisico di Arcetri

linda.podio@inaf.it

Invited Talk

Observations of protostellar disks suggest that planets formation may start early, in disks of $\lesssim 10^5$ yr. The physical and chemical properties of young disks are strongly influenced by the intense and variable accretion/ejection activity, and by the interaction with the environment. The disk gains mass rapidly from the infalling envelope, as well as from accretion streamers. Because of the high accretion rate, young disks are warm and the snowlines are pushed outwards, with important implications for the growth of dust grains and the composition of the nascent planets. Accretion streamers and the shocks occurring where the streamer hits the disk, can drastically alter the disk's kinematical structure, mass budget, stability, and chemical composition. In addition, recent models and observations suggest that disk-winds can transport large grains from the inner disk to the envelope. The possible fallback of the grains in the outer disk regions would then promote dust growth and mixing in the disk, with crucial effects on the formation and composition of planets. I will review the physical and chemical properties of protostellar disks, and how these are affected by environmental and accretion/ejection processes.

The ALMA-FAUST revolution: Hunting large-grains factories in protostellar outflow cavities

Tuesday 11th March 2025 14:15

Giovanni Sabatini

INAF - Osservatorio Astrofisico di Arcetri

giovanni.sabatini@inaf.it

Contributed Talk

Planet formation models still face a crucial challenge: millimeter-sized dust grains in protoplanetary discs migrate rapidly inwards, hindering their growth into planetesimals - the building blocks of planets. However, recent high-resolution ALMA observations, taken as part of the FAUST Large Programme, suggest an alternative scenario. We have discovered dust-rich cavity walls associated with the protostellar objects IRS7B and L1551, located in the Corona Australis (CrA) and in the Taurus star-forming regions, respectively. The sub-mm spectral index (α) derived from Band 3 and Band 6 observations indicates possible grain growth in the outflow cavities. In this talk I will present new results from other young protostellar systems observed in ALMA-FAUST. I will discuss the implications of dust growth in outflow cavities and how this mechanism could overcome the radial drift barrier and potentially revolutionize our understanding of planet formation. I will also look at the impact of these dusty structures on the chemical evolution of protoplanetary systems.

Protostellar outflow shocked regions: astrochemical laboratories at our disposal - The case of L1157

Tuesday 11th March 2025 14:30

Juliette Robuschi

Institut de Planétologie et d'Astrophysique de Grenoble (IPAG)

juliette.robuschi@univ-grenoble-alpes.fr

Contributed Talk

Chemical compounds, and in particular organic molecules, have been observed and are thought to be formed during all stages of star formation. Among the ∼320 species that have been detected in the ISM to date, we are particularly interested in the so-called interstellar complex organic molecules (iCOMs), which are carbonaceous molecules containing ≥6 atoms, of which at least one is other than C or H. It is currently thought that there are two possible ways for these iCOMs to form: on the surface of dust grains, or in the gas phase, the latter of which we are interested in here. To study the evolution of organic chemistry in the gas phase, we are targeting the protostellar stage, during which supersonic ejection processes (≥100 km/s) from the central object cause the formation of shocked regions. These shocks are the siege of a very specific chemistry, as radicals and species previously trapped on dust grains, frozen mantles or in the core are released into the gas phase, where we can observe them and where they can react to form new molecules. We focus on the study of the molecular outflow driven by the protobinary L1157-mm, which has three shocked regions of different and well constrained ages. Observations of these three regions with the NOEMA interferometer allow us to study the evolution of the gas-phase chemistry with time. Finally, gas-phase chemical modeling of the source, coupled with the observations, gives us an additional understanding of how the detected iCOMs form.

A new outflow from the Class 0/I binary system [BHB2007]11 revealed by ALMA

Tuesday 11th March 2025 14:45

Antonio Martínez-Henares

Centro de Astrobiología (CAB, CSIC-INTA)

amartinez@cab.inta-csic.es

Contributed Talk

During the early stages of star formation, accretion processes such as infall from the envelope and molecular streamers, and ejection of matter through winds and jets, take place simultaneously and distribute the angular momentum of the parent molecular cloud. The Class 0/I binary [BHB2007]11 shows evidence for accretion and ejection at the scales of the circumbinary disk and the inner close binary. Recent observations, however, show two elongated structures with hints of outflowing motion in the direction perpendicular to the main CO outflow launched from the circumbinary disk. We have analyzed these structures with molecular data obtained with ALMA within the FAUST Large Program. The gas kinematics are consistent with outflowing motions in the direction perpendicular to the main CO outflow. Plus, elongated, compact SiO emission close to the binary system has a similar orientation to that observed for the larger-scale structures, suggesting that it likely arises from the shocked material at the base of a new second outflow. We derive mass loss rates and evaluate the rotation of this potential new outflow. The observations trace the material moving at velocities closer to the ambient cloud velocity, which could not be probed in previous observations of the self-absorbed emission of CO. This work illustrates the importance of tracing different spatial scales and velocity ranges with a rich molecular dataset to understand the complex dynamics in the evolution of protostars.

The [D/H] abundance derived from protostellar outflows across the Galactic disk measured with JWST

Tuesday 11th March 2025 15:00

Logan Francis

Leiden University

francis@strw.leidenuniv.nl

Contributed Talk

The total deuterium abundance [D/H] is set by only the creation of deuterium in Big Bang Nucleosynthesis, and its destruction within stellar interiors. Measurements of spatial variations in the total [D/H] can thus provide a probe of Galactic chemical evolution. However, most measurements of [D/H] are only sensitive to the gas-phase deuterium, and the amount of deuterium sequestered in dust grains is debated. With JWST MIRI/MRS, gas-phase [D/H] can be measured at unprecedented sensitivity through observation of mid-IR lines of H_2 and HD, while the refractory component can be probed through various forbidden lines. Using data from the JWST Observations of Young protoStars (JOYS) program, we analyze the gas-phase [D/H] abundance and the distribution of refractory species in protostellar outflows. Maps of the emission lines show HD is correlated with the H_2 S(7), [S I], and [Fe I], which trace high velocity jet knots and bright bow-shocks. We show the gas-phase [D/H] varies between our low-mass sources by up to a factor of$\sim$4, despite these sources likely having formed from gas in the Galactic disk with constant total [D/H]. Most measurements of gas-phase [D/H] from our work produce [D/H]$\lesssim 1.0 \times 10^{-5}$, a factor of 2-4 lower than the total [D/H] expected from Galactic chemical evolution models. The variations in the gas-phase [D/H] within the outflows and the low values with respect to models suggest that significant depletion of deuterium into the dust may be occurring.

The shocking arrival of a streamer toward a protostar in Perseus

Tuesday 11th March 2025 15:15

Maria Teresa Valdivia Mena

European Southern Observatory

MariaTeresa.ValdiviaMena@eso.org

Contributed Talk

Streamers, elongated gaseous structures that range from a few hundred to over 10,000 au, have emerged as a novel mechanism of material supply to protostellar and protoplanetary disks. Thanks to advanced millimeter/submillimeter interferometers like ALMA and NOEMA, we now know that streamers are frequently found around protostars, rather than being isolated occurrences. However, their effects on disk composition are only recently being studied in detail. In this talk, I will present detections of sulfur dioxide (SO_2, a known shock tracer) toward the Class I source Per-emb 50, which are located between the streamer detected for this source and its disk. The SO_2 emission consists of several velocity components, tracing part of the disk kinematics as well as the inner envelope, but its emission peaks are offset from the position of the protostar. The different components that SO_2 traces have different temperatures and densities. These results suggest that streamers produce shocks that can change the local conditions of the planet-forming disk.

Molecular richness in protostars: a paradise for astrochemists

Tuesday 11th March 2025 16:15

Ana López-Sepulcre

IPAG/IRAM

ana.lopez-sepulcre@univ-grenoble-alpes.fr

Invited Talk

Protostars are subject to numerous dynamical events that shape the physics and chemistry of the subsequent evolutionary stages leading to a star and planetary system like our own. Accretion streamers, violent ejections of material in the form of jets and outflows, dynamic interactions with neighbouring protostars, ... All of these and other physical ingredients leave characteristic molecular imprints on the gas and dust surrounding the newly-formed protostellar objects. As such, molecules in protostars are powerful tools to investigate not only the chemistry but also the physics associated with this crucial evolutionary phase of star formation.

From an observational point of view, the past few years have witnessed huge steps forward in this area, unveiling the chemical richness and diversity found among different protostars with unprecedented sensitivity and spatial resolution. This is undoubtedly thanks to the development of sensitive spectroscopic instrumentation, both ground- and space-based, spanning wavelengths from the infrared to centimetre regimes. Despite these exciting observational advances, having a complete explanation of why the molecules we see in protostars are there (or not there) currently remains an unsolved puzzle and requires an interdisciplinary effort in which astronomers and chemists inevitably need to work hand in hand.

New observational and theoretical challenges have been revealed in the field which make us look to the future with hopeful eyes. I will summarise what we have learnt, in the past decade or so, about the molecular richness of solar-mass protostellar sources, and suggest a few guidelines to stimulate progress in the field.

Probing the evolution of oxygen-bearing complex organic molecules (O-COMs) from ice to gas

Tuesday 11th March 2025 16:45

Yuan Chen

Leiden Observatory

ychen@strw.leidenuniv.nl

Contributed Talk

Complex organic molecules (COMs), usually defined as carbon-containing molecules with at least six atoms, have attracted great interest serving as the first step from simple species toward the building blocks of life. So far, more than 100 COMs have been firmly or tentatively detected in space, and most of the detections were made toward protostellar cores (also called 'hot cores'). However, the transition from case studies (e.g., on Sgr B2 and IRAS 16293-2422) to large-sample surveys has only come forth in the recent five years or so. Here we report systematic studies on ten O-COMs in the gas phase toward a dozen high-mass protostars as a subsample of the Complex Chemistry in hot Cores with ALMA (CoCCoA) survey. In particular, our attention is drawn not only to those abundant O-COMs with 1-2 carbon atoms, but also those less studied larger molecules such as acetone (CH_3COCH_3) and propanal (C_2H_5CHO). We found intriguing trends that aldehydes (i.e., molecules with the CHO group) are overall less abundant than O-COMs of other types, while CH_3-bearing molecules (such as CH_3OCH_3, CH_3OCHO, and CH_3COCH_3) are generally the most abundant among the species with the same amount of C atoms. In the meantime, the gas abundances of some of the O-COMs are compared to their ice abundances, which have recently been derived from JWST/MIRI observations. By conducting gas-to-ice comparisons of O-COMs in the same sources, we can shed some light on their chemical evolution from ice to gas.

A New Mechanism for Forming Hot Corinos: Shocks from Binary Interactions

Tuesday 11th March 2025 17:00

Munan Gong

Max Planck Institute for Extraterrestrial Physics

munan@mpe.mpg.de

Contributed Talk

Hot corinos are regions of elevated temperatures surrounding low-mass protostars, distinguished by their rich astrochemical inventory. They provide a unique window into the chemical and physical conditions of the early formation stages of low-mass stars like our Sun. The origin of hot corinos, however, is still a mystery. Only a limited number of hot corinos have been studied in detail, and even fewer have been well-resolved spatially. In this talk, we present the smoking gun evidence of the origin of the hot corino system, IRAS 16293A. High-resolution (∼10 AU) ALMA observations show dust hot spots, coinciding with the location of complex organic molecule emission in the circumbinary disk away from both binary protostars. We conduct numerical simulations to further confirm that the temperature and location of the hot spots can be reproduced by shocks from binary interactions. Our study marks the first system in which the location of the hot corinos is spatially resolved by observations, and the formation mechanism is validated by numerical simulations. Our discovery opens a new window for understanding the astrochemical and dynamical properties of disks around low-mass binary protostars.

Sagittarius B2(N), a gold mine to investigate the formation of complex organic molecules

Tuesday 11th March 2025 17:15

Arnaud Belloche

Max-Planck-Institut für Radioastronomie

belloche@mpifr-bonn.mpg.de

Contributed Talk

We used ReMocA, a sensitive imaging spectral line survey performed with ALMA over a broad frequency range at high angular resolution, to decipher the chemical composition of hot molecular cores in the high-mass star forming region Sgr B2(N). We derived the column densities of almost 50 (mainly organic) molecules (not counting isotopologs) as well as upper limits for about 150 species toward a compact group of four hot cores located in the sub-region Sgr B2(N2). We use this gold mine to explore the correlations (or lack thereof) between the four hot cores and between these sources and several other hot cores/corinos that have been studied in detail in the inner Galaxy. We also investigate the relationships within various families of molecules. We will report on the main findings of this study. Our goal is to provide useful constraints to astrochemical models in order to improve our understanding of the formation of complex organic molecules in star forming regions.

The Pathway to Prebiotic Chemistry: molecular precursors from space

Tuesday 11th March 2025 17:30

Víctor M. Rivilla

Centro de Astrobiología (CAB, CSIC-INTA)

vrivilla@cab.inta-csic.es

Contributed Talk

Prebiotic experiments in the laboratory have suggested that the chemistry that allowed the emergence of life could have started from relatively simple molecular precursors, species with only a handful of atoms. Since our Solar System was formed from a molecular cloud in the interstellar medium, an obvious question naturally arises: could the chemistry that occurs in space have a fundamental contribution for triggering prebiotic chemistry here on Earth, or elsewhere in the Galaxy? To answer this question we need first to know the limits of interstellar chemical complexity. In this talk I will present the most recent results of our query of new species with astrobiological interest in space, combining ultra-sensitive unbiased spectral surveys and spectroscopic studies in the lab. I will show our findings towards the molecular cloud G+0.693-0.027 located in the Galactic Center, where we have detected more than 20 new molecular species in the last years containing all five key elements for life (C, H, O, N, S and P). Among others, we have identified the first glycine isomer detected in space, glycolamide (NH_2COCH_2OH); key precursors of RNA nucleotides such as hydroxylamine (NH_2OH) or 1,2-ethenediol ($(CHOH)_2$); and precursors of lipids, such as ethanolamine ($NH_2CH_2CH_2OH$) and propanol ($CH_3CH_2CH_2OH$); and also new interstellar species with phosphorus such as the cation PO^+.

JOYS+ study of solid state $^{12}C/^{13}C$ isotope ratios in protostellar envelopes with JWST

Tuesday 11th March 2025 17:45

Nashanty Brunken

Leiden University

brunken@strw.leidenuniv.nl

Contributed Talk

The carbon isotope ratio is a powerful tool for studying the evolution of stellar systems due to its sensitivity to the local chemical environment. During the pre-stellar stage the multiple vibrational modes of CO_2 and CO ice, that peak in the near- and mid-infrared, provide a unique opportunity to examine the $^{12}C/^{13}C$ ratio in the solid state. Now with the new era of the James Webb Space Telescope the entire 2 - 28 μm spectral region has become available for the first time, enabling a simultaneous detection of the various weak and strong ice absorption features of CO_2 and CO for solar-mass systems. The JOYS+ study of solid state $^{12}C/^{13}C$ ratios covers a large sample of 17 low-mass young stellar objects for which we determine column densities and extract isotope ratios from the multiple vibrational modes of CO_2 and CO ice. Our findings indicate that the ices leave the pre-stellar stage with elevated ratios with the respect to the local interstellar medium and that fractionation becomes a significant factor during the later stages of star and planet formation.

Towards new frontiers through the ALMA Wideband Sensitivity Upgrade (WSU)

Wednesday 12th March 2025 09:00

Anna Miotello

ESO

amiotell@eso.org

Invited Talk

In the coming years ALMA will be developing its most ambitious upgrade since its conception: the Wideband Sensitivity Upgrade (WSU). This consists of an increase of the instantaneous spectral bandwidth by as much as a factor of four, while retaining full spectral resolution over the entire bandwidth, thus resulting in increases of the spectral scan speed up to a factor of 50 for the highest spectral resolution. In addition, an upgrade of the full signal chain of ALMA - from the receivers and digitisers, all the way through to the correlated data - will result in increases in sensitivity for all observations. In this talk I will introduce ALMA WSU, review its status, and discuss its relevance for the field of Astrochemistry.

Molecular evolution throughout planetary system formation: from molecular clouds to comets

Wednesday 12th March 2025 09:30

Álvaro López-Gallifa

Center for Astrobiology (CAB), CSIC-INTA

Alvaro.LopezGallifa@eso.org

Contributed Talk

Stars and planets are born within dense regions of molecular clouds, which contain a rich chemical reservoir of molecules. Some of them have a high prebiotic interest, and they could have been delivered through meteorites and comets that were formed in the parental molecular cloud of our Solar System. We study the chemical evolution throughout planetary system formation, from molecular clouds in extragalactic and galactic environments to star forming regions and comets. We use data from two ALMA Large Programs consisting of unbiased spectral surveys, GUAPOS (G31.41+0.31 Unbiased ALMA sPectral Observational Survey, P.I. Maite Beltrán) and ALCHEMI (ALMA Comprehensive High-resolution Extragalactic Molecular Inventory, P.I. Sergio Martín). The GUAPOS project targets the high-mass star-forming region, G31.41+0.31 (G31 hereafter) which is one of the most chemically rich sources in our Galaxy and its associated chemically rich shocked region. The ALCHEMI project targets the starburst nearby galaxy NGC 253, in whose central molecular zone we study 4 molecular clouds. We perform a comparative study using dozens of molecules detected in both NGC 253 and G31 to evaluate the molecular evolution in the first two stages of a planetary system formation. The results from these sources are put into context by comparing the molecular abundances with other sources in different stages such as the Solar-like protostar IRAS 16293-2422B and two comets (67P/Churyumov-Gerasimenko and 46P/Wirtanen).

Hot cores in the outer Galaxy: impact of metallicity on the formation of complex organic molecules

Wednesday 12th March 2025 09:45

Youxin Wang

Max-Planck-Institut für Radioastronomie

yxwang@mpifr-bonn.mpg.de

Contributed Talk

Many complex organic molecules (COMs) in star forming regions are believed to form on the surfaces of dust grains or in their ice mantles. Therefore, we expect both the reduced metallicity and dust-to-gas ratio in the outer Galaxy to have an impact on the chemical composition of these regions. To test this, we use NOEMA to perform an imaging spectral line survey of the hot core candidate G135.27+2.79 at a galactocentric distance of 13.1 kpc. Our NOEMA observations in the 1.3 mm range have led to the identification of 43 species, including their isotopologues and deuterated variants. Among these are COMs with up to nine atoms, detected toward a hot (>100 K) and compact (< 5000 au) region. These detections confirm G135.27+2.79 as the second known hot core in the outer Galaxy. The rotational temperatures and column densities of the detected molecules are derived under the LTE approximation. Hot-core simulations with the three-phase astrochemical code MAGICKAL with reduced metallicity and dust-to-gas ratio and under normal conditions predict that certain molecules have a significantly reduced abundance (relative to methanol) at low metallicity and dust-to-gas ratio while others keep a similar abundance. The model predictions are approximately consistent with our observations when we compare the COM abundances of G135.27+2.79 with those in hot cores/corinos within the Solar circle, suggesting that metallicity and dust-to-gas ratio do have an impact on the formation of COMs.

Origin and fate of interstellar S-bearing molecules: insights from observations and experiments

Wednesday 12th March 2025 10:00

Julia Santos

Leiden Observatory

santos@strw.leidenuniv.nl

Contributed Talk

The observed sulfur content in dense interstellar clouds and protostellar environments constitutes only a small fraction of the expected cosmic value, with the bulk of its reservoir remaining unknown. One hypothesis is that the missing sulfur is locked away in or beneath the icy mantles that shroud interstellar dust grains, challenging its observation. This distinctive feature of sulfur-bearing species makes them critical for understanding the evolution of volatile and refractory components during star and planet formation. In this presentation, I will showcase recent laboratory experiments on interstellar ice analogues that offer particularly promising new pathways to S-bearing organics. We find that SH radicals can initiate a prolific sulfur reaction network under interstellar conditions, leading to the formation of CH_3CH_2SH, CH_2CHSH, $HSCH_2CH_2SH$, H_2S2, OCS, and tentatively CH_3CHS and CH_2CS. Computational calculations further elucidate key reaction routes in this network. I will also present ALMA observations of gaseous SO_2 and OCS towards 26 MYSOs from the ALMAGAL survey, compared with literature ice data-including JWST observations. These species are particularly relevant since they are major carriers of gaseous sulfur and the only sulfurated molecules detected in ices to date. Such comparisons provide powerful information on the chemical and physical environments of these molecules and their potential inheritance by planetesimals.

The chemistry of protoplanetary disks

Wednesday 12th March 2025 14:00

Romane Le Gal

IPAG/IRAM

romane.le-gal@univ-grenoble-alpes.fr

Invited Talk

The chemistry of protoplanetary disks is central to understanding the origins of planetary systems and, ultimately, the potential for life. This review talk will present the state of the art in the study of disk chemistry, surveying the latest insights into the formation and evolution of chemical species in the different disk's regions, from the cold outer zones to the warmer inner regions. I will discuss how recent progress in observational techniques, including ALMA and JWST, have provided unprecedented detail in identifying molecular species, tracing chemical gradients, and better understanding disk dynamics. I will highlight the interplay between gas-phase and solid-state chemistry, how stellar radiation impacts the chemistry and molecular distribution, and the role of disk dynamics and dust grain evolution in setting disk chemical makeup. I will also pinpoint key open questions in the field, such as the interstellar inheritance, the potential mechanisms driving complex organic molecule formation in such environments, and the influence of disk chemistry on planetary composition. These topics, among others, will serve as focal points for discussion, fostering dialogue on bridging gaps in our understanding of these primordial chemical environments. This last session will aim to encourage collaborative discussion on the future directions of protoplanetary disk chemistry, focusing on the observational and modeling efforts needed to tackle outstanding questions in the field.

A fish out of water: unique observations of water in planet-forming disks

Wednesday 12th March 2025 14:30

Margot Leemker

University of Milan

margot.leemker@unimi.it

Contributed Talk

Water is a crucial ingredient for life as we know it on Earth. Furthermore, water enhances planet formation and it is the main carrier of oxygen, one of the most abundant elements. Still, the trail of water from clouds to planets is unclear. Water on Earth may be inherited from its parent molecular cloud, but it is also possible that water has been destroyed and reformed along the water trail from the cloud to the disk. In addition, spatially resolved observations of water in planet-forming disks are extremely rare, hiding one of the most important molecules from our sight at the moment planets are forming. In this talk I will show the latest results looking at water in planet-forming disks, including both the first spatially resolved observations of the main water isotopologue tracing the spatial extent of water, and the most rare isotopologue observed to date tracing whether or not water is inherited from the earliest phases of star and planet formation.

Understanding JWST results: What thermochemical models tell us about the cold H_2O content in disks

Wednesday 12th March 2025 14:45

Marissa Vlasblom

Leiden Observatory

vlasblom@strw.leidenuniv.nl

Contributed Talk

JWST is allowing us to characterize the chemical composition of the inner, planet-forming regions of protoplanetary disks in more detail than even before. One particularly interesting finding is a prominent cold H_2O reservoir seen in compact, drift-dominated disks that may trace ice sublimation near the H_2O snowline, a site where planets may form. We investigate the origin of this cold emission using DALI thermochemical models. Interestingly, models with H_2O abundances set by a chemical network do not show this cold emission inherently. Instead, an enhancement in abundance at the snow surface of 1-2 orders of magnitude is needed. We investigate what conditions or processes can produce such an enhancement in abundance, and thus how the presence or absence of this cold H_2O reservoir can inform us of the conditions under which planets form in the inner regions of the disk.

Chemical differentiation within a binary Class II disk system

Wednesday 12th March 2025 15:00

Beatrice Kulterer

Center for Astrophysics | Harvard & Smithsonian

beatrice.kulterer@cfa.harvard.edu

Contributed Talk

We do not know if the chemical composition of protoplanetary disks is set by nature or by nurture. Studying the chemistry of binary systems offers the unique opportunity to investigate this, as one could assume that two disks born from the same cloud share their chemical composition. This has however never been studied in detail. I am going to present data on MHO 1+2, a binary Class II disk in Taurus that has been targeted by observations with the SMA and ALMA. MHO 1+2 is part of an on-going Large Program at the SMA called SMA-SPEC (PI: K. Öberg) that covers >120 GHz in bandwidth for 40 bright, close-by protoplanetary disks. Utilizing this Large Program, I will present the first unbiased chemical survey of a binary system complemented by select high-resolution snapshots. The SMA data reveals that there is a clear chemical differentiation between the two components of the binary, which provides the first proof that the chemistry in binaries is not shared between sources and driven by nurture over nature. The ALMA data (PI: F. Long) reveals the presence of a stream of material that accretes from the natal cloud onto the disks, which is possibly the culprit of the chemical differentiation. In my talk I will highlight findings from the ALMA and SMA data, and demonstrate that in order to truly understand the chemistry in protoplanetary disks, and therefore the volatile component of planet-forming material, we need to get an unbiased view of their chemical composition.

Correlation in the emission of carbon-bearing species with dynamical state of protoplanetary disks

Wednesday 12th March 2025 15:15

Felipe Alarcón

Università degli studi di MIlano

felipe.alarcon@unimi.it

Contributed Talk

We present an observational study investigating the presence, or lack thereof, of correlations between molecular tracers and the dynamical states of a set of protoplanetary disks. The dynamical states were measured through high-resolution ALMA observations as part of the exoALMA Large Program sample. We contrast these dynamical states with the emission of carbon-bearing species such as methanol (CH_3OH) and formaldehyde (H_2CO). Our research introduces a novel approach to exploring the relationship between the chemical complexity and dynamical evolution of protoplanetary disks, integrating both numerical models and observational data. We usually interpret molecular observations by forward-modelling them with quasi-equilibrium chemistry. It would be important to understand if this assumption is correct when disks are significantly stirred. The analysis will shed light on how the chemical composition in planet-forming disks changes and how some stellar properties, such as stellar mass for example, can play a predominant role or if the dynamical evolution of the disk overrides the stellar influence on the disk chemistry. Such understanding will illustrate whether disks can have a different intrinsic composition based on their dynamical evolution/state, and whether these variations can have long-term implications for the chemical reservoirs available for planet formation.

TBD: Future perspective with cm observations, ngVLA and SKA

Thursday 13th March 2025 09:00

Izaskun Jiménez-Serra

Affiliation

`email`

Invited Talk

TBD

Chasing O-bearing Organics in protoplanetary disks: Early results from DECO ALMA Large Program

Thursday 13th March 2025 09:30

Claudio HernÁndez-Vera

Pontificia Universidad Católica de Chile

cahernandezv@uc.cl

Contributed Talk

The chemistry within protoplanetary disks (PPDs) plays a crucial role in shaping the makeup of future planets, linking the chemical makeup of disks to exoplanet atmospheres and the potential for habitability. Detecting complex organic molecules (COMs) in PPDs is vital for understanding these links. However, many oxygen-based COMs are likely inherited from earlier stages and remain trapped on the surfaces of dust grains. Smaller organic molecules, such as formaldehyde (H_2CO), which are considered precursors to COMs on icy dust grains, may serve as tracers in this context. However, contributions from gas-phase reactions complicate the interpretation of H_2CO as a clear indicator of icy grain chemistry. Although H_2CO has been extensively studied in PPDs, the lack of a representative statistical dataset has left its formation mechanisms uncertain. We present early results from The Disk-Exoplanet C/Onnection (DECO) ALMA Large Program, which observed several lines, including multiple H_2CO transitions across 80 disks in four star-forming regions. DECO examines a variety of "less-studied," compact, and faint disks, aiming to uncover how disk chemistry changes with different types of stars, disks, and environments, as well as to explore links between disk gas and exoplanet atmospheres. Our results on H_2CO provide essential clues about its formation and its role as a COM tracer on icy grains.

Constraining the physics of protoplanetary disks within Earth-like orbits: The warm molecular disk

Thursday 13th March 2025 09:45

Cade Bürgy

MPIA Heidelberg

buergy@mpia.de

Contributed Talk

A large fraction of exoplanets orbit within ∼1 au of their parent star suggesting either the formation at larger radii and planet migration towards shorter orbits or the in-situ formation at the current orbit. In both scenarios, our knowledge about planet formation and planet-disk interaction is limited by the predictions of disk models necessitating observational constraints of the physical conditions of the inner disk within Earth-like orbits. In this work, we use the CO overtone emission as a bonafide disk tracer to probe the innermost disk conditions. For the first time, we combine simultaneous optical interferometry using GRAVITY (UTs) and high-resolution CRIRES+ spectra. The combination of spectro-interferometric and high spectral resolution observations has allowed us to locate the CO emission and derive the temperature, column density, and kinematics of the CO-emitting gas for a sample of 4 intermediate-mass Herbig Ae/Be stars. Our results reveal that for all targets the CO is emitted from gas in Keplerian rotation within the dust sublimation front, that is, within the dust-free disk. Furthermore, we infer that the CO emitting gas is warm (~ 2000 K) and dense ($\sim 1 \times 10^{21}$ cm^{-2}). Finally, in order to reproduce our CRIRES+ spectra, broad local line widths are required which significantly exceed pure thermal broadening. These results show the potential of combining high resolution spectroscopy and interferometry to constrain the degree of turbulence in the inner disk.

A multi-molecular perspective: chemical complexity as a probe of the 2D physical structure of disks

Thursday 13th March 2025 10:00

Viviana Pezzotta

Università degli Studi di Milano

viviana.pezzotta@unimi.it

Contributed Talk

In recent years, the outstanding capabilities of ALMA led to new line detections and further analysis of a variety of chemical species hosted by protoplanetary disks. These observations, along with the development of sophisticated chemical codes, are paving the way to a further understanding of the role of chemistry in the process of planet formation. Gas temperature and density gradients induce a molecular vertical stratification in disks. By analyzing simultaneously different emission lines, we can thus leverage the chemical complexity of disks to investigate their physical properties at different heights across the disk vertical extent. We propose a multi-molecular approach to gas kinematics, involving the extraction and simultaneous analysis of several molecular rotation curves, including chemical species with hyperfine transitions. We fit the rotation curves simultaneously with a single model including contributions from stellar and disk gravity, pressure gradients and vertical thermal stratification. The vertical stratification leaves clear imprints in the rotation curves, with statistically significant differences between lines originating in the upper layers and the ones near the disk midplane. We show how the combination of the disk thermal structure, molecular stratification and pressure structure we can access through kinematics bears the potential to a further step into the physical and chemical characterization of the 2D structure of planet-forming disks.

Chemical Characterisation of Solar System Bodies with in-situ Space Probes

Thursday 13th March 2025 14:00

Nozair Khawaja

Institute of Space Systems, University of Stuttgart

khawajan@irs.uni-stuttgart.de

Contributed Talk

Numerous space missions have been sent across the solar system to explore planets, moons, asteroids, and comets. Investigating small solar system bodies is the key to unlocking insights into the chemical and physical properties related to planetary formation and evolution. (Sub-)micron-sized dust particles ejected from moons, asteroids, and comets possess important properties that convey information about the chemistry of these planetary bodies (Khawaja et al., 2024). In particular, studying how organic molecules have evolved and are distributed across the solar system is vital for understanding their chemical properties. Space probes equipped with an in-situ analytical scientific payload have played a pivotal role in investigating the composition of the atmospheric, surface, and subsurface environments of these planetary bodies (Arevalo Jr & Ryan M. Danell, 2019). Cosmic dust essentially constitutes 'free samples' emerging from different planetary and celestial bodies, conveying compositional information. In situ probes with onboard mass spectrometers aim to characterise the chemical composition of planetary bodies to gain insights into their structure, formation history, and evolution. In this talk, I will present the chemical properties of different planetary bodies in the solar system derived from (interplanetary and interstellar) dust particles sampled by mass spectrometers onboard space missions.

Exploring the Galilean moon volatile composition with SWI on JUICE

Thursday 13th March 2025 14:30

Eva Wirström

Chalmers University of Technology

eva.wirstrom@chalmers.se

Contributed Talk

Tracing the origin and formation of objects in our own Solar System - like planets, moons, comets and asteroids - by studying their chemical composition forms a crucial link towards general understanding of the chemical inheritance from prestellar cores to exoplanets. The composition of the Galilean moon exospheres reflects their surface composition but potentially also that of their subsurface. This is illustrated at Enceladus, where the composition of persistent plumes constrain the composition of the subsurface oceans (e.g., Peter et al, 2024) and even that of the building blocks that formed the satellite (Mousis etal 2009). The Submillimetre Wave Instrument (SWI) on ESAs JUICE mission, successfully launched in April 2023, is designed to record high resolution spectra in two sub-mm bands around 600 and 1200 GHz. It thus covers several rotational transitions of H_2O and HDO, but also of CO, O_2, CS, SO_2, HCN, CH_4, and NH_3. I will discuss how, during its tour in the Jovian system, it will be used to characterise the volatile composition and distribution of the Galilean moon exospheres, including that of potential plumes and subsurface oceans.

The chemical diversity of chondrules from their formation in protoplanetary envelopes

Thursday 13th March 2025 14:45

Mohamad Ali-Dib

CASS / New York University Abu Dhabi

malidib@nyu.edu

Contributed Talk

Chondrules are also sub-mm-to-mm- sized spherical objects, which have experienced extremely severe and variable thermal histories and display immense diversity of mineralogical compositions and textures. The chemical heritage and chronology of chondules has been used to argue for a fundamental role of these objects in the early accretionary processes that built the first planetary embryos. However, an alternative broad view - itself encompassing many discrete hypotheses - posits that chondrules in fact form from processes driven by the interaction of the Solar nebula with planetary embryos. These two mutually-exclusive views have very different implications for our understanding of how planets form and what chondrules can tell us about the early Solar System. However, despite the obvious importance of resolving this issue, proposed scenarios for chondrule formation have each been criticised for failing to explain at least some key observations. Here, we propose that the dynamical interactions of dust grains with the hot hydrogen-rich atmospheres of planetary embryos is a preferable scenario for the origin of chondrules. We show how this model is consistent with the major observables and explains the chemical diversity of chondrules.

Experimental ice simulations for the interpretation of ice and organics observations in the Solar System

Thursday 13th March 2025 15:00

Guillermo Muñoz Caro

Aff

email

Contributed Talk

TBD

Adsorption of water on olivine and the origin of Earth's water

Thursday 13th March 2025 15:15

Luca Vattuone

UniversitÃă degli Studi di Genova

luca.vattuone@unige.it

Contributed Talk

L. Vattuone 1,2, M. Smerieri 2, L. Savio 2, A.M. Asaduzzaman 3, K. Muralidharan 4, M. Rocca 1,2 1 DIFI UniversitÃă di Genova, Italy 2 IMEM-CNR Genova, Italy 3 School of Science, Engineering and Technology Pennsylvania State University, USA 4 Department of Materials Sciences and Engineering; Lunar and Planetary Laboratory, University of Arizona, USA Earth's water is usually believed to be delivered by comets or wet asteroids after the Earth formed: however wet asteroids and comets have elemental and isotopic properties that are inconsistent with those of the Earth. It was thus proposed that water was introduced by adsorption onto grains in the accretion disc prior to planetary growth, with bonding energies so high as to be stable under high temperature conditions. We investigated adsorption of H_2O on olivine both by laboratory experiments under UHV conditions and by numerical simulations. We found [1] that water adsorbs dissociatively on the olivine 100 surface at the temperature (approx. 500-1500 K) and water pressure (approx. 10-8 bar) expected for the accretion disc, leaving an OH adlayer that is stable at least up to 900 K. If an effective mechanism able to produce water from hydroxyl exists, many Earth oceans could form. Such mechanism would be effective in all disc environments around young stars leading to conclude that water should be prevalent on terrestrial planets in the habitable zone also around other stars. [1] Vattuone L et al. 2013, Phil Trans R Soc A.

Invited review talk on the chemical characterization of exoplanet atmospheres

Thursday 13th March 2025 16:30

Luis Welbanks

Arizona State University

luis.welbanks@asu.edu

Invited Talk

TBD

Radial variations in nitrogen, carbon, and hydrogen fractionation in the PDS 70 planet-hosting disk

Thursday 13th March 2025 17:00

Luna Rampinelli

University of Milan

luna.rampinelli@unimi.it

Contributed Talk

Recent exoplanetary studies revealed a broad diversity in the exoplanetary population, suggesting that the outcomes of planet formation are similarly diverse. Footprints of the journey of building blocks of planets are stored in exoplanetary atmospheres, which are the result of a complex chemical evolution from the parental cloud down to protoplanetary disks. In particular, isotopic ratios of the main elements (hydrogen, carbon, nitrogen, oxygen) are powerful tracers of the formation history of planetary material. While isotopic ratios have been measured for a variety of astronomical objects along the timeline of planet formation, a complete study of isotope fractionation at the protoplanetary disk stage is still missing. I will present ALMA high resolution line emission observations of the PDS 70 disk, which is the best source where to test the chemical link between forming planets and their natal environment, as it is the only disk with two multi-wavelength directly detected protoplanets. Thanks to the unprecedented spatial resolution, I will show radially resolved $^{14}N/^{15}N$, $^{12}C/^{13}C$, and H/D ratios extracted from HCN isotopologues observations. In particular, radial variations of fractionation levels reveal how different fractionation processes dominate at different planet-forming scales. In this context, I will show how the presence of two giant protoplanets affects the radial profiles of isotopic ratios in a planet-hosting disk.

Volatile composition of the HD 169142 disk and its embedded plantet

Thursday 13th March 2025 17:15

Luke Keyte

Queen Mary University of London

l.keyte@qmul.ac.uk

Contributed Talk

Determining the abundances of key volatiles within protoplanetary disks is essential for establishing connections between the composition of disks and the planets that form within them. This talk explores the chemistry of HD 169142, a Herbig Ae star hosting a molecule-rich disk with an embedded protoplanet. Using high-resolution ALMA data and advanced thermochemical modelling, the elemental abundances of carbon, oxygen, and sulfur are characterised at small spatial scales. Particular focus is placed on analysing the first-ever detection of SiS in a protoplanetary disk, with emission near the protoplanet vastly exceeding model predictions. This suggests a potential origin in shocked gas or localised outflows, offering a unique probe into ongoing planet formation processes. Our findings are contextualised in terms of the potential atmospheric composition of the embedded planet, and highlight the diagnostic power of sulfur-bearing molecules as probes of protoplanetary disk chemistry.

Quantifying the C/O ratio in the planet-forming environments around very low-mass stars

Thursday 13th March 2025 17:30

Javiera Díaz-Berríos

University of Leeds

pyjkd@leeds.ac.uk

Contributed Talk

The material in planet-forming disks will determine the composition of planets; hence, it is crucial to understand the physical and chemical processes that set the abundance and distribution of key volatiles. Recent James Webb Space Telescope (JWST) observations of disks around three very low-mass ($\sim$0.1 $M_\odot$) stars have revealed their hydrocarbon-rich inner regions (e.g., C_2H_2, C_4H_2, and C_6H_6), with column densities significantly higher than predicted. To understand and interpret these observations, we employ chemical kinetics models using the physical structure of the inner disk around an M-Dwarf star and compute the abundances of key volatiles. We adopt different initial elemental abundances to mimic the effects of carbon enhancement and oxygen depletion (C/O from 0.44 to 88) and quantify how the abundances and distributions of key volatiles respond to C/O variations. We attempt to constrain the elemental ratios that best explain the trends in the observations. In this talk, we present the model results and discuss how the magnitude of the mechanisms that set the inner-disk composition is not necessarily equal for the three sources even if they all show a hydrocarbon-rich inner disk. We also talk about the implications for planet formation and some caveats to take into consideration at the moment to interpret the results from chemical models.

Gas dynamics and chemistry around an embedded planet

Thursday 13th March 2025 17:45

Alex Cridland

University Observatory of Munich (USM)

a.cridland@lmu.de

Contributed Talk

The chemical properties of exoplanets are inherited from their natal protoplanetary disk. In models that compute the link between disks and planets one generally assumes that the chemical state of the material is unchanged as it flows from the disk to the planet. However the gas is heated as it falls deeper into the planet's gravitational potential, potentially leading to a drastic change in its chemical makeup between the hot circumplanetary disk and the much colder protoplanetary disk.

In this talk I will present recent work post-processing a hydrodynamic simulation with a chemical kinetic model to demonstrate the chemical processing of the gas as it flows from the cold ($\sim$ 40 K) protoplanetary disk to the hot ($\sim$ 200-800 K) circumplanetary disk.

The large change in temperature releases all of the available volatiles into the gas phase which could change the rate at which elements like carbon and oxygen are transported to the atmosphere of giant planets. In addition the warm temperatures allow for unique chemistry to occur in the circumplanetary environment which could differentiate it from the protoplanetary disk observationally.

Small planet atmospheres from the ground: state-of-the-art and future perspectives

Friday 14th March 2025 09:00

Eric Palle

Affiliation

email

Invited Talk

TBD

Probing Mini-Neptune Atmospheres: the case of K2-18b

Friday 14th March 2025 09:30

Gareb Enoc Fernandez Rodriguez

Universidad de La Laguna (ULL), Instituto de Astrofísica de Canarias (IAC)

gareb.fernandez@gmail.com

Contributed Talk

The Kepler and TESS missions found a multitude of planetary systems with Super-Earths and/or Mini-Neptunes in compact orbits around their host stars. Planets in this range of sizes and orbits appear as a common outcome of planetary formation, although they are not present in our Solar System. Remote-sensing spectroscopy of their atmospheres is key to understanding their bulk composition and possible formation pathways, such as the relative amounts of rock and volatiles, the persistence of a primordial H-He envelope, and ideally their elemental ratios. K2-18b is one of the smallest exoplanets with robust atmospheric detections (CO_2 and CH_4), leading to hypotheses that it is a hycean, likely inhabited, planet (Madhusudhan et al. 2023), or a gas-rich mini-Neptune (Wogan et al. 2024). The previous molecular detections, albeit with different possible interpretations, make it a particularly relevant case of study. We re-reduced and analysed the JWST NIRISS and NIRSpec data taken during two transits in 2023, confirming the detection of CO_2 and CH_4 in the atmosphere of K2-18 b. Moreover we quantitatively test the impact of different treatments of stellar limb-darkening, corrections for an occulted spot (and unocculted ones), instrumental ramps, spectroscopic binning and outlier rejection in the atmospheric transmission spectrum and the effect these have on possible molecular detections, highlighting the case of CO.

Characterizing Earth-like Exoplanets: Insights from Earthshine Observations

Friday 14th March 2025 09:45

Giulia Roccetti

ESO

giulia.roccetti@eso.org

Contributed Talk

The next generation of ground- and space-based telescopes, such as ANDES and PCS at the ELT and the mission concept Habitable World Observatory (HWO), will enable the study of exoplanets in reflected light, extending this capability to rocky planets. To better understand Earth as an exoplanet, we analyze its spatially unresolved visible reflected spectrum via the sunlight reflected by Earth onto the Moon (Earthshine). Using the 3D Monte Carlo radiative transfer code MYSTIC, we generate synthetic spectra and phase curves of Earth in both intensity and polarization, incorporating realistic 3D atmospheric pressure-temperature profiles, patchy clouds, and wavelength-dependent surface albedo maps. By comparing these simulations with Earthshine data, we evaluate the sensitivity of key spectral features for planetary characterization and habitability assessment. Our findings highlight the necessity of detailed atmospheric and surface albedo modeling to accurately reproduce Earthshine observations. These insights are essential for future missions targeting Earth-like exoplanet characterization. By advancing our understanding of Earth's radiative and spectral properties, we establish a basis for interpreting observations of similar distant planets. We also formulate an optimal strategy, through a comparison of spectroscopy and spectropolarimetry, for assessing the chemical diversity of Earth-like exoplanets with upcoming telescopes.

Posters

Molecular emission from a protostellar jet-disk wind interaction

Erika Alquicira Peláez

UNAM

erika.alquicira@correo.nucleares.unam.mx

POSTER

Protostellar jets are common signatures shown by very young protostars. This high-velocity jet and the cavity comprise a molecular outflow that, additionally, could interact with the wind generated by the circumstellar disk wind that surrounds the protostar. We are interested in studying the interaction between the jet and a disk wind, considering their molecular evolution. We used WALKIMYA-2D, axisymmetric chemo- hydrodynamical code, to simulate the interaction between the jet, disk wind, and the environment.

An Organic Deuteration Survey of Starless Cores

Hanga Andras-Letanovszky

University of Arizona

hangaa@arizona.edu

POSTER

Starless cores and gravitationally-bound, collapsing prestellar cores are the incipient phase of star and planet formation. We must understand the evolution of starless and prestellar cores, as the initial conditions of the future protoplanetary disk are set during this phase. A comparison of the chemical maturity of a starless core with its physical properties, such as central density, kinetic temperature, and virial stability, allows for characterization of its chemical evolution rate. Deuteration, where deuterium replaces one or more hydrogen atoms in a molecule, is favored in the cold, dense environments of starless cores, making it a very effective probe of chemical maturity. The B10 region of the Taurus Molecular Cloud is a pristine environment for the study of starless core evolution due to its lack of embedded protostars. We surveyed 11 cores in B10 in oH_2CO, HDCO, and pD_2CO with the ARO 12m telescope. We find that HDCO, previously thought to deuterate primarily on icy grain surfaces, does not correlate well with CH_2DOH, a known tracer of icy grain surface deuteration. We investigate the possibility of a gas-phase component to HDCO deuteration by comparing it to N_2D^+, a known gas-phase deuteration tracer. We find a general lack of correlation between deuterated organic molecules and the physical parameters of the cores. This may indicate that the cores are evolving at different rates, and that deuteration provides a unique measure of core chemical evolution.

HCl in massive star-forming regions across various scales

Lennart Boehm

ESO Garching

lennart.boehm@eso.org

POSTER

Although its nucleosynthesis history is not fully understood, Cl is primarily produced in the interstellar medium via core-collapse supernovae, with the weak s-process in massive stars as a secondary source of ^{37}Cl. Stellar models predict a ^{35}Cl/^{37}Cl ratio between 1 and 5, but observations of Cl-bearing molecules have been limited due to their high-lying transitions. I will present recent observations of the HCl 1âĂŞ0 line at 625 GHz, carried out using the SEPIA660 receiver on the APEX 12 m sub-mm telescope. We detected both isotopologues toward 27 Galactic sources, spanning a range of Galactocentric radii, doubling the number of sources where it has previously been detected. Of these, 11 show pure emission with possible outflow features, while the remaining display complex profiles with mixed emission and absorption. An average isotopic ratio of 2.4$\pm$0.8 was found, with no clear trend with galactocentric radius. The observed outflow wings motivated us to map HCl emission in the massive star-forming region IRAS 12326-6245, probing chlorine distribution and isotopic ratio on smaller scales. Following its ubiquitous abundance across the Milky Way, HCl was also investigated towards nearby galaxies; it was detected in absorption toward NGC 4945, which marks the first detection of HCl in a nearby galaxy.

ALMA reveals thermal and non-thermal desorption of methanol ice in the HD 100546 protoplanetary disk

Lucy Evans

University of Leeds

l.e.evans@leeds.ac.uk

POSTER

There is growing evidence that planet formation is already underway during the protoplanetary disk stage, making the chemical study of such objects imperative when considering the planet-forming environment. This talk presents ALMA observations which study the chemistry of two Herbig disks: HD100546 and IRS48. I will present briefly the resultant chemical inventory of these two objects which enables the first detailed characterisation of the complex organic reservoir. The main topic of the talk will focus on multiple detected lines of methanol and formaldehyde, towards HD100546, which likely hosts two giant planets. Methyl formate is also detected, revealing another level of chemical complexity. Previous research has suggested that methanol has an inherited origin in HD100546 as it could not form efficiently in situ. As the simplest complex organic molecule (COM), methanol is fundamental within the context of astrochemical origins, representing a bridge between simple molecules and more complex compounds vital to life. Multiple lines of methanol and formaldehyde are detected towards the hot inner and cold outer disk, suggesting that the outer dust grains are icy. Through rotational diagram analysis, we constrain for the first time the temperature and column density of these two organic molecules in both spatial components. This enables a thorough investigation into the organic chemical history of this disk, including methanol inheritance and thermal vs non-thermal desorption.

UV Processing of Icy Pebbles in Disks

Lizxandra Flores-River

Globe institute, University of Copenhagen

lizxandra.rivera@sund.ku.dk

POSTER

Icy dust particles emerge in star-forming clouds and are subsequently incorporated in protoplanetary disks, where they coagulate into larger pebbles up to mm in size. In the disk, moderate levels of disk turbulence can lift small particles to the disk surface, where they can be destroyed. Nevertheless, studies of comets and meteorites generally find that ices at least partly retained their ISM composition before being accreted onto planetesimals. Here we model this process using hydrodynamical simulations with turbulence in the outer protoplanetary disk. We use the PLUTO code in a 2.5 D global accretion setup and include Lagrangian dust particles of 0.1 and 1 mm sizes. In a post-processing step, we use the RADMC3D code to generate the local UV radiation field to assess the level of ice processing of pebbles. We find that a small fraction ($sim17\%$) of 100 microns size particles are frequently lifted up to Z/R=0.2 which can result in the loss of their pristine composition as their residence time in this layer allows for effective CO and water photodissociation. The larger 1 mm size particles remain UV-shielded in the disk midplane throughout the dynamical evolution of the disk. Our results indicate that the assembly of icy bodies via the accretion of drifting mm-size icy pebbles can explain the pristine ice from the ISM. Nevertheless, particles smaller than 100 microns experience UV processing and may mix with unaltered icy pebbles, resulting in a less ISM-like composition.

Study of radial and vertical structure of the edge-on protoplanetary disk surrounding SSTtau042021

Coralie Foucher

Laboratoire d'Astrophysique de Bordeaux

coralie.foucher@u-bordeaux.fr

POSTER

Understanding the complexity of gas and dust structures in planet-forming disks is essential for a comprehensive view of planetary formation. We present an analysis of the nearly edge-on protoplanetary disk around SSTTau 042021 (inclination 90.6 ± 0.4deg), based on archival ALMA data. Edge-on disks like SSTTau 042021 are valuable laboratories for directly observing molecular stratification, bypassing challenges in vertical structure analysis faced by inclined disks. Using the tomographic method of Dutrey et al., we reconstruct the 2D brightness temperature distribution Tb(r,z) for CO isotopologues (^{12}CO, ^{13}CO, and C^{18}O). We investigate the disk molecular layer location and the dust disk properties. This method, performed on high-resolution data ($\sim 0.3''$), allows for accurate measurements of CO temperatures. Our results show, in particular, a good agreement between the CO and dust temperatures (within 8-12 K) near the mid-plane. This study highlights the power of high-resolution tomography for probing disk stratification and provides insights for refining model approximations of vertical temperature gradients in protoplanetary disks.

Deuteration of carbon chains in the prestellar core L1544

Katharina Giers

1. Max-Planck-Institute for Extraterrestrial Physics

kgiers@mpe.mpg.de

POSTER

Deuterated molecules are a useful diagnostic tool to probe the evolution and the kinematics in the earliest stages of star formation. Due to the low temperatures and high densities in the centre of prestellar cores, deuterium fractionation is enhanced there. In fact, prestellar cores show an increase in the deuterium fraction (>10%) compared to other starless cores (Crapsi et al. 2005). The low-mass prestellar core L1544 is known to show very high levels of deuteration in several molecules (Crapsi et al. 2005, Redaelli et al. 2019, ChacÃşn-Tanarro et al. 2019, Giers et al. 2022, Giers et al. 2023). We present deuteration maps of the carbon-chain molecules c-C_3H_2, CH_3CCH, and HC_3N, observed towards L1544 with the IRAM 30m single-dish radio telescope. We use these to investigate the physical structure of a core on the verge of forming a protostar. The molecular segregation between CH_3CCH and the other two carbon chains allows us to analyse differences in the chemical structure across the core. By comparing the deuteration ratios, we are able to put constraints on the chemical processes regulating deuterium fractionation that we apply in our astrochemical codes (e.g. SipilÃď et al. 2019). Furthermore, we use radiative transfer modelling to reproduce the observed spectra and deepen our understanding of the physical structure of the core.

Tracing chemical evolution of high-mass star-forming regions

Akash Gupta

1. Physikalische Institute, Universität zu Köln

agupta@ph1.uni-koeln.de

POSTER

High-mass star-forming regions are critical environments for understanding the chemical evolution of the interstellar medium (ISM) and the life cycle of Giant Molecular Clouds (GMCs). These star-forming regions undergo rapid and dynamic chemical evolution shaped by UV radiation field, feedback from stellar winds, ionization from cosmic rays, etc. These environments lead to the generation of rich chemical regions, including the synthesis of complex organic molecules. In this work, we use high-resolution MHD simulations for high-mass star formation and post-process it with the rate-equation-based gas-grain code, Saptarsy, to trace the evolution of various molecules as the star-forming region evolves. The recent improvements in the code mean it can deal with gas phase, gas-grain, and dust surface reactions using a multi-layered dust model.

Spatial distribution of phosphorus carriers in galactic and extragalactic star-forming regions

David Haasler

Centro de AstrobiologÃŋa (CAB, INTA-CSIC)

dhaasler@cab.inta-csic.es

POSTER

Phosphorus (P) is a crucial element for life given its central role in several biomolecules, although the formation mechanism of P-bearing molecules in the interstellar medium still remains poorly understood. Using observations from the ALMA Comprehensive High-resolution Extragalactic Molecular Inventory (ALCHEMI) project, we carried out an LTE and a non-LTE analysis to model the emission of P-bearing molecules towards the nearby starburt galaxy NGC 253. We report the detection of a P-bearing molecule, phosphorus nitride (PN), for the first time in an extragalactic environment, towards two giant molecular clouds of NGC 253. Using complementary observations carried out with ALMA, we targeted the low mass star-forming region IRAS 16293-2422 to map the spatial distribution of P-bearing molecules at a high spatial resolution (50 au). The observations target three sets of rotational transitions of PN and phosphorus monoxide (PO), allowing us to perform a multi-transition analysis to study the excitation of these molecules. The observations show that the emission of PN and PO arises from shocked material traced by the shock tracers sulfur monoxide (SO), and sulfur dioxide (SO_2). Comparison of the observations with chemical models supports the formation of P-bearing molecules in shocked regions where a yet unidentified P-carrier is desorbed from the dust grain surface and gas phase reactions lead to the formation of PN and PO.

Chemical Abundances of a Sample of M Dwarf Host Stars Observed by APOGEE

Ester Nascimento

National Observatory (Brazil)

esternascimento@on.br

POSTER

M dwarf stars are the most abundant yet least studied stars in the universe. Their cooler temperatures and low luminosities have made their characterization possible only recently, especially in the infrared, where their emission peaks. These stars are sensitive to the detection of smaller planets and remain on the main sequence longer than hotter stars, making them great targets for exoplanet searches and planetary system characterization. Analyzing the chemical abundances of the host stars is a way to explore their relationship with orbiting planets, as stellar chemistry reflects the molecular cloud composition that formed both the star and its planets. In this context, this study aims to determine the chemical abundances of a sample of 34 M dwarf stars with planets confirmed. Infrared spectra from the APOGEE survey were analyzed through spectral synthesis with the radiative transfer code Turbospectrum and the BACCHUS wrapper, using 1D plane-parallel MARCS LTE atmospheric models and the APOGEE DR17 line list. To validate our methodology, we performed a consistency test on another 21 M dwarf stars with known abundances. Results showed good agreement with literature values, with an average deviation of -0.02 dex across all elements, with the largest deviations found for magnesium (0.12 dex) and chromium (0.10 dex). These results indicate the suitability of our methodology for studying the 34 new M dwarf host stars, and the findings from this sample will be discussed.

Application of machine learning techniques for analysing molecular emission lines

Karolina Plakitina

Institute of Astronomy RAS

plakitina.kv@outlook.com

POSTER

Modern astronomy deals with enormous set of spectral data obtained from observations of molecular emissions in various sources-including infrared dark clouds, protostars, and HII regions. Traditional data analysis methods become less effective when processing such extensive datasets. In this work, we explore the application of machine learning techniques for analysing molecular emission lines to characterise astronomical objects and their astrochemical properties. Utilising data from the MALT90 survey, which observes the Galactic plane at 3 mm wavelengths, we discuss various clustering algorithms and dimensionality reduction methods that simplify the identification of objects. Our findings demonstrate that machine learning methods effectively identify two groups of star-forming regions among other types of astronomical sources. These groups are distinguished by line intensities of molecules which have different astrochemical origins. This approach holds promise for processing data collected with advanced facilities like JWST and ALMA, leading to more efficient analysis of astronomical data.

Modelling the long-term effects of moving shadows on protoplanetary disk chemistry

Jorge Perez Gonzalez

Heidelberg University/ Max Planck Institute for Astronomy

jorge.perez_gonzalez@uni-heidelberg.de

POSTER

The carbon-to-oxygen (C/O) ratio of a gas giantâĂŹs atmosphere is widely considered a tracer of its formation history, allowing us to link the composition of its atmosphere to the region of the protoplanetary disk in which it was accreted. C/O variations in a disk have been traditionally modelled by careful consideration of the snowlines of major volatile species, varying only in the radial direction. However, recent observations of the well-studied disk HD 100546 suggest that the gas phase C/O ratio can also vary azimuthally. This is thought to be related to a dust over-density which casts a shadow on the outer disk, freezing out volatiles in an azimuthally localised region which moves on an orbital timescale. In this work we investigate the permanent effects of a moving shadow on the disk chemistry. We present a numerical model which simulates dust growth and settling, which tracks the transport of icy dust grains towards colder, deeper regions. This process potentially sequesters volatiles permanently from the gas phase near the disk midplane. Our results show that, under the favorable conditions of our simulation, shadowing and dust evolution are inefficient at inducing detectable changes in the gas-phase C/O ratio using current observational facilities. Our model provides a platform for future work to investigate the effects of shadowing on the wider protoplanetary disk population.

Compact or large? CO observations of the faintest planet-forming disks

Giulia Ricciardi

ESO Garching

giulia.ricciardi@eso.org

POSTER

Planet-forming disks observed by ALMA surveys often exhibit surprisingly faint continuum and CO emission, raising doubts about whether these disks contain enough material to account for the known exoplanet population. Despite this, the fainter end of the disk population - which shows compact, unresolved continuum emission and non-detections in CO isotopologues - has received little detailed investigation. It remains unclear whether this is due to faint but spatially extended emission or intrinsically compact disk structures. Distinguishing between these scenarios is crucial: if such disks are indeed compact, including their gaseous components, and optically thick, their inner regions could harbor significant reservoirs of material, potentially capable of forming gas giants within Jupiter's orbital radius. In this poster we present new ALMA data that target ^{13}CO (3-2) and ^{12}CO (3-2) lines in 18 CO-faint Lupus disks, probing the gaseous component of the faintest planet-forming disks. If the observations confirm that these disks are radially compact and optically thick, we could imply a substantial planet-forming capacity within 10 au in a significant fraction of Lupus disks. Furthermore, if these disks are indeed compact, they challenge widely accepted theories of disk evolution, such as viscous evolution and MHD-driven processes, which cannot account for such small outer radii. Since Lupus is a young, low-density star-forming region, external truncation processes are also unlikely to explain these compact gaseous structures, further emphasising the need for a revised understanding of disk evolution.

A Wideband Chemical Survey of Planet Formation with SMA

Clara Ross

CAB

clara.ross@cfa.harvard.edu

POSTER

Spectroscopic surveys of protoplanetary disks provide robust constraints on the chemical and physical conditions that influence the efficiency and pathways of planetary formation. Over the past decade, several surveys such as the SMA Project DISCS and the ALMA Large Program MAPS have set the stage for understanding the chemical complexities of planet-forming environments at millimeter wavelengths, but these surveys have been targeted towards specific molecular transitions. Here, we show the first results of SMA-SPEC, the first chemically unbiased survey of a large number of protoplanetary disks, with an analysis of LkCa 15 and MWC 480. With the full sample of 40 disks, the 120 GHz bandwidth survey will allow us to address fundamental questions about the chemical diversity of protoplanetary disks, including but not limited to disk masses, elemental ratios, ionization levels, and chemical inheritance during the planet formation process.

Exploring chemical complexity in the birthplaces of stars: the G+0.693 and G+0.633 molecular clouds

David San Andrés

CAB

david.sanandres@cab.inta-csic.es

POSTER

Astrochemistry is now living its golden age, with nearly one quarter of the 320 molecules that constitute the current total interstellar census having been detected just in the last three years. In this scenario, one of the sources that has demonstrated a leading role is the Galactic Center G+0.693-0.027 molecular cloud, which has already been consolidated as one of the richest chemical reservoirs in our galaxy. Among the 135 species that have been identified towards it, this cloud hosts to date the unique reports of key prebiotic species, such as ethanolamine, glycolamide, cyanomethanimines or carbonic acid. These detections not only give support to the plausible exogenous-delivery scenario for the origin of life on Earth, but also contribute to unveiling the true chemical complexity of the interstellar medium, which provides the key ingredients later to be inherited by the next generations of stars and planetary bodies. However, the current shortage in the number of detections of such species imposes severe limitations into the understanding of the chemistry linked to these species under interstellar conditions, driving the search for new chemically-rich sources a prime necessity. In this talk, I will present the discovery of a new promising interstellar laboratory, the Galactic Center G+0.633-0.0604 molecular cloud. This cloud exhibits a similarly rich chemistry as G+0.693, offering valuable insights into the astrochemical input for star formation at its earliest stages.

New discoveries in the G+0.693-0.027 molecular cloud: Discovery of new O-, N- and S-bearing species

Miguel Sanz-Novo

Centro de Astrobiologia (INTA-CSIC)

miguel.sanz.novo@cab.inta-csic.es

POSTER

In recent years, there has been a notable increase in new interstellar discoveries within the field of astrochemistry. In particular, the Galactic center molecular cloud G+0.693-0.027 (hereafter G+0.693) is recognized among the most relevant "astronomical mines" based on the detection of nearly 20 new interstellar molecules. Herein, we will present several of the latest discoveries, based on the superb sensitivity of an unbiased, ultradeep spectral survey carried out with the Yebes 40 m and IRAM 30 m telescopes toward G+0.693. Among these new detections we find carbonic acid (HOCOOH), the first interstellar molecule containing three oxygen atoms and the third carboxylic acid detected in the interstellar medium (ISM) to date, glycolamide, the first interstellar glycine isomer, and several S-bearing species such as thionylimide (HNSO) and protonated carbonyl sulfide ($HOCS^+$). Overall, these new findings shed light on the actual levels of interstellar chemical complexity and pave the way for further integrated efforts across observations, theory, and laboratory research.

Probing Sulfur Chemistry in starless cores

Laura Schöller

MPE

lausch@mpe.mpg.de

POSTER

Starless cores characterize the earliest stage in star formation and act as ideal laboratories for studying the different physical and chemical processes devoid of protostellar feedback. Over time, they evolve into pre-stellar cores nearing the gravitational collapse to form stars. At this stage, the core contains material that eventually will contribute to star and planet formation. While evolved starless cores are better suited for studying the most molecules (e.g., water and COMs [Complex Organic Molecules]), sulfur-bearing molecules represent an exception, as they show a significant depletion in dense cores compared to their abundance in diffuse regions. In this work, a sample of 8 starless cores at different evolutionary stages was observed. The targeted molecules contain families covering carbon/ oxygen and sulfur (e.g., CS, SO, SO_2) and combinations of carbon, oxygen, and sulfur (e.g., OCS). Additionally different isotopologues such as ^{34}S or ^{13}C were detected. The objective is to investigate their correlation with indicators such as the CO depletion factor, the dust temperature, and the H_2 column density to enhance the understanding of sulfur's crucial role in the chemistry of starless cores and its broader implications for star formation.

Hunting for methanol in a water rich, planet forming disk

Alessandro Soave

Università di Bologna

alessandro.soave2@unibo.it

POSTER

Methanol (CH_3OH), being the simplest possible complex organic molecule (COM), plays a key role among all the chemical species of prebiotic interest detected in space. Across the different stages of Young Stellar Objects (YSOs) evolution, methanol has been found only in a handful of protoplanetary disks. One of the most promising candidate disk to search for methanol is HL Tau, due to the recent discovery of warm water vapour emission (Facchini et al., Nature Astronomy 2024): since methanol and water have a similar volatility, CH_3OH is expected to emit from the same region of the disk where water has been detected. In this poster I will present my latest results regarding the analysis of the best ALMA archival datasets to look for methanol inside HL Tau. Employing advanced state-of-art techniques, such as image reconstruction and line stacking in the visibility plane, I was indeed able to derive stringent upper limits on the methanol column density and to discover one possible methanol transition. Within a thermalised framework, I found a low upper limit on the methanol-to-water column density ratio $\lesssim 10^{-2}$ for HL Tauri, similar to the one measured for Solar System comets. This result marks a major step in understanding how the methanol-to-water ratio changes during the evolution of YSOs, especially in the poor-constrained protoplanetary disk stage.

A Window into Chemistry on Icy Dust Grains - the Deuterated Ammonia and Methanol in Ophiuchus Survey

Lucille Steffes

University of Arizona

ljsteffes@arizona.edu

POSTER

Observing CH_3OH and CH_2DOH, which enter the gas phase through non-thermal desorption in starless cores, allows us to peer through a window onto the icy surfaces of dust grains at the earliest part of the star formation process. Observations of starless and prestellar cores have detected singly deuterated methanol (CH_2DOH) at a 75% detection rate and at abundances more than four orders of magnitude larger than the atomic D/H ratio. However, all but two of the published observations are in Taurus with only one core observed in Ophiuchus. Using the Arizona Radio Observatory 12 m telescope, we observe methanol (CH_3OH), CH_2DOH, and singly deuterated ammonia (NH_2D) in starless and prestellar cores in Ophiuchus with the coldest dust temperatures, comparing the deuterium fractions on icy dust grains with those in the gas phase. Additionally, gas in Ophiuchus - a more active star forming region than Taurus - is disturbed as stars form, which may cause prestellar cores to evolve chemically and physically at different rates than those in Taurus, leading to a different distribution of deuterium fractions in prestellar cores with otherwise similar conditions. This survey will allow us to compare the deuterium fractions between Ophiuchus and Taurus in cores with similar average densities. We will also examine the relationship between the deuterium fractions in cores of Ophiuchus with the physical parameters in starless and prestellar cores such as density, temperature, and virial ratio.

A detailed analysis of H2O emission in the JWST-MIRI spectra of 8 millimeter-compact disks

Milou Temmink

Leiden Observatory

temmink@strw.leidenuniv.nl

POSTER

H_2O is one of the key ingredients for habitability. While it is not yet fully understood how forming planets obtain their H_2O reservoirs, the molecule has a striking imprint on the mid-infrared spectrum of planet-forming disks. With many ro-vibrational (below 10 micron) and pure rotational (above 10 micron) transitions distributed throughout the 4.9-27.5 micron wavelength range observed by JWST/MIRI-MRS, the available H_2O reservoirs in the inner disks can be investigated. Disks that are compact in the dust millimeter emission are especially interesting targets for the characterisation of their H_2O reservoirs. As their compactness is thought to be the result of efficient radial drift, a larger reservoir of H_2O near its snowline may be expected compared to their large, structured counterparts. In this talk, I will present the first results of an extensive analysis of the H2O emission of 8 compact disks around isolated stars, all part of the MINDS GTO program. These results will highlight the trends seen in the H_2O emission, include full descriptions of the rotational H_2O spectra using both power-law and multiple component slab models, and demonstrate the likeliness of an enhanced cold (T=150-180 K) reservoir, due to the efficient radial drift, through promising line ratios.

Chemical model of protostellar cores and applications

Le N. Tram

Leiden Universitye

nle@strw.leidenuniv.nl

POSTER

Interstellar complex organic molecules (iCOMs) are thought to form on grain surfaces and subsequently enter the gas phase through desorption. This presentation will discuss the enhanced gas-grain chemical model, UCLCHEM, which now features a one-dimensional aspect, and its application in interpreting iCOM detections within protostellar environments. It is evident that some iCOMs, like methanol, are generated farther from the core, while others, such as ethanol, are found closer. The second update emphasizes the suprathermal rotation of grains caused by their interaction with directional radiation or gas flow. This dynamic rotation induces centrifugal energy on a thinner icy surface, lowering the potential barrier for iCOMs and increasing the rate of desorption. Rapid rotation can also break thick ice layers into smaller pieces through centrifugal forces. As a result, these small fragments release iCOMs transiently during thermal spikes, whereas larger fragments can accelerate thermal sublimation more effectively than the original icy grains. These new non-thermal desorption mechanisms significantly impact the understanding of iCOM origins in star-forming regions and highlight the importance of considering the effect of suprathermal rotation of icy grains when using molecules to trace physical conditions in these areas.

High-mass prestellar cores: what are the forces in presence to prevent the gravitationnal collapse ?

Maxime Valeille-Manet

Institut de PlanÃĺtologie et d'Astrophysique de Grenoble

maxime.valeille@outlook.fr

POSTER

To better understand the formation of high-mass stars, it is necessary to identify the youngest precursors of massive stars ($M > 8\ M_{\odot}$), even before collapse (so-called prestellar cores), within high-mass star-forming regions. Using a new automatized method for systematically detecting outflows from proto-stellar cores, we search high-mass prestellar cores in the ALMA-IMF survey, i.e. cores without significant outflowing emission. For this, we rely on the CO(2-1) and SiO(5-4) lines. We show that 30 cores with a mass greater than 8 $M_{\odot}$ are such good prestellar candidates in the ALMA-IMF survey (Valeille-Manet et al. subm). They cover a mass range from 8 to 54 $M_{\odot}$, with 12 cores more massive than 16 $M_{\odot}$ that will most certainly form a high-mass star in the future. We can then derive statistical lifetimes in several bins of mass with short lifetimes below 10^5 yr for the most massive cores. But on the other hand, the obtained lifetimes are relatively large with values of the order of $10 \times T_{ff}$, suggesting the need of a support against gravity to prevent the cores to collapse on a free-fall time as expected. Using the DCN(3-2) and 13CS(5-4) lines, we studied the turbulence in the 12 most massive prestellar core candidates and found supersonic turbulence in all the cores (Valeille-Manet et al in prep). A Virial analysis reveals that additional magnetic field strengths between 5 and 50 mG would be needed for around 2/3 of the 12 cores to justify their long lifetimes.

Understanding JWST results: What thermochemical models tell us about the cold H_2O content in disks

Marissa Vlasblom

Leiden Observatory

vlasblom@strw.leidenuniv.nl

POSTER

JWST is allowing us to characterize the chemical composition of the inner, planet-forming regions of protoplanetary disks in more detail than even before. One particularly interesting finding is a prominent cold H_2O reservoir seen in compact, drift-dominated disks that may trace ice sublimation near the H_2O snowline, a site where planets may form. We investigate the origin of this cold emission using DALI thermochemical models. Interestingly, models with H_2O abundances set by a chemical network do not show this cold emission inherently. Instead, an enhancement in abundance at the snow surface of 1-2 orders of magnitude is needed. We investigate what conditions or processes can produce such an enhancement in abundance, and thus how the presence or absence of this cold H_2O reservoir can inform us of the conditions under which planets form in the inner regions of the disk.

Optical and infrared characterization of young stellar clusters associated with the Sh2-296 Nebula

Lucas Volpe

Universidade de São Paulo

lucasmrvolpe@usp.br

POSTER

An important case-study for star formation is the Canis Major R1/OB1 (CMa) young star association, which consists of hundreds of B-type stars, emission nebulae and embedded star clusters. This work aims to reduce and analyze images of three of these clusters associated with the main component in CMa, the Seagull Nebula (Sh2-296), focusing on the methodology used to detect and identify members, also covering the characterization of the gas around the clusters. Images of the three clusters were acquired by the SOAR telescope in the near infrared using the SPARTAN camera (J, H, K, Cont3, Brγ and H_2 filters), and in the optical using the SAM module (R, Hα, [SII] and [OIII] filters). The IR images provide data on young stellar objects that are members of the cluster, characterized based on the color-color and color-magnitude diagrams presented. With optical data, we carried out astrometric calibration and studied the gas distribution through operations between images in different filters in the search for condensations and substructures of the gas around the cluster. The analysis of the spatial and kinematic distribution of gas aims to contribute to the understanding of the star formation context of CMa and its history of events, marked by possible supernova explosions. To characterize the stellar population, complementary data from public databases (WISE, 2MASS, Gaia DR3) are also used for comparison with the identified objects, in addition to visual extinction maps.

A deep-dive into Raman spectra of lab-produced insoluble organic matter

Adibah Nur Zainol Abidin

Technische Universiteit Delft (TU Delft)

A.bintiZainolAbidin@tudelft.nl

POSTER

Meteorites, in particular carbonaceous chondrites, contain large quantities of soluble and insoluble organic matter (SOM/IOM), classified based on their solubility in solvents and acid. While much attention was given to smaller molecules such as SOM, the formation of IOM macromolecules is still an enigma. Since ice-coated dust grains are abundant in interstellar medium and protoplanetary disk, it necessitates various laboratory studies on energetic processing of icy grains to shed some light on relationships between ice, SOM, IOM and radiation. With our ICEBEAR setup, we previously demonstrated that IOM can be synthesized through heavy irradiation of simple extraterrestrial-like ice. Raman analyses of our preliminary data showed a remarkable agreement of the D- and G-band shapes recorded for the residues with data obtained from primitive carbonaceous chondrites. However, the different fitting procedures by a number of literatures resulted in variations of a standard Raman spectra. We thus attempt to refine the spectral analyses from our previous code of two Lorentzian peak-fitting to five Lorentzian peak-fitting. Our results show high degeneracy of the fitting problem due to the increase in number of free parameters and the inadequacy of physical boundary assignments to the Raman peaks. Moving forward, it is therefore necessary for the scientific community to further analyze how the D-and G- band are fitted in differentiating attributions to Raman band assignments.

Extracting protoplanetary gas disk properties: the perspective from ALMA DECO LP

Luigi Zallio

ESO

luigi.zallio@eso.org

POSTER

The field of planet formation is undergoing rapid development, mostly thanks to the transformational capabilities of ALMA. The disk gas radius (Rgas) is one of the fundamental properties needed for constraining disk evolution all the way to planet formation. For example, disk radii can be used to disentangle viscous and MHD wind accretion. Rgas can be measured from molecular emission, mostly CO, observed with ALMA, but it is critical to have analysis tools capable of retrieving all the information hidden in the data in a reliable way. Usually, disk radii have been measured from the CO images and only for a limited number of bright and extended disks. In interferometry, however, images are highly processed data products, and this introduces systematic biases which are difficult to quantify. I will present a new strategy which retrieves the disk size directly in the visibilities, the native quantity measured by the interferometer. The analysis, implemented in the code CSALT (Andrews et al., in prep.), is based on a parametric model of the disc structure and emission; this approach allows a robust statistical inference of the model parameters. In this talk, I will present preliminary results obtained with this new technique for a subset of protoplanetary disks from the DECO Large Program (P.I. Ilse Cleeves). I will show the results on my analysis for the three isotopologues ^{12}CO, ^{13}CO, $C^{18}O$, and I will outline the improvements with respect to other approaches.

Extracting physical properties of barely-resolved protoplanetary disks using visibilities

Luigi Zallio

ESO

luigi.zallio@eso.org

POSTER

The field of planet formation is undergoing rapid development, mostly thanks to the transformational capabilities of ALMA. The vertical height (z(r)) is one of the fundamental properties needed for constraining disk formation and evolution. For example, extracting z(r) in different isotopologues tells us about the vertical structure of disks. Z(r) can be extracted from molecular emission, mostly CO, observed with ALMA, but it is critical to have analysis tools capable of retrieving all the information hidden in the data in a reliable way. Usually, disk radii have been measured from the CO images and only for a limited number of bright and extended disks. In interferometry, however, images are highly processed data products, and this introduces systematic biases which are difficult to quantify. I will present a new strategy which retrieves z(r) directly in the visibilities, the native quantity measured by the interferometer. The analysis, implemented in the code CSALT (Andrews et al., in prep.), is based on a parametric model of the disc structure and emission; this approach allows a robust statistical inference of the model parameters. In this talk, I will present preliminary results obtained with this new technique for a subset of barely resolved protoplanetary disks retrieved from the ALMA archive. I will show the results on my analysis for different molecular tracers, and show how this new technique allows us to robustly extract z(r) for observations with moderate ang res.