AstroChemical Newsletter #48

November 2019

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

Abstracts

Ingredients for Solar-like Systems: protostar IRAS 16293-2422 B versus comet 67P/Churyumov-Gerasimenko

M. N. Drozdovskaya, E. F. van Dishoeck, M. Rubin, J. K. Jørgensen, K. Altwegg

Our modern day Solar System has 4.6×1e9 yrs of evolution behind it with just a few relics of its birth conditions remaining. Comets are thought to be some of the most pristine tracers of the initial ingredients that were combined to produce the Earth and the other planets. Other low-mass protostars may be analogous to our proto-Sun and hence, could be used to study the building blocks necessary to form Solar-like systems. This study tests this idea on the basis of new high sensitivity, high spatial resolution ALMA data on the protoplanetary disc-scales (~70 au) of IRAS 16293-2422 and the bulk composition of comet 67P/Churyumov-Gerasimenko, as determined for the first time with the unique in situ monitoring carried out by Rosetta. The comparative analysis of the observations from the Protostellar Interferometric Line Survey (PILS) and the measurements made with Rosetta Orbiter Spectrometer for Ion and Neutral Analysis (ROSINA) shows that the relative abundances of CHO-, N-, and S-bearing molecules correlate, with some scatter, between protostellar and cometary data. A tentative correlation is seen for the first time for P- and Cl-bearing compounds. The results imply that the volatile composition of cometesimals and planetesimals is partially inherited from the pre- and protostellar phases of evolution.

MNRAS, Volume 490, Issue 1, November 2019, Pages 50–79
DOI: 10.1093/mnras/stz2430
Full-text URL: https://arxiv.org/abs/1908.11290

The ALMA-PILS survey: propyne (CH3CCH) in IRAS 16293−2422

H. Calcutt, E. R. Willis, J. K. Jørgensen, P. Bjerkeli, N. F. W. Ligterink, A. Coutens, H. S. P. Müller, R. T. Garrod, S. F. Wampfler and M. N. Drozdovskaya

Context. Propyne (CH3CCH) has been detected in a variety of environments, from Galactic star-forming regions to extragalactic sources. Such molecules are excellent tracers of the physical conditions in star-forming regions.</br> Aims. This study explores the emission of CH3CCH in the low-mass protostellar binary, IRAS 16293--2422, examining the spatial scales traced by this molecule, as well as its formation and destruction pathways.</br> Methods. ALMA observations from the Protostellar Interferometric Line Survey (PILS) are used to determine the abundances and excitation temperatures of CH3CCH towards both protostars, exploring spatial scales from 70 to 2400 au. The three-phase chemical kinetics model MAGICKAL is also used,

to explore the chemical reactions of this molecule. </br> Results. CH3CCH is detected towards both IRAS 16293A and IRAS 16293B and is found to trace the hot corino component around each source in the PILS dataset. Eighteen transitions above 3 sigma are detected, enabling robust excitation temperatures and column densities to be determined in each source. In IRAS 16293A, an excitation temperature of 90 K and a column density of 7.8e15 cm-2 best fits the spectra. In IRAS 16293B, an excitation temperature of 100 K and 6.8e15 cm-2 best fits the spectra. The chemical modelling finds that in order to reproduce the observed abundances, both gas-phase and grain-surface reactions are needed. </br> Conclusions. CH3CCH is a molecule whose brightness and abundance in many different regions can be utilised to provide a benchmark of molecular variation with the physical properties of star-forming regions. It is essential when making such comparisons, that the abundances are determined with a good understanding of the spatial scale of the emitting region, to ensure that accurate abundances are derived. This is an abridged version of the abstract.

Accepted in A&A
Full-text URL: https://arxiv.org/abs/1909.13329

Molecules in the CepE-mm jet: evidence for a shock-driven photochemistry ?

J. Ospina-Zamudio, B. Lefloch, C. Favre, A. López-Sepulcre, E. Bianchi, C. Ceccarelli, M. De Simone, M. Bouvier, C. Kahane

The chemical composition of protostellar jets and its origin are still badly understood. More observational constraints are needed to make progress. With that objective, we have carried out a systematic search for molecular species in the jet of CepE-mm, a template for intermediate-mass Class 0 protostars, associated with a luminous, high-velocity outflow. We made use of an unbiased spectral line survey in the range 72-350 GHz obtained with the IRAM 30m telescope, complementary observations of the CO J=3-2 transition with the JCMT, and observations at 100" angular resolution of the CO J=2-1 transition with the IRAM Plateau de Bure interferometer. In addition to CO, we have detected rotational transitions from SiO, SO, H2CO, CS, HCO+ and HCN. A strong chemical differentiation is observed in the southern and northern lobes of the jet. Radiative transfer analysis in the Large Velocity Gradient approximation yields typical molecular abundances of the order of 1e-8 for all molecular species other than CO. Overall, the jets exhibit an unusual chemical composition, as CS, SO and H2CO are found to be the most abundant species, with a typical abundance of (3-4)x1e-8. The transverse size of the CO jet emission estimated from interferometric observations is about 1000 au, suggesting that we are detecting emission from a turbulent layer of gas entrained by the jet in its propagation and not the jet itself. We propose that some molecular species could be the signatures of the specific photochemistry driven by the UV radiation field generated in the turbulent envelope.

MNRAS, Volume 490, Issue 2, December 2019, Pages 2679–2691
DOI: 10.1093/mnras/stz2733
Full-text URL: https://arxiv.org/abs/1909.12002

Reactivity of HCO with CH3 and NH2 on Water Ice Surfaces. A Comprehensive Accurate Quantum Chemistry Study

Enrique-Romero, Joan and Rimola, Albert and Ceccarelli, Cecilia and Ugliengo, Piero and Balucani, Nadia and Skouteris, Dimitrios

Interstellar complex organic molecules (iCOMs) can be loosely defined as chemical

compounds with at least six atoms in which at least one is carbon. The observations of iCOMs in star-forming regions have shown that they contain an important fraction of carbon in a molecular form, which can be used to synthesize more complexes, even biotic molecules. Hence, iCOMs are major actors in the increasing molecular complexity in space, and they might have played a role in the origin of terrestrial life. Understanding how iCOMs are formed is relevant for predicting the ultimate organic chemistry reached in the interstellar medium. One possibility is that they are synthesized on the interstellar grain icy surfaces, via recombination of previously formed radicals. The present work focuses on the reactivity of HCO with CH3/NH2 on the grain icy surfaces, investigated by means of quantum chemical simulations. The goal is to carry out a systematic study using different computational approaches and models for the icy surfaces. Specifically, DFT computations have been benchmarked with CASPT2 and CCSD(T) methods, and the ice mantles have been mimicked with cluster models of 1, 2, 18, and 33 H2O molecules, in which different reaction sites have been considered. Our results indicate that the HCO + CH3/NH2 reactions, if they actually occur, have two major competitive channels: the formation of iCOMs CH3CHO/NH2CHO or the formation of CO + CH4/NH3. These two channels are either barrierless or present relatively low (<=10 kJ/mol equal to about 1200 K) energy barriers. Finally, we briefly discuss the astrophysical implications of these findings.

ACS Earth Space Chem. 2019, 3, 10, 2158-2170
DOI: 10.1021/acsearthspacechem.9b00156
Full-text URL: https://arxiv.org/abs/1909.12686

Graphene oxide nanoparticles in the interstellar medium

P.J. Sarre

Dust particles play a major role in the formation, evolution and chemistry of interstellar clouds, stars, and planetary systems. Commonly identified forms include amorphous and crystalline carbon-rich particles and silicates. Also present in many astrophysical environments are polycyclic aromatic hydrocarbons (PAHs), detected through their infrared emission, and which are essentially small flakes of graphene. Astronomical observations over the past four decades have revealed a widespread unassigned ‘extended red emission’ (ERE) feature which is attributed to luminescence of dust grains. Numerous potential carriers for ERE have been proposed but none has gained general acceptance. In this Letter it is shown that there is a strong similarity between laboratory optical emission spectra of graphene oxide (GO) and ERE, leading to this proposal that emission from GO nanoparticles is the origin of ERE and that these are a significant component of interstellar dust. The proposal is supported by infrared emission features detected by the Infrared Space Observatory (ISO) and the Spitzer Space Telescope.

Monthly Notices of the Royal Astronomical Society: Letters, Volume 490, Issue 1, November 2019, Pages L17–L20
DOI: 10.1093/mnrasl/slz131
Full-text URL: https://arxiv.org/abs/1908.07787

Origin of hydrogen fluoride emission in the Orion Bar: An excellent tracer for CO-dark H2 gas clouds

U. Kavak, F.F.S. van der Tak, A.G.G.M. Tielens, R.F. Shipman

The hydrogen fluoride (HF) molecule is seen in absorption in the interstellar medium (ISM) along many lines of sight. Surprisingly, it is observed in emission toward the Orion

Bar, which is an interface between the ionized region around the Orion Trapezium stars and the Orion molecular cloud. We aim to understand the origin of HF emission in the Orion Bar by comparing its spatial distribution with other tracers. We examine three mechanisms to explain the HF emission: thermal excitation, radiative dust pumping, and chemical pumping. We used a Herschel/HIFI strip map of the HF J = 1-0 line, covering 0.5' by 1.5' that is oriented perpendicular to the Orion Bar. We used the RADEX non-local thermodynamic equilibrium (non-LTE) code to construct the HF column density map. We use the Meudon PDR code to explain the morphology of HF. The bulk of the HF emission at 10 km s^-1 emerges from the CO-dark molecular gas that separates the ionization front from the molecular gas that is deeper in the Orion Bar. The excitation of HF is caused mainly by collisions with H2 at a density of 1e5 cm^-3, together with a small contribution of electrons in the interclump gas of the Orion Bar. Infrared pumping and chemical pumping are not important. We conclude that the HF J = 1-0 line traces CO-dark molecular gas. Similarly, bright photodissociation regions associated with massive star formation may be responsible for the HF emission observed toward active galactic nuclei.

A&A, Forthcoming article
DOI: 10.1051/0004-6361/201936127
Full-text URL: https://arxiv.org/abs/1910.00707

The HH 212 interstellar laboratory: astrochemistry as a tool to reveal protostellar disks on Solar System scales around a rising Sun

C. Codella, C. Ceccarelli, C.-F. Lee, E. Bianchi, N. Balucani, L. Podio, S. Cabrit, F. Gueth, A. Gusdorf, B. Lefloch, B. Tabone

The investigation of star forming regions have enormously benefited from the recent advent of the ALMA interferometer working in the mm- and submm-wavelength spectral windows. More specifically, the unprecedented combination of high-sensitivity and high-angular resolution provided by ALMA allows one to shed light on the jet/disk systems associated with a Sun-like mass protostar. In this context, also astrochemistry enjoyed the possibility to analyze complex spectra obtained using large bandwidths: several interstellar Complex Organic Molecules (iCOMs; C-bearing species with at least 6 atoms) have been detected and imaged around protostars, often thanks to a large number of rotational-vibrational lines. This in turn boosted the study of the astrochemistry at work during the earliest phases of star formation paving the way to the chemical complexity in planetary systems where Life could emerge. There is mounting evidence that the observations of iCOMs (e.g. CH3CHO or NH2CHO) can be used as unique tool to shed light, on Solar System scales (< 50 au), on the molecular content of protostellar disk. The increase of iCOMs abundances occur only under very selective physical conditions, such as those associated low-velocity shocks found where the infalling envelope is impacting the rotating accretion disk. The imaging of these regions with simpler molecules such as CO or CS is indeed paradoxically hampered by their high abundances and consequently high line opacities which do not allow the observers to disentangle all the emitting components at these small scales. In this respect, we review the state-of-the art of the ALMA analysis about the standard Sun-like star forming region in Orion named HH 212, associated with a pristine jet-disk protostellar system. We enrich the discussion with unpublished ALMA datasets, showing (i) how all the physical components involved in the formation of a Sun-like star can be revealed only by observing different molecular tracers, and (ii) how the observation of iCOMs emission, observed to infer the chemical composition of star forming regions, can be used also as unique tracer to image protostellar disks on Solar

System scales, i.e. where planets will eventually form.

ACS Earth Space Chem. 2019, 3, 10, 2110-2121
DOI: 10.1021/acsearthspacechem.9b00136
Full-text URL: http://arxiv.org/abs/1910.04442

The role of C/O in nitrile astrochemistry in PDRs and planet-forming disks

Le Gal, Romane; Brady, Madison T.; Öberg, Karin I.; Roueff, Evelyne; Le Petit, Franck

Complex nitriles, such as HC3N, and CH3CN, are observed in a wide variety of astrophysical environments, including at relatively high abundances in photon-dominated regions (PDR) and the UV exposed atmospheres of planet-forming disks. The latter have been inferred to be oxygen-poor, suggesting that these observations may be explained by organic chemistry in C-rich environments. In this study, we first explore if the PDR complex nitrile observations can be explained by gas-phase PDR chemistry alone if the elemental C/O ratio is elevated. In the case of the Horsehead PDR, we find that gas-phase chemistry with C/O $\gtrsim$ 0.9 can indeed explain the observed nitrile abundances, increasing predicted abundances by several orders of magnitude compared to standard C/O assumptions. We also find that the nitrile abundances are sensitive to the cosmic ray ionization treatment, and provide constraints on the branching ratios between CH3CN and CH3NC productions. In a fiducial disk model, an elevated C/O ratio increases the CH3CN and HC3N productions by more than an order of magnitude, bringing abundance predictions within an order of magnitude to what has been inferred from observations. The C/O ratio appears to be a key variable in predicting and interpreting complex organic molecule abundances in photon-dominated regions across a range of scales.

Accepted for publication in ApJ
Full-text URL: https://arxiv.org/abs/1910.01554

Quantum Effects on the D + H3+ → H2D+ + H Deuteration Reaction and Isotopic Variants

Niyazi Bulut, Alfredo Aguado, Cristina Sanz-Sanz and Octavio Roncero

The title reaction and its isotopic variants are studied using quasi-classical trajectory (QCT) (without taking into account corrections to account for the possible zero point energy breakdown) and ring polymer molecular dynamics (RPMD) methods with a full dimensional and accurate potential energy surface which presents an exchange barrier of approximately 0.144 eV. The QCT rate constant increases when the temperature decreases from 1500 to 10 K. On the contrary, the RPMD rate constant decreases with decreasing temperature, in semiquantitative agreement with recent experimental results. The present RPMD results are in between the thermal and translational experimental rate constants, extracted from the measured data to eliminate the initial vibrational excitation of H3+ , obtained in an arc discharge. The difference between the present RPMD results and experimental values is attributed to the possible existence of non thermal vibrational excitation of H3+ , not completely removed by the semiempirical model used for the analysis of the experimental results. Also, it is found that, below 200 K, the RPMD trajectories are trapped, forming long-lived collision complexes, with lifetimes longer than 1 ns. These collision complexes can fragment by either redissociating back to reactants or react to products, in the two cases tunneling through the centrifugal and reaction barriers, respectively. The contribution of the

formation of the complex to the total deuteration rate should be calculated with more accurate quantum methods, as has been found recently for reactions of larger systems, and the present four atoms system is a good candidate to benchmark the adequacy of RPMD method at temperatures below 100 K.

J. Phys. Chem. A (accepted)
DOI: 10.1021/acs.jpca.9b06081
Full-text URL: https://pubs.acs.org/doi/10.1021/acs.jpca.9b06081

A three-phase approach to grain surface chemistry in protoplanetary disks: Gas, ice surfaces and ice mantles of dust grains

M. Ruaud and U. Gorti

We study the effects of grain surface reactions on the chemistry of protoplanetary disks where gas, ice surface layers and icy mantles of dust grains are considered as three distinct phases. Gas phase and grain surface chemistry is found to be mainly driven by photo-reactions and dust temperature gradients. The icy disk interior has three distinct chemical regions: (i) the inner midplane with low FUV fluxes and warm dust (>~ 15K) that lead to the formation of complex organic molecules, (ii) the outer midplane with higher FUV from the ISM and cold dust where hydrogenation reactions dominate and, (iii) a molecular layer above the midplane but below the water condensation front where photodissociation of ices affects gas phase compositions. Some common radicals, e.g., CN and C2H, exhibit a two-layered vertical structure and are abundant near the CO photodissociation front and near the water condensation front. The 3-phase approximation in general leads to lower vertical column densities than 2-phase models for many gas-phase molecules due to reduced desorption, e.g., H2O, CO2, HCN and HCOOH decrease by ~ two orders of magnitude. Finally, we find that many observed gas phase species originate near the water condensation front; photo-processes determine their column densities which do not vary significantly with key disk properties such as mass and dust/gas ratio.

Accepted for publication in ApJ
Full-text URL: https://arxiv.org/abs/1910.01097

Investigations into the rotational spectrum of isotopic methyl mercaptan, (13)CH3SH, in the laboratory and towards Sagittarius B2(N2)

V. V. Ilyushin, O. Zakharenko, F. Lewen, S. Schlemmer, E. A. Alekseev, M. Pogrebnyak, R. M. Lees, L.-H. Xu, A. Belloche, K. M. Menten, R. T. Garrod, H. S. P. Müller

Methyl mercaptan (CH3SH) is a known interstellar molecule with abundances high enough that the detection of some of its minor isotopologues is promising. The present study aims at providing accurate spectroscopic parameters for the (13)CH3SH isotopologue to facilitate searches in the interstellar medium at millimetre and submillimetre wavelengths. Through careful analysis of recent CH3SH spectra from 49-510 GHz and 1.1-1.5 THz recorded at natural isotopic composition, extensive assignments were possible not only for the ground torsional state of (13)CH3SH, but also in the first and second excited states. The torsion-rotation spectrum displays complex structure due to the large-amplitude internal rotation of the (13)CH3 group, similar to the main and other minor isotopic species of methyl mercaptan. The assigned transition frequencies have been fitted to within experimental error with a 52-parameter

model employing the RAM36 programme. With predictions based on this fit, (13)CH3SH was searched for in spectra from the Atacama Large Millimetre/submillimetre Array (ALMA) towards the Galactic centre source Sgr B2(N2). Several transitions were expected to be observable, but all of them turned out to be severely blended with emission from other species, which prevents us from identifying (13)CH3SH in this source.

Can. J. Phys accepted
Full-text URL: https://arxiv.org/abs/1910.02259

On the size of the CO-depletion radius in the IRDC G351.77-0.51

G. Sabatini, A. Giannetti, S. Bovino, J. Brand, S. Leurini, E. Schisano, T. Pillai and K. M. Menten

An estimate of the degree of CO-depletion (fD) provides information on the physical conditions occurring in the innermost and densest regions of molecular clouds. A key parameter in these studies is the size of the depletion radius, i.e. the radius within which the C-bearing species, and in particular CO, are largely frozen onto dust grains. A strong depletion state (i.e. fD>10, as assumed in our models) is highly favoured in the innermost regions of dark clouds, where the temperature is <20 K and the number density of molecular hydrogen exceeds a few ×1e4 cm^−3. In this work, we estimate the size of the depleted region by studying the Infrared Dark Cloud (IRDC) G351.77-0.51. Continuum observations performed with the Herschel Space Observatory and the LArge APEX BOlometer CAmera, together with APEX C18O and C17O J=2→1 line observations, allowed us to recover the large-scale beam- and line-of-sight-averaged depletion map of the cloud. We built a simple model to investigate the depletion in the inner regions of the clumps in the filament and the filament itself. The model suggests that the depletion radius ranges from 0.02 to 0.15 pc, comparable with the typical filament width (i.e.~0.1 pc). At these radii, the number density of H2 reaches values between 0.2 and 5.5×1e5 cm^−3. These results provide information on the approximate spatial scales on which different chemical processes operate in high-mass star forming regions and also suggest caution when using CO for kinematical studies in IRDCs.

Accepted by Monthly Notices of the Royal Astronomical Society (MNRAS)
DOI: 10.1093/mnras/stz2818
Full-text URL: https://arxiv.org/abs/1910.02981

Chemical complexity in high-mass star formation: An observational and modeling case study of the AFGL 2591 VLA 3 hot core

C. Gieser, D. Semenov , H. Beuther, A. Ahmadi , J.C. Mottram, Th. Henning, M. Beltran, L.T. Maud, F. Bosco, S. Leurini, T. Peters, P. Klaassen, R. Kuiper, S. Feng, J.S. Urquhart, L. Moscadelli, T. Csengeri, S. Lumsden, J.M. Winters, S. Suri, Q. Zhang, R. Pudritz, A. Palau, K.M. Menten, R. Galvan-Madrid, F. Wyrowski, P. Schilke, Á. Sánchez-Monge, H. Linz, K.G. Johnston, I. Jiménez-Serra, S. Longmore, and T. Möller

We present a detailed observational and modeling study of the hot core VLA 3 in the high-mass star-forming region AFGL 2591, which is a target region of the NOrthern Extended Millimeter Array (NOEMA) large program CORE. Using NOEMA observations at 1.37 mm with an angular resolution of ~0."42 (1 400 au at 3.33 kpc), we derived the

physical and chemical structure of the source. We modeled the observed molecular abundances with the chemical evolution code MUSCLE (MUlti Stage ChemicaL codE). Results. With the kinetic temperature tracers CH3CN and H2CO we observe a temperature distribution with a power-law index of q = 0.41+-0.08. Using the visibilities of the continuum emission we derive a density structure with a power-law index of p = 1.7+-0.1. The hot core spectra reveal high molecular abundances and a rich diversity in complex molecules. The majority of the molecules have an asymmetric spatial distribution around the forming protostar(s), which indicates a complex physical structure on scales < 1 400 au. Using MUSCLE, we are able to explain the observed molecular abundance of 10 out of 14 modeled species at an estimated hot core chemical age of ~21 100 years. In contrast to the observational analysis, our chemical modeling predicts a lower density power-law index of p < 1.4. Reasons for this discrepancy are discussed. Conclusions. Combining high spatial resolution observations with detailed chemical modeling allows us to derive a concise picture of the physical and chemical structure of the famous AFGL 2591 hot core. The next steps are to conduct a similar analysis for the whole CORE sample, and then use this analysis to constrain the chemical diversity in high-mass star formation to a much greater depth.

accepted for publication in Astronomy & Astrophysics
Full-text URL: https://arxiv.org/abs/1910.05081

Modeling deuterium chemistry in starless cores: full scrambling versus proton hop

O. Sipilä, P. Caselli, J. Harju

We constructed two new models for deuterium and spin-state chemistry for the purpose of modeling the low-temperature environment prevailing in starless and pre-stellar cores. The fundamental difference between the two models is in the treatment of ion-molecule proton-donation reactions of the form XH+ + Y -> X + YH+, which are allowed to proceed either via full scrambling or via direct proton hop, that is, disregarding proton exchange. The choice of the reaction mechanism affects both deuterium and spin-state chemistry, and in this work our main interest is on the effect on deuterated ammonia. We applied the new models to the starless core H-MM1, where several deuterated forms of ammonia have been observed. Our investigation slightly favors the proton hop mechanism over full scrambling because the ammonia D/H ratios are better fit by the former model, although neither model can reproduce the observed NH2D ortho-to-para ratio of 3 (the models predict a value of ~2). Extending the proton hop scenario to hydrogen atom abstraction reactions yields a good agreement for the spin-state abundance ratios, but greatly overestimates the deuterium fractions of ammonia. However, one can find a reasonably good agreement with the observations with this model by increasing the cosmic-ray ionization rate over the commonly adopted value of ~1e-17 s^-1. We also find that the deuterium fractions of several other species, such as H2CO, H2O, and CH3, are sensitive to the adopted proton-donation reaction mechanism. Whether the full scrambling or proton hop mechanism dominates may be dependent on the reacting system, and new laboratory and theoretical studies for various reacting systems are needed to constrain chemical models.

A&A, Volume 631, November 2019, A63
DOI: 10.1051/0004-6361/201936416
Full-text URL: https://arxiv.org/abs/1909.04341

Announcements

COSPAR2020-B0.1: Unifying planetary system formation out of elementary building blocks: from dust, gas and ice to our Solar System and exoplanets

"Unifying planetary system formation out of elementary building blocks: from dust, gas and ice to our Solar System and exoplanets". at the 43rd COSPAR Scientific Assembly that will be held in Sydney, Australia, 15-22 August, 2020. https://www.cospar2020.org/ https://www.cospar-assembly.org/ **********IMPORTANT DATE********** ABSTRACT SUBMISSION DEADLINE is 14 FEBRUARY 2020 ********** Scientific Rationale: The assembly of planetary systems can no longer be considered a process exclusive to mature circumstellar (i.e., protoplanetary) disks, as strings of evidence are pushing its onset to the earliest phases of star formation. These findings require previously separate communities to come together and to exchange expertise. This event offers the venue for such exchange in the form of a unique interdisciplinary platform for discussing the full evolutionary sequence of our Solar System and of exoplanetary systems that may be analogous and different from our own. The event is open to experts on the Solar System, its small and large bodies; exoplanets; protoplanetary disks, embedded and prestellar phases of star formation. It will cover studies of gas, ice, dust and larger bodies from theoretical, observational and experimental perspectives. This science is stimulated by the increasing amount of in-situ measurements from past missions such as Cassini and Rosetta, present missions like New Horizons, and upcoming missions such as JUICE and Europa Clipper. Simultaneously, the field is being revolutionized with interferometric observations from powerful facilities such as ALMA, exoplanet demographics from transits and radial velocities (e.g., TESS, ESPRESSO) and with experimental studies in state-of-the-art laboratories simulating the various space environments. This event is sponsored by and coordinated with Commissions B1, E4 and F3. Main Scientific Organizers: Maria Drozdovskaya (CSH; Switzerland) & Diego Turrini (INAF-IAPS; Italy) Scientific Organizing Committee: Michael Ireland, ANU, Australia; Stavro Ivanovski, INAF-OATS, Italy; Niels Ligterink, CSH, Switzerland; Gianfranco Vidali, Syracuse, U.S.A.; Eric Herbst, UVA, U.S.A.; Martin Rubin, UniBe, Switzerland; Trevor Ireland, ANU, Australia; Raphael Marschall, SwRi, U.S.A.; Sho Sasaki, Osaka, Japan; Sean Andrews, CfA, U.S.A. Confirmed Invited Speakers: Fred Ciesla (University of Chicago, U.S.A.) Joanna Drążkowska (University Observatory of the Ludwig Maximilian University of Munich, Germany) Davide Fedele (INAF/Osservatorio Astrofisico di Arcetri, Italy) Mark Krumholz (ANU, Australia) Jeong-Eun Lee (Kyung Hee University, South Korea) Yamila Miguel (Leiden University, The Netherlands) Paola Pinilla (Max Planck Institute for Astronomy in Heidelberg, Germany) Alessandro Sozzetti (INAF/Osservatorio Astronomico di Torino, Italy) Frances Westall (CNRS in Orléans, France) Makoto Yoshikawa (JAXA, Japan)

Interstellar Shock School

The registration is now open on the website of our session on interstellar shocks in Les Houches school of Physics: https://isss.sciencesconf.org. The session will be held in the Physics School of Les Houches in France in March, 22-27, 2020. It will give a comprehensive view of the role and impacts of shocks, that are ubiquitous in galaxies and their close environments. The session will include lectures on physical and chemical processes in interstellar shocks, observations, models, experiments, as well as hands-on sessions. The speakers are confirmed but the program may still be subject to minor changes. The number of participants is limited to 50. To register to the session, please create a login on the sciencesconf website and then follow the instructions given in the

registration form section. In case of oversubscription, we will have to make a selection among all potential attendants. This is why we ask all applicants to send a small text of intent (between 5 and 10 lines), presenting your research interests, the particular project or subject for which you wish to attend the session, and a few words to explain your motivation to do so. Consequently, a notification of application to the session and this text of intent should be addressed to isss-leshouches at phys.ens.fr. Financial support will be attributed to selected students. Our intention is to waive the accomodation costs for successfull applicants. To the participants who wish to benefit from this funding, we kindly ask to join a brief (typically one-page) CV to their email containing the application notification and the text of intent addressed to isss-leshouches at phys.ens.fr.

PacifiChem 2020 - Misconceptions in Astrochemistry: A Chemist's Guide

Honolulu, Hawaii, USA, December 15-20, 2020 https://pacifichem.org Earth provides only a small cross-section of the rich environments where molecules form, react, excite, and are studied. The origin of molecules in extraterrestrial environments, in particular, has fascinated scientists since the pioneering detection of CH, CH+, and CN in interstellar space more than 80 years ago. More than 200 species are known, ranging in complexity from carbon monoxide (CO) to cyanobenzene (C6H5CN) and buckyballs (C60). Nevertheless, many facets of astrochemistry remain unanswered or contentious. The elucidation of how molecules form in non-terrestrial environments brings together chemists from across the subdisciplines and even researchers from across the sciences at large. Such a fast-growing and significantly interdisciplinary field naturally brings practitioners together who often seem to speak different scientific languages and who approach similar problems in surprisingly different ways. Consequently, critical errors, disagreements, and misconceptions have arisen. This symposium will provide a forum to address findings that have been misinterpreted, improperly utilized, or otherwise ignored. By working to eliminate misconceptions and exploring the current boundaries of astrochemical knowledge, new experiments and models can be more effectively designed to resolve key unanswered aspects of molecular synthesis in extraterrestrial space. Abstract submission opens January 1, 2020. This symposium is open to contributions and will consist of half-day oral sessions with topics including: 1. Gas Phase Astrochemistry 2. Condensed Phase Astrochemistry 3. Computational Astrochemistry & Astrochemical Modeling 4. Emerging Trends in Astrochemistry 5. When Chemists and Astronomers Disagree

15 Marie Sklodowska-Curie PhDs to study Exoplanets and Planet Forming Disks

The Marie Sklodowska-Curie Innovative Training Network CHAMELEON "Virtual Laboratories for Exoplanets and Planet Forming Disks" brings together expertise to study exoplanetary atmospheres and planet-forming disks, including observations and computational modelling. The network will consist of 15 Early Stage Researchers (PhD students) and the respective supervisors/local research groups. Each PhD student will be primarily hosted at one of six European Universities, and enrolled at another of these institutes that will act as a secondary host. They will study for a joint degree from their primary and secondary host institutes. All researchers will be expected to start at their primary host institutes no later than September 2020. For a complete list of all open PhD positions within this training network and application instructions, please visit the CHAMELEON ITN website: http://chameleon.wp.st-andrews.ac.uk/. The general eligibility and mobility rules of Marie Sklodowka-Curie Actions apply for all available positions. http://chameleon.wp.st-andrews.ac.uk/