Book of Abstracts

Monday 1st of April 2019

Session 1: Chemical networks and complex (prebiotic) molecules in star formation

TALKS SESSION 1

Gas-phase chemistry and molecular complexity in space: how far do they go?

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In the sequence of steps which are believed to have led from elementary particles to the emergence of life, an important one is the formation of relatively complex organic molecules from the simple parent species abundant in space. The accumulation of organic molecules of increasing complexity, indeed, is accepted as an important stage preceding the appearance of the first living organisms. But how massive organic synthesis could occur in primitive Earth, i.e. a water-dominated environment, is still a matter of debate.
The aggregation of H, O, C, N and other atoms into molecules and their subsequent chemical evolution are occurring also now in the Universe, as witnessed by the identification of ca. two hundred gaseous molecules in the interstellar medium, including also species with a prebiotic potential (e.g. formamide and glycolaldehyde). The possible link between those prebiotic molecules synthesized in space and the appearance of life on Earth is not only interesting per se, but it might offer exciting support to the conjecture that life is a widespread phenomenon in the Universe, rather than a local, fortuitous case. The processes leading to interstellar prebiotic gaseous molecules under the harsh conditions of interstellar objects are far from being understood. Most current astrochemical models privilege grain-surface chemistry because gas-phase chemistry is not believed to have the capability of leading to complex species. In this scenario, grain-surface chemistry is not only responsible for the formation of hydrogenated molecules during the pre-collapse phase, but also for the whole set of the observed organic molecules. Nevertheless, as recently pointed out by experimental and theoretical work on several gas-phase reactions, many gas-phase routes have actually been overlooked, while their inclusion in the astrochemical models with the parameters determined in laboratory experiments or via accurate theoretical calculations could be decisive in reproducing the observed abundances of prebiotic molecules. In this talk, the status of our knowledge of interstellar gas phase chemistry will be addressed. Several reactions that are believed occur in the upper atmosphere of Titan will also be noted.

Empirical study of formamide (NH_2CHO) formation around young O-type stars

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Formamide (NH_2CHO) is an important prebiotic molecule as it has been proposed as a precursor to amino acids and other important molecules of life. In my talk, I detail the results of a high angular resolution (0.2") ALMA observations of several different young high-mass stars and how the spatial extent and kinematics of formamide (NH_2CHO) in the surrounding gas compares to two of its possible parent species isocyanic acid (HNCO) and formaldehyde (H_2CO). This is important astrochemical work because there is debate about whether formamide is formed in ice and melts off once it becomes warm (from HNCO) or in already warm gas (from H_2CO). The results of this pilot study will be followed up with future ALMA observations.

A timeline for massive star-forming regions via astrochemical studies

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Deuteration chemistry, provides a tool with which to measure star-formation timescales.
In this talk I will show some of our recent results from state-of-the-art hydrodynamical simulations of collapsing clumps and filaments where, for the first time, we have followed the evolution of deuterated tracers (e.g. H_2D^+) along with magnetic fields, turbulence, hydrodynamics, and gravity.
I will also present some recent observations on N_2D^+/H_2D^+ ratio as a possible combined chemical clock.

Gas-phase formation routes for interstellar Complex Organic Molecules: reactivity based on quantum chemistry computations

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How could life emerge on an originally inorganic Earth? This is the main question faced in the field of prebiotic chemistry. Indeed, life as we know it is ruled by quite complex organic processes and the involved molecules were surely not present at the surface of the early Earth.
In order to solve this issue, two main, and not incompatible, hypotheses have been made. An endogenous synthesis one, based on the theory that building blocks of life such as amino acids or nucleobases, for instance, were synthesized in the atmosphere of the early Earth and/or in oceans, and an exogenous delivery one, according to which those building blocks were synthesized in space and then brought to Earth by comets and asteroids.
In this contribution, based on state-of-the-art quantum chemistry computations, both hypotheses will be considered. First, possible gas-phase formation routes in the interstellar medium for two molecules of prebiotic interest will be investigated: glycolaldehyde ($HOCH_2CHO$), the simplest sugar-related molecule, able to ease the formation of more complex sugars [1] and formamide (H_2NCHO), a possible precursor that might be able to link the appearances of metabolism and genetics. [2,3,4] And then, thanks to a synergy between experimental and theoretical chemistry, a potential way of forming mercaptoacetaldehyde ($HSCH_2CHO$), [5] a possible prebiotic precursor of cysteine, [6] will be explored in the peculiar conditions of the early Earth's ocean.

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Abiotic synthesis of complex organics in the Universe

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The late stages of stellar evolution from asymptotic giant branch stars to planetary nebulae are now known to be an active phase of molecular synthesis. Over 80 gas-phase molecules have been detected through rotational transitions in the mm/submm region. Infrared spectroscopy has also detected inorganic minerals, fullerenes, and organic solids. The synthesis of these molecules and solids take place over very low density ($<10^6$ cm^{-3}) and short ($\sim10^3$ yr) time scales. The complex organics are observed to have mixed aromatic/aliphatic structures and may be related to the complex organics found in meteorites, comets, interplanetary dust particles, and planetary satellites. The possible links between stellar and solar system organics will be discussed.

Searching for Phosphorus-bearing molecules in Solar-type Star Forming Regions

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Despite a rather low elemental abundance of 3e-7, Phosphorus is one of the main biogenic elements. As such, P-bearing compounds, in particular their P-O bond, play a key role in many biochemical and metabolic processes in living systems. However, Phosphorus chemistry in the ISM has received little attention and remains poorly understood. We present here the results of a systematic seach for P-bearing molecules in solar-type star-forming regions as part of the Large Program ASAI with the IRAM 30m telescope, and with the NOEMA interferometer. The ASAI sample comprised 10 objects illustrative of the different chemical stages of evolution of a sun-like protostar, from the early to the late protostellar (Class I) stage, and two protostellar shock regions.
Transitions of the simple PN and PO molecules were detected towards a subsample of protostars and shock regions, allowing to derive their molecular abundance in the emitting gas. We will discuss the results of our study, in particular towards the shock region, which was subsequently observed at 2" angular resolution with the NOEMA interferometer. A simple modelling using the UCL_CHEM code coupled with a parametric C-shock model shows the important role played by atomic N in the formation and destruction routes of PO and PN.

Seeds of Dust and Planets: Forming the First Benzene Ring From the Ground Up

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Five and six membered aromatic rings are ubiquitous in life and chemistry on Earth, and in the polycyclic aromatic hydrocarbons (PAHs) in the ISM that may contain up to 25% of interstellar carbon and be the seeds for carbonaceous dust. The formation of the first ring, benzene (C_6H_6) is a bottleneck in the bottom-up generation of PAHs both on Earth and in the ISM, and has led many to speculate that PAHs are instead formed by the degradation of macroscopic carbonaceous soot expelled from late-stage AGB stars. Our recent detection of cyanobenzene (C_6H_5CN) in TMC-1, a cold dark cloud at the earliest stages of star formation radically alters this perspective. I will present a combined laboratory and observational investigation demonstrating that the first aromatic benzene ring can indeed be synthesized from small, abundant precursors in the gas phase and in the absence of any star. This in turn would indicate that this important reservoir of both carbon and the potential seeds of dust and planet formation already exist at the earliest stages of the process.

Organic Molecules: How to See the Forest from the Trees

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In our quest for large organic molecules in the interstellar/circumstellar medium, the main difficulty is to disentangle their spectral signatures among the observed forest of bands. We propose a new approach to the problem, by defining a number of key transitions that would come from parts of the whole molecule and that would characterize its fingerprint. If these key transitions are observed together in the same astrophysical target, it may be that we are detecting the whole from its part.

Complex Molecules in Hot Molecular Cores: Are we getting closer to the detection of Amino Acids?

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The astronomical search for the simple amino acid glycine (NH2CH2COOH) in the interstellar medium begin about 40 years ago with the construction of the first laboratory spectra and have continued up to the present. Now, with the construction of extremely sensitive interferometers (e.g. ALMA) and single dish antennas the possibility of such detection is still open. In this talk, I will revise the new searches in bright hot molecular cores and their cousins hot corinos, and how theoretical synthetic spectra is helping us with this task. Up to the date, however, there is the detection of many very complex molecules in the interstellar medium that give us some expectations to detect aminoacids.}

Abundant Z-cyanomethanimine in the interstellar medium: paving the way to the synthesis of adenine

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Understanding the origin of life on Earth is one of the most challenging problems in astrophysics in the framework of astrobiology. To shed light on this complex topic, a comprehensive study of the chemical complexity of the interstellar medium (ISM) that feeds the formation of stars and planets it is absolutely needed. Adenine, one of the nucleobases of DNA and RNA, is a basic ingredient in the RNA-world scenario for the origin of life on Earth. HCN dimers has been proposed as precursors of adenine, and thus understanding their formation mechanisms is of crucial importance. In this talk I will present the first detection in the ISM of the Z-isomer of cyanomethanimine (HNCHCN), the most stable dimer of HCN. Our IRAM 30m observations towards the Galactic Center quiescent molecular cloud G+0.693 have detected Z-HNCHCN with an abundance of 1.5×10^{-9}, six times higher than that of the previously detected E-isomer. This ratio [Z/E]~6 cannot be explained by the two chemical formation routes previously proposed, which predicts abundances ratios between 0.9 and 1.5. The observed [Z/E] ratio is in good agreement with thermodynamic equilibrium at the gas kinetic temperature (130−210 K). Since isomerization of this species is not possible in the ISM, the two isomers may be formed at high temperature. New chemical models, including surface chemistry on dust grains and gas-phase reactions, should be explored to explain our findings. Whatever the formation mechanism, the high abundance of Z-HNCHCN shows that precursors of adenine are efficiently formed in the ISM. This is a crucial step to understand how the basic ingredients of life could have been assembled in the ISM before their incorporation to the primitive Earth.

First-principles analyses on formation and dissociation of small molecules in interstellar environment

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The origin of biomolecules such as amino acid is recently thought to be extraterrestrial. Abiotic chemical reaction in interstellar cloud may produce biological macromolecules. Glycine, the simplest species of amino acid, is expected to exist in molecular cloud. In fact, amino acetonitrile, the precursor of glycine, was observed as an interstellar medium (ISM) and hydantoin, another type of the precursor, was found in meteorites. Glycine itself was also found in meteorite and observed in the comet 81P/Wild 2 by NASA's Stardust spacecraft. These experimental reports strongly indicate the existence of interstellar amino acid. However, interstellar glycine has not been observed yet. It is still unknown whether amino acid is formed on ice dust or in carbonaceous chondrite. Atacama Large Millimeter/submillimeter Array (ALMA) now tries to discover interstellar glycine and its precursors. In this presentation, the formation processes of glycine by first-principles calculations are shown. We also show the photodissociation process of methanol, which was also observed in ISM.

POSTERS SESSION 1

The Dawn of Organic Chemistry

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I will give the overview of the ERC (European Research Council) Project the Dawn of Organic Chemistry, namely the emergence of organic chemistry in the first phases of a Solar-like Planetary System.

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^{13}C isotope chemistry in O and C-rich AGB star envelopes

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We present a new chemical model for the study of ^{13}C chemistry in the envelopes of AGB stars. Our model consists of a chemical network derived from a subset of the UMIST RATE12 database and includes species containing hydrogen, oxygen, nitrogen, sulphur, silicon and up to two carbon atoms per molecule, including all singly and doubly ^{13}C-substituted isotopologues. The full network contains 252 species coupled by 4839 reactions and is appropriate for use in both oxygen and carbon rich envelopes. The dominant source of ^{13}C fractionation in both cases is the selective photodissociation of ^{13}CO in the inner parts of the circumstellar envelope/shell, where ^{12}CO is self shielded, which results in an enriched source of atomic ^{13}C for the ensuing chemistry. Tracing the radial evolution of $^{12}C/^{13}C$ in AGB star envelopes is crucial for the interpretation of single-dish and interferometric observations, which will help determine the intrinsic nucleosynthetic ratio vs. the molecular ratio. Improved knowledge of these isotopic ratios is expected to provide insight into the contributions of evolved star ejecta to Galactic chemical evolution, as well as isotopic anomalies found in meteoritic samples

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Low temperature condensation of polyaromatic carbon grains from PAHs

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Carbon is ubiquitous in space and plays a key role in the evolution of the ISM and the formation of stars and planets. Yet the journey of carbon from large organic molecules to dust grains (or vice versa) still raises many open questions. ISO and Spitzer observations of infrared emission features between 3-20 micron (collectively known as aromatic infrared bands, AIBs) towards diverse targets (HII regions, reflection nebulae, post-AGB stars) have informed laboratory research with astronomical constraints. Although the structure of the carriers is still not precisely determined, they are generally characterized as aromatic, leading to two competing hypotheses: PAHs (polycyclic aromatic hydrocarbon) or condensed aromatic-aliphatic nanograins. Our goal is to reproduce analogs to interstellar dust and to shed light on the origin and molecular structure of these carriers.
Generally, laboratory analogs are condensed with different techniques (combustion, plasma, ablation) leading to samples spanning a wide variety of structure and aromatic/aliphatic ratios. Here we present the results of a study using the COsmic SImulation Chamber (COSmIC) experimental facility at NASA Ames. The COSmIC setup includes as Pulsed Discharge Nozzle (PDN) used in grain condensation. The PDN is fed by a supersonic jet of Argon seeded with organic molecules of increasing size (i.e., increasing ring number), that include benzene, naphthalene, anthracene and pyrene. High voltage pulses generate a plasma discharge in the stream of the jet-cooled supersonic expansion (50-150 K). Grains are condensed within the cold plasma and are collected in-situ onto substrates placed a few centimeters away from the electrodes. The grains are extracted from the COSmIC chamber and characterized ex-situ via infrared microscopy and mass spectrometry. Infrared absorption spectra in the 3-16 micron range exhibit stretching and bending modes associated to CC bonds within the rings and CH groups attached to the rings and are also accompanied by aliphatic group vibrations, broad bands and plateaus, suggesting the presence of a mixed aromatic-aliphatic backbone. The solid grain samples are further characterized via the laser desorption mass spectrometry technique in collaboration with the de Vries group at UCSB. In this technique, laser desorption volatilizes low vapor pressure molecules from a surface into the gas phase without fragmentation or thermal degradation. Jet cooled molecules are excited and photo-ionized and the ions are detected in a time-of-flight mass spectrometer. Mass spectra reveal the rich molecular complexity within the grains and show the presence of molecules larger in mass than the seed for all PAH precursors. These results allow us to propose a new picture of stable molecular pathways in PAH-grain condensation. The correlative study of both infrared and mass spectra will further help benchmark laboratory to astronomical spectra. We discuss how this study provides new links between the molecular PAHs and the condensed phase of cosmic carbon.

Complex Organic Molecules in the Low-Metallicity Large Magellanic Cloud

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Using the Atacama Large Millimeter/submillimeter Array (ALMA) 1.3 mm observations, we detected complex organic molecules (COMs) dimethyl ether (CH_3OCH_3) and methyl formate (CH_3OCHO), together with their likely parent species methanol (CH_3OH), in two locations in the star-forming region N113 in the Large Magellanic Cloud (LMC). This is the first time the interstellar COMs containing more than six atoms are conclusively detected outside the Galaxy and in the low-metallicity environment. The physical and chemical properties of sources with COMs detection, and the association with the H_2O and OH maser emission indicate that they are hot cores. Prior to this study, only one hot core had been identified in the LMC, but no COMs were detected. The fractional abundances of COMs in N113 scaled by a factor of 2.5 to account for the lower metallicity in the LMC are comparable to those found at the lower end of the range in Galactic hot cores. This is a surprising result as previous theoretical and observational studies indicated that the abundance of methanol in the LMC is very low. We continue to explore the properties of hot cores in N113 and their physical environment using ALMA observations probing a wide density range.
Interstellar COMs may be a chemical link to the prebiotic molecules that were involved in the processes leading to the origin of life. The presence of COMs in the low-metallicity LMC indicates that a possibility of the emergence of life as it happened on Earth is open in the low-metallicity systems in an early universe.

Molecular study of two intermediate-mass hot cores in the region of OMC1s

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We present interferometric observations of the intermediate mass cores of the sources Ori 139-409 and Ori 134-411 in the southernmost part of the Orion Molecular Cloud (OMC1s). The observations were conducted with the Submillimeter Array (SMA) in its extended configuration. The receivers were tuned at a frequency of 230.534 GHz in the upper side band (USB) and 220.534 GHz in the lower side band (LSB) and have a full bandwidth of 4 GHz. The resulting spectra shows a very rich content of molecular transitions detected at 4sigma or better, totaling 37 transitions lines from 15 species, dominated by methanol (CH3OH), Methyl Cyanide (CH3CN) and carbonyl sulfide (OCS) that display lines in excess of 15K. We have calculated the physical parameters (rotational temperatures and column densities) of the observed regions using the XCLASS code and the moments 0 (integrated intensity) and 1 (velocity weighted intensity) using the appropriate tasks of the reduction codes KARMA and MIRIDAD. We did not find significant differences between the hot cores analyzed, which could plausibly indicate that a similar evolutionary status. Additionally, both sources show molecular contents typical of low and high-mass regimes. The analysis is still on-going and the final results will be submitted for publication soon.

Complex molecules at EGO's & ATLASGAL's High Mass Star Forming Regions

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Interstellar medium contains dust and gas, at high densities and cool conditions molecules could proliferate. These species provide information of the physical conditions of their environments, through their and vibrational spectra, whose among other data, could bring density, temperature, as well large scale movement information. In the higher densities places, complex molecules (conformed by more than 6 atoms) have been detected. In spite of complex molecules are only detected in the gas phase, their more plausible formation are carried out by means of reactions with ice mantled or interstellar grains. In this way, outflow environment offer us an ideal chemical laboratory to look for complex molecules, as depending on the strength of the shock that this process cause the medium ends compressed. This facts can cause destruction of grain material and/or liberation of the ice mantles. Also, the high temperatures in the shock, up to a few thousand K, can drive chemical reactions not present in cold gas. Line surveys of shocks, therefore, provide an alternative way to probe the ice composition of cold clouds. Also, as they are detected in Young Stellar Objects (YSOs), complex molecules are expected to be common ingredients for a new planetary systems. In the following, we analyze the spectra of ten Massive Young stellar Objects (MYSOs), using their higher signal to noise lines, which we have labeled as CH_3OH, CH_3OCHO and CH_2DOH. Our observations are conformed by 40 sqarcsec maps at 1 mm band using APEX and IRAM telescopes, both whit a 1 GHz bandwidth coverage. The line analysis was made assuming an LTE approximation and from the sources with multi-transition information. A rotational diagram was computed. Also, we look for the spatial congruence along adjacent velocity channels looking for complex molecules associated with the outflows of our sample, whose have been previously traced by SiO 5-4 (~10 km/s). We have compiled an average Trot of ~28K for our sources and found a methanol and methyl formade enhancement along the entire sample. Single deuterated methanol have also been proposed to been found. Nevertheless further observations with higher spatial resolution and a wider bandwidth coverage are necessary and at days conforms a hot topic which is being analyzed in order to have an updated and more reliable scenario.

Tuesday 2nd of April 2019

Session 2: Astrochemistry of young and mature star + disk systems

TALKS SESSION 2

Organic molecules in protoplanetary disks

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One of the major problem in Astrochemistry is whether the organic chemistry during the star and planet formation process is inherited by planets and small bodies of the final planetary system. Indeed, planets and comets formation occurs through the combination of dust and gas lying within the disks surrounding young stars. And, among the molecules found in comets, some of them have also been detected in the interstellar medium (ISM). This leads one to ask whether these molecules were altered or formed in the protosolar nebulae or whether they are of direct ISM heritage. Consequently, understanding the formation of organic molecules, especially those of prebiotic interest, and the mechanisms that lead to their incorporation in asteroids and comets, might very well be of crucial importance for understanding the emergence of life. Thanks to recent progress in radioastronomy instrumentation for (sub)millimeter arrays such as with ALMA and NOEMA (high angular resolution and high sensitivity), new results have been obtained. I will review some notable results on the detection of organic molecules, including prebiotic molecules, towards protoplanetary disks.

Evolution of ices and deuteration during the formation stage of protoplanetary disks

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Ices are important carriers of volatile elements, such as carbon and oxygen, in star and planet forming regions, and thus ices are key ingredients of habitable planets. It is important to understand the evolution of ices from its formation in prestellar stages to delivery to planets.
Astronomical observations have revealed that icy molecules, such as water and methanol, are already present in cold prestellar stages, and they are highly enriched in deuterium. It remains unclear whether ices formed in the prestellar stages are delivered to a forming protoplanetary disk without significant alteration or (partly) destroyed en route into the disk via thermal and UV processing.
In this presentation, we present results of a series of astrochemical simulations from molecular clouds to forming disks, considering a layered ice structure and deuterium fractionation chemistry (Furuya et al. 2015, 2016, 2017). We adopt a semi-analytical, axisymmetric, two-dimensional collapsing core model with post-processing gas-ice astrochemical simulations, in which a layered ice structure is considered. The physical and chemical evolutions are followed until the end of the main accretion phase. Consistent with previous study (Visser et al. 2011), our models suggest that interstellar water ice is delivered to forming disks without significant alteration, while interstellar icy organics are partly destroyed by UV processing. It is also found that in forming disks icy organics are more enriched in deuterium than water ice. The differential deuterium fractionation in water and organics is inherited from prestellar stages.

Tracing chemical inheritance in protoplanetary disks

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The chemical composition of nascent planets is set by the molecular inventories of the dust and gas rich protoplanetary disks in which they form. Understanding these environments is therefore crucial to predicting potential habitability, as well as uncovering the origin of Earth's organic reservoir. Recent gains in the sensitivity and resolution of (sub)mm observations have revolutionized our understanding of disk chemistry, enabling the detection of prebiotic precursors such as CH_3CN, CH_3OH, and HCOOH. Major challenges remain, however, including how to connect ALMA observations of gas-phase disk organics with the bulk icy reservoir responsible for comet and planet formation. Such extrapolations require both (1) complete disk molecular inventories and (2) detailed characterization of molecular abundance distributions. In this talk I discuss recent observational progress toward these two goals, enabling better constraint of disk chemical models and comparisons to Solar System cometary measurements.

First, I present a new analysis technique for detecting weak spectral lines and highlight results from its application to an unbiased ALMA spectral line survey of two disks. Five new molecular species are detected for the first time in disks, a ~20% increase in the the number of known disk species. Second, I present new observations of the complex organics CH_3CN and CH_3OH toward a small sample of disks and interpret these results in the context of protostellar inheritance vs. disk chemical reset. Comparing chemical model predictions of CH_3CN abundances with Solar System cometary measurements, I show that inheritance of nitriles from interstellar ices likely occurred in the Solar Nebula, in agreement with recent results from the Rosetta mission.

Observations of gaseous debris disks

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Recently, several debris disks harboring a gas component have been discovered in survey observations at optical, infrared, and radio wavelengths, and its origin has been discussed in terms of the evolution of protoplanetary disks and the formation of planetary bodies. In fact, many debris disks are known to reveal submillimeter-wave CO emission, e.g., 49 Ceti (Hughes et al. 2017), β Pictoris (Dent et al. 2014), and ~ 15 others (Hughes et al. 2018). In addition to the CO emission, the submillimeter-wave [C I] emission has also been observed toward a few debris disks. For instance, Higuchi et al. (2017) detected the bright [C I] 3P1–3P0 toward 49 Ceti and β Pictoris with the ASTE 10 m telescope. Interestingly, the [C I] intensity is found to be higher than the CO intensity, which contrasts with the protoplanetary disk case (Tsukagoshi et al. 2015). However, the origin of the strong [C I] emission from debris disks is not well understood. In this talk, we present previous studies of gaseous debris disks and also present a high-quality image of 49 Ceti in the [C I] emission observed with ALMA.

Astrochemistry of protoplanetary disks

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What sets the composition of nascent planets is a fundamental question in astronomy, and one that is extremely timely considering the large number of exoplanets with very different characteristics that have been discovered in the past years. Whether these planets can host life depends directly on the volatile composition and distribution of the gas where they form, i.e. protoplanetary disks. Thanks to the great sensitivity and spatial resolution of current mm-facilities, we can start to understand how and what is the origin of the material that is incorporated into planets.

In this talk I will present observations of simple organic species detected in protoplanetary disks, including carbon chains, HCN and H_2CO. Spatially resolved multi-line ALMA observations now allow us to trace the radial and vertical distribution of these key organic species in the outer disk, and we are close to start resolving their structure in the inner disk. This is a natural question after the remarkable rich structure of the dust continuum emission we have recently seen in disks by the DSHARP ALMA Large Program.

POSTERS SESSION 2

TUPURI: A large survey of debris disks with the LMT

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We present the TUPURI project, a large survey of debris disks to be carried out with the LMT in the next years, along with its first results for a few bright spatially resolved debris disks (Epsilon Eridani, Vega, HD48682), observed with the LMT during the Early-Science Phase.

The TUPURI survey will study a few hundreds of known debris disks and their host stars. The most relevant bulk of observations will be carried out with the future LMT TOLTEC continuum camera, which will provide maps of the targets at three distinct millimeter wavelengths: 1.1, 1.4, and 2.0 mm. The spatial resolution provided by the 50 meter LMT main dish (about 5 arcsec) will allow to spatially resolve a significant number of disks and to assess the properties of the dust.

A spectroscopic follow-up at mm wavelengths will be carried out, for a selected sample, with the SEQUOIA and B4R spectrometers at the LMT, for detecting and studying the possible molecular gas content in the disks. The TUPURI mm observations, along with ancillary data at other wavelengths, will also allow to investigate the properties of the disks host stars, with particular emphasis in the structure of the outer atmospheres.

Authors: M.Chávez Dagostino, E. Bertone, O. Vega, J. Marshall and the TUPURI team.

Spectral line surveys of evolved stars and protostars with the Large Millimeter Telescope

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Spectrally unresolved molecular line surveys with the Redshift Search Receiver (RSR) on the Large Millimeter Telescope (LMT) are presented toward massive star-forming regions and protoplanetary nebulae. The RSR observes simultaneously a frequency range from 73 to 111 GHz, at a spectral resolution of 31 MHz (~100 km/s at the center of the band). A sample of massive protostars with class I methanol maser emission were found to present a variety of molecular transitions typical of the different environments where the massive stars are born. We study correlations of different molecular species as a function of the maser activity. In the protoplanetary nebulae we found that the chemical content of extreme outflows are particularly rich and oxygen- and sulfur-bearing molecules.

Session 3: Scenarios on the emergence of life on Earth and beyond.

TALKS SESSION 3

An Universe teeming with life?

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Following the publication of the Origin of Species in 1859, many naturalists adopted the idea that living organisms were the historical outcome of gradual transformation of lifeless matter. These views soon merged with the developments of biochemistry and cell biology and led to the proposals by Oparin and Haldane of a heterotrophic of the origin of life, which transformed the discussion of the emergence of the first cells into a workable multidisciplinary research program. The heterotrophic theory of the origin of life requires the synthesis of organic compounds prior to the emergence of the first living entities. Analysis of carbon-rich meteorites and the laboratory simulations of the primitive Earth suggest that the prebiotic environment was endowed with a large suite of organic compounds of biochemical significance, many organic and inorganic catalysts, purines and pyrimidines, i.e., the potential for template-dependent polymerization reactions; and membrane-forming compounds. The remarkable coincidence between the monomeric constituents of living organisms and those synthesized in Miller-type experiments appears to be too striking to be fortuitous. Although it is not known the relative importance that the different sources of organic molecules played in the emergence of life, the available evidence suggest that the chemistry of the primitive environment was shaped both by exogenous and different endogenous sources of organic compounds.
However, how the ubiquitous nucleic acid-based genetic system of extant life may have originated from such a mixture is one of the major unsolved problems in contemporary biology. The discovery of catalytically active RNA molecules provided considerable credibility to prior suggestions that the first living entities were largely based on ribozymes, in an early stage called the RNA world. There are many indications of the robustness of the RNA world hypothesis, but at the time being the hiatus between the primitive soup and the RNA world is discouragingly enormous, and the problem of how RNA came into being is still an open one. Precellular evolution was not a continuous, unbroken chain of progressive transformations steadily proceeding to the first living systems. Many prebiotic cul-de-sacs and false starts probably took place. While it may be true that the transition to life from non-living systems did not require a rather narrow set of environmental constrains, we cannot discount the possibility that even a slight modification of the primitive environment could have prevented the appearance of life on our planet. However unpalatable this conclusion may be, life may be a rare and even unique phenomenon in the Universe.

The discovery of exocomets and their possible relationship to organic life on exoplanets

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To date, over 20 young stellar systems have been found to harbor exocomets. We discuss their neans of detection and their relationship with parent exoplanets and the possibility that they may be seeding organics and ices onto the exoplanets as perhaps happened in Earth's past.

Resolving The Young Sun's Paradox on Early Earth - Clues from Mars

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Understanding how the simple molecules present on the early Earth may set a path for complex biological molecules, the building blocks of life, represents one of greatest unsolved questions of modern science. Another great challenge is to understand how the late Archean Earth supported liquid surface water under the young Sun, which was 25% fainter. I will present our new concept of how these two problems can be reconciled if we look at eruptive history and space weather from the young Sun at the time when life started on Earth. Our theoretical model suggests that energetic protons accelerated in shock waves driven by frequent and powerful coronal mass ejection events and Corotating Interacting Regions produced by the young Sun's wind penetrated into the nitrogen-rich weakly reducing atmosphere and initiated the reactive chemistry by breaking molecular nitrogen, carbon dioxide, and methane, producing nitrous oxide, the potent greenhouse gas, and hydrogen cyanide, an essential compound for life. I will also discuss the results of our lab experiments at Tokyo Tech to show the efficient production of amino acids via energetic proton exposure. Can we find young Earths with similar prebiotic atmospheric chemistry?

The road to life: inanimate complex systems, the case of Planetary Nebulae.

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At the age of 10^{10} yr, or earlier, the universe built living beings. Much earlier it built, and still does, other complex systems. Understanding these systems will come through Physics: living complexity and inanimate complexity sharing the same laws? Planetary Nebulae (PNe) are complex, organized objects, and their origin, evolution and physico-chemical characteristics are relatively well understood. We attempt to quantify complexity in PNe, and compare with other systems.
The extraordinary bipolar PNe Abell 14 is presented and the need for new complexity metrics is discussed.

<u>Special Session:</u> on General aspects of star formation and the interstellar medium

The "black box" genome of Deinococcus radiodurans becoming greyish

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In the Deinococcaceae group are known to exist robust extremophilic bacterial species, as Deinococcus radiodurans. Attempts to better understand its robustness have specially focused on analyses of its responses against extreme doses of gamma radiation, to explain survival mechanisms of Deinococcus radiodurans against other stresses, as desiccation and heat. Even under simulated extraterrestrial environments it has thrived to deal with severe biological damages. D. radiodurans has many defensive mechanisms, and transcriptomes/proteomes made in response to gamma radiation and desiccation revealed that some genes and proteins had undefined functions, while others have never been expressed under those conditions. Therefore, it is expected that such gene products with obscure function can code for novel resistance proteins to these extreme conditions. The present review aims at elucidating the current efforts for describing the survival mechanisms of this species, covering not only the progress of previous works but also some of the remaining exclusive proteins of D. radiodurans which may be responsible for its renowned stress resistance. This particular resistance toolbox with novel and exclusive proteins was referred as the “Black Box Genome of D. radiodurans”.

Halophilic bacteria strategies help to understand habitability aspects of the Solar System

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Mars and Europa are two of the planetary objects of prime astrobiological importance in the Solar System. The existence of a vast water ocean enriched with sulfates below the icy crust of Europa, with the possibility to find hydrothermal activity as a source of energy, and the discovery of geological evidences pointing to the existence of salty water running on the surface of Mars together with more evidences of an ancient wet Mars, are all facts that have raised the question of whether Europa's interior as well as Mars surface or sub-surface may harbor environments favorable for life subsistence.
Motivated by these precedents we performed some systematic studies aimed to investigate the capabilities of Salinibacter ruber, an extreme halophile; Cobetia marina, a moderate halophile, and Bacillus pumilus, a halotolerant bacterium, to survive to different conditions that mimic the surface of the planet Mars, and the salty water ocean of the satellite Europa. The strategies used in each case were also investigated.
Our results point to a considerable tolerance to salinity displayed by the studied bacteria, even beyond that imposed only by sodium chloride (NaCl). Under these bases, a discussion on the habitability potential of the Europa's ocean where sulfates have been found, and of the surface of Mars, where chlorates and perchlorates have been reported, will be presented.

Ejection velocity of the Orion fingers

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The interaction of a high velocity clump of gas has been described by the plasmon model, which considers balance between ram pressure and the internal stratified structure of the decelerated clump. In this work we propose an analytical model to describe the mass loss of such a clump due to the interaction with the environment, describing its influence on the plasmon dynamics. We carried out comparisons between an analytic model and axisymetric gasdynamic simulations of plasmon evolution. Comparing with the complete analytic model from which we can infer the position and the mass loss of the clump as function of the clump's density and the environment ratio. We use these results to obtain the ejection velocity of the clumps that generated the Orion fingers in the explosive event of the region Orion BN/KL.

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

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We present a study of the depletion of CO in the IRDC G351.77-0.51. Knowledge of the degree of CO-depletion provides information on the physical conditions occurring in the innermost and the densest regions of molecular clouds. A key issue in the radius within which the CO is depleted (R_{dep}). To estimate the depletion map on the cloud scale, we use the dust continuum (Hi-Gal), combined with APEX $C^{18}O$(2-1) line observations. We built a simple model to investigate the size of the CO-depleted region in G351. The model suggests that $R_{dep} < 0.1$ pc where $n(H_2) > 3 \times 10^4$ cm^{-3}. These results provide crucial information on the spatial scales on which different chemical processes operate in high-mass star forming regions and also presents a warning for using CO as kinematical studies in IRDCs.

The chemical age of high-mass clumps

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Chemistry is a powerful tool to time the star-formation process.
I will focus on the potential of the relative abundance of o-H_2D^+ and N_2D^+ as an evolutionary indicator. We have recently explained their opposite behavior with time using simple considerations on the formation paths, depletion of heavy elements, and evaporation from the grains.
I will then discuss the very first direct measurement of the ortho-to-para ratio of H_2D^+ in the high-mass regime, from APEX and SOFIA observations.

Wednesday 3rd of April 2019

Session 4: Exoplanet characterization and the search for biomarkers

TALKS SESSION 4

In search of Earth analogs around solar twins

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The solar system is a landmark regarding habitable systems in the universe, as it is the only system currently known where life has flourished. Stars similar to the Sun, the so-called solar twins, have stellar evolution paths similar to the Sun, and some of them may hosts planetary systems resembling our own. We have been characterizing different properties of the Sun relative to solar twins, in a strictly differential analysis, to reveal how unique is the Sun in its chemical composition, in particular regarding the refractory elements, which are key in the formation of rocky planets. We have been also studying the stellar activity cycles of solar twins and searching for planets around these stars. I will report our most recent findings, and our new efforts towards finding an Earth analog around a solar twin.

Planets of other suns

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I will present the PennState-Toruń Planet Search sample of other suns, stars with solar masses at various evolutionary stages, and their companions. For all stars in the sample detailed spectroscopic analysis resulted in precise mass determinations, and multiple precise radial velocity measurements allowed for assessment of their companions status. The sample already contains six planetary systems discovered by us. I will present several new planetary systems in the sample and a summary of current results.

"Solaris". Global network of robotic telescopes for stellar astronomy and exoplanets.

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"Solaris" is global network of robotic telescopes with one of the telescopes equipped with a small but very efficient mid-resolution echelle spectrograph BACHES. The 0.5-m telescopes are located at sites having similar separation in longitude and nearly identical latitudes: South African Astronomical Observatory, Republic of South Africa (Solaris-1 and -2), Siding Spring Observatory, Australia (Solaris-3) and Complejo Astronomico El Leoncito, Argentina (Solaris-4). The network is operational since April 2014 and was originally envisioned to carry out a timing search for circumbinary planets around eclipsing binary stars. The photometric survey has resulted so far in about 16.5TB TB of scientific data (i.e. not counting calibration frames, 2.2 million images). The total sample of various photometric targets was ~300. Approximately 200 of them were initially tried for the timing survey. This timing survey target list was subsequently narrowed down to about 80 targets. The timing survey was complemented with a spectroscopic survey of eclipsing binaries that covered ~380 binary systems. The total number of high resolution spectra exceeded 4500, and the telescope time granted since 2010 was ~250 nights. It is likely the largest ever high resolution spectroscopic survey of eclipsing binaries. We will present the current status of the network, incoming results from both the photometric and spectroscopic efforts and the opportunities to use the network for new projects.

Inferring the Size Scales of Planetary Systems Using Resolved Debris Discs

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Circumstellar debris discs are tenuous remnant rings of icy and rocky material left over from planet(esimal) formation processes around their host stars. Possible relationships between stellar luminosity and disc parameters have been examined. Based on analysis of a sample of 39 spatially resolved debris discs at infrared wavelengths by Herschel, a trend between stellar luminosities (L_{star}) and the ratio of the discs' resolved radii to blackbody radii (R_{disc}/R_{bb}) was noted. We have examined a larger sample of resolved debris discs from archival far-infrared Herschel observations in order to determine the fidelity of that trend. We further examine whether the inferred extents of these discs are consistent with self-stirring models or may be indicative of dynamical perturbation by a planetary companion. Disc radii were determined by fitting the source brightness profiles with simple annular disc models convolved with a PSF. We obtain good agreement between the resolved extent of debris discs as measured at millimetre wavelengths and the estimates based on L_{star} and R_{disc}/R_{bb} at far-infrared wavelengths, suggesting that the measured trend is a fair, albeit imperfect, predictor of actual disc extent. Furthermore, we identify several systems with radii larger than expected given the ages of their host stars, based on comparison with simple stirring models. Obtaining a reliable indirect measure of the radii of debris discs is of paramount importance to facilitate interpretation of their architectures, possible stirring, and formation mechanisms, from unresolved data e.g. such as is expected from Spica. Such data can be combined with the results of exoplanet detections from e.g. TESS and Gaia to identify the importance of disc-planet interactions to the evolutionary histories of these planetary systems.

Earth-like planets around Low Mass Stars

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Warm terrestrial planets conform the most natural place where we can expect to find evidence for life similar to our own beyond the Solar System. Despite that we would all like to study Earth-like planets around sun-like stars, these remain elusive with our current capabilities. Red dwarf stars smaller than the sun are the most numerous in our Galaxy and the Solar neighborhood. Also, due to their smaller size and mass, small terrestrial planets can now be routinely detected around them using the transit and the Doppler spectroscopy techniques. Depending on the method used for the detection, different techniques can be used to attempt characterization of their atmospheres.
I will review the detection of very nearby red dwarf planets and the observational opportunities they can offer.

The CARMENES Survey for M Dwarf Planets

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M dwarfs are very interesting targets for searches for habitable planets. They are the most numerous type of star; therefore our closest cosmic neighbors may well live on a planet orbiting an M dwarf. It is also easier to look for Earth-like planets around low-mass stars, as they give rise to relatively large radial-velocity variations and deep transits. Third, planets of M dwarfs may be different from those of the Solar System as they experience stronger UV and X-ray irradiation. This provides opportunities for comparative studies of planetary atmospheres under varying conditions.

We are conducting a survey of 300 nearby M dwarfs (average distance only 13pc), with the goal of finding terrestrial planets in their habitable zones. We have built a pair of spectrographs that are optimized specifically for measuring precise radial velocities of cool stars. This CARMENES instrument is now operational at the 3.5m telescope of Calar Alto Observatory in Spain.

We have detected the signatures of several previously known planets as well as discovered new ones, with masses down to a few Earth masses, including a cold super-Earth orbiting Barnard's star. We have determined the mass of a transiting planet found by the K2 mission, and are preparing for the follow-up of TESS planets. We have used the He 10830 line to observe evaporating atmospheres of several planets; our data indicate that the evaporating gas is directly influenced by the stellar UV flux.

The CARMENES survey is also generating a unique data set for studies of M star atmospheres, rotation, and activity. The spectra cover important diagnostic lines for activity, as well as molecular lines sensitive to magnetic fields. Correlating the time series of these features with each other, and with wavelength-dependent radial velocities, provides excellent discrimination between planetary companions and stellar radial velocity "noise", and generates new insight into the physical properties of M dwarf atmospheres.

I will provide an overview of what we are learning from the CARMENES survey about the terrestrial planet population around nearby cool stars.

ALMA observations and radiative transfer modelling of low- and high-mass star-forming systems

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I will present the user-friendly 'sf3dmodels' Python package developed by Izquierdo, which is able to create complex 3D models in the context of star formation. These models are then plugged into the widely-used radiative transfer codes LIME and RADMC3D to calculate synthetic images of their dust and free-free continuum, as well as their molecular and recombination line emission. Then I will show the first two published applications of these tools: In Izquierdo, Galván-Madrid et al. (2018) we modelled ALMA observations of the massive YSOs in W33A, an object that we naively thought it was a massive disk in the pre-ALMA days, and that current data revealed is a multiple, complex system being fed by accretion filaments. In Galván-Madrid, Liu et al. (2018) we modelled the effects of self-obscuration in class 0 protostellar disks, where we found that we can explain observed shallow (sub)mm spectral indices without the need to invoke for very fast growth of dust grains, as well as reproduce resolved images of dark lanes (hamburguers) in these Young Stellar Objects when observed with the maximum resolution achievable with ALMA.

POSTERS SESSION 3

Computer simulation of the oligomerization process in solid chiral amino acids

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In biochemistry, the level of organization in amino acids starts in a bottom-up approach, with Glycine. Glycine is the smallest amino acids and it forms feasibly in different abiotic conditions. Since this amino acid has not a chiral center it is classified as the less complex amino acid. In complexity, the next amino acid is Alanine, with a chiral center. Chirality is a geometrical property that widely permeates in biology, in which much effort has been focused given its importance in structure and interactions of amino acids and peptides. We approach this phenomenon from the point of view of the solid state of the amino acids. The molecules that build up crystals, might have some chemical performance as organic catalysts thus, yielding new molecules such as small peptides with relevance in molecular evolution and prebiotic chemistry. The chiral D, L, and DL-amino acids were simulated by means of HyperChem, by using their unit cells to obtain an oligomerization process. Our preliminary results show that the L amino acids in the solid state promote the oligomerization process compared to the D and LD solids. We discuss the possible mechanisms of these processes.

Acknowledgments

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The behavior of aldehydes of astrobiological importance under irradiation

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The steady-state γ-radiolysis of aldehydes of astrobiology importance in aqueous solutions or their pure state have been studied in extreme conditions of temperature and irradiation doses. We carried out the irradiation in a cobalt-60 gamma source (Gammabeam 650 PT), with doses up to 360 kGy, at three temperatures (77 K, 198 K, and 295 K). For the analysis, we used various spectroscopic and chromatographic analytical methods. The results show that the target compounds: formaldehyde, glyceraldehyde, glycolaldehyde are labile under these conditions and decomposed into sugar-like compounds that are important for use in chemical-evolution studies. The initial step for the radiolytic decomposition of the studied aldehydes is abstraction reactions of the target compound by OH, from the radical formed by the γ-radiolysis of water. The formed radical decomposes in a series of smaller oxidation products.

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Is there life on Earth ?

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Earth is the only planet known to be saturated with life since billions of years. Micro-organisms, viruses, fungi and DNA fragments have been found in the Earth atmosphere at various altitudes. Can those manifestations of life be detected from their interactions with the sun light? In other words, would far observers be able to detect the presence for instance of DNA in the Earth atmosphere through spectroscopic observations?
Inversely, could a terrestrial observer detect life manifestations in the atmosphere of an exoplanet? Before thinking of life detection on another planet, the first step is to verify if life is detectable in the Earth atmosphere.
In this context, laboratory experiments were performed by taking FT-IR spectra of different bacteria and of free DNA (damaged and not damaged). They were then compared with atmospheric spectra, taken from astronomical observations at high airmass in the same band width.
First results are surprisingly interesting since a common pattern appear.

Sorption of amino acids onto minerals: the first step to consider origin of life´s scenarios

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To consider any prebiotic environment consistent with origin of life scenarios, there are three basic requirements they must comply: 1) continuous synthesis of organic molecules, 2) available energy sources and 3) a reaction medium. The next step to reach molecular complexity is the ability to concentrate organic molecules. In this way, we performed sorption experiments of some amino acids, glycine, arginine and aspartic acid, onto minerals (i.e. olivine, pyroxene and plagioclase), as a function of pH. These conditions, pH changes, mineral diversity and organic matter are present at the submarine hydrothermal systems.
Our first results suggest that minerals can concentrate some amino acids. The sorption of arginine onto olivine (at basic pH) was effective, in fact this system showed the higher potential sorption, until 34 %. This capability may be associated with electrostatic interactions. However, in other experiments the sorption percentage was practically null, this is true for the system including aspartic acid in solution with no pH modifications, and the behaviour was the same for the three minerals used. Nonetheless, some systems (i.e. Aspartic acid/pyroxene) with similar charge distribution showed a sorption until 15 % which suggests that other mechanisms may have an important role in sorption process. To understand the mechanisms involved in the interactions between amino acids and mineral structures is crucial to define what physicochemical conditions are required to reach high concentration of those molecules.

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Computer simulation of a primitive peptide in a mineral environment analogous to the Naica System

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Studies carried out in the cave of the giant gypsum crystals, the Naica System, revealed the presence of microorganisms inside them. Thus, it is important to perform computational simulations to get an insight in the possible molecular mechanisms that stabilize the organic compounds inside the crystalline lattice. These possible mechanisms might help to understand the preservation of organic molecules and the potential of the crystals to maintain living forms.

The computational simulation uses a peptide formed from the most common amino acids (in α helix and β sheet configurations) interacting with a gypsum (selenite) unit cell. Our preliminary results indicate that the organic phase (α helix) is stabilized by the action of the aqueous environment. The energy of the system is negative, suggesting the formation of the peptide. As future work, we plan to enrich the simulation of the inorganic phase, adding two more variables to the simulation (temperature gradient, cations/anions in dissolution) to explain the mechanisms of the stability oforganic compounds inside the Naica system.

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Microstructural and spectroscopical characterization of the Allende meteorite: Its relevance in prebiotic chemistry

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Using the latest spectrophotometric data update of the GAMA collaboration (Galaxy and Mass Assembly), some of the most significant properties of galaxies in pairs were studied, by means of mass-rate relations of star formation and mass-metallicity. The novelty of this work with respect to others (which used data from the SDSS), lies in the study of galaxies in pairs of smaller separation, in addition to the use of a complete mapping up to a redshift of 0.35. Sub-samples of galaxies were made in pairs according to its multiplicity and range of redshift. These were compared with their similar subsamples of control galaxies (isolated galaxies), to discover the sensitivity of the changes in the properties under this selection The Allende meteorite is one of the most studied Mexican meteorites. It fell in Allende town (Chihuahua, Mexico in 1969) and it has a diverse mineral phase composition1,2. Also, some organic compounds, such as alanine, were found in the meteorite 3,4. The previous fact is of main relevance because this meteorite is older than the solar system. In this project, we characterized the mineral composition of a fragment of the Allende meteorite by using ATR-FTIR, X-ray powder diffraction and EDS, describing the mineral phases and then, atomic force microscopy (topography and magnetic modes), scanning electron microscopy, polarized light microscopy and stereoscopic microscopy experiments were performed. Afterwards, we simulated a similar system in 100 ps in a molecular dynamics in MM+, AMBER for molecular mechanics force fields and PM3 and TENDO as semi-empirical methods. Furthermore, we carried out the self-assembly of D, L and D,L alanine crystals. The crystals were grown in presence of electric fields, so the analyzed crystals are studied through spectroscopy and the different microscopies and results compared to the computer simulations with a without electric field. These results are discussed from the point of view of chemical evolution and prebiotic chemistry.

Could life emerge on the icy moons of the Solar System?

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It has been proposed that the origin of life on Earth occurred at the bottom of the ocean in hydrothermal vents. Recently, an oceanographic expedition to the Gulf of California was carried out to investigate the field of hydrothermal vents that was discovered in 2015 at Pescadero Basin (Goffredi et al. 2017). In this field, which is at 3800 meters deep, the hydrothermal fluids record maximum temperatures of 290ºC and, among their geochemical characteristics, the presence of methane and calcite stands out. However, in spite of all these extreme conditions of temperature, pressure, darkness, and pH a great diversity of organisms was found. We assume that the hydrothermal vents found at Pescadero Basin harbor a community of archaea and thermophilic bacteria intimately related to the geology of the region. In Astrobiology, it has been proposed that on the ocean floor of the satellites Europa (Jupiter) and Enceladus (Saturn) there are hydrothermal systems similar to terrestrial that could harbor extremophiles. We want to compare the physical, chemical, biological and geological characteristics of the Pescadero Basin with the conditions estimated in the oceans of Europa and Enceladus to propose a habitability model for the existence of life on the icy moons. In this work we present the bases of the project, which is a PhD thesis in its initial process.

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Prebiotic Fatty Acid Vesicles through Photochemical Dissipative Structuring

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We describe the photochemical dissipative structuring of fatty acids from CO and CO_2 saturated water under the solar UVC and UVA photon potential prevalent at Earth's surface during the Archean. Their association into vesicles and their subsequent association with other fundamental molecules of life such as RNA, DNA and carotenoids to form the first protocells is also suggested to occur through photochemical dissipative structuring. In particular, it is postulated that the first vesicles were formed from conjugated linolenic (C18:3n-3) and parinaric (C18:4n-3) acids which would form vesicles stable at the high temperatures (~85 °C) and the somewhat acidic pH values (6.0-6.5) of the Archean ocean surface, resistant to divalent cation salt flocculation, permeable to ions and small charged molecules, but impermeable to short DNA and RNA, and, most importantly, highly dissipative in the prevailing UVC+UVA regions.

Pondering on the origin of life from abiogenesis

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Currently, theories have been developed that seek to explain the origin of life from abiogenesis. The most accepted are the RNA world and the iron-sulfur world. The most recent proposals take some elements of the theories presented before trying to shed more light on the origin of life by providing new approaches and elements to have a more solid argument. However, there is a need to test them by well-designed experiments. The objective of this review is to contrast these different theories.

Irradiation of cytosine adsorbed in a clay mineral

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Chemical evolution is the process through which simple compounds generate organic compounds that are essential for the development of life. The study of chemical evolution provides insights into the steps that preceded the appearance of life. A critical factor in chemical evolution is related to the chemical stability of the compounds formed by abiotic processes. In this context, the study of the stability of cytosine in an aqueous solution exposed to a high radiation field while it is adsorbed onto clay mineral was studied. Cytosine is an essential compound in chemical evolution studies due to its participation in biological systems as the nucleic acids. Several mechanisms should have been present both to form molecules and to endure them in the environment. Mineral surfaces may have been one of those protective mechanisms. The results showed that clay protects from the radiation to the cytosine molecules and that this protection was extended to molecules in the surrounding environment. In this regard, it is proposed that the participation of clays in preserving important molecules was crucial to the formation of more complex molecules.

***Authors*: Alejandro Paredes-Arriaga, Adriana Meléndez- López, Sergio Ramos-Bernal, Alejandro Heredia, Alicia Negrón-Mendoza**

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The nature reconstruction of the Last Universal Common Ancestor of all living beings

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There are many intriguing questions about how the last universal common ancestor lived after the emergence of life. In the last years, many approaches have been applied to explore it, from geological records to comparative genomic analysis. Now, with the advent of machine learning algorithms and a huge amount of genomes and big data is possible to explore and deduce more clearly the nature of LUCA and some characteristics of its descendants at the early evolution of life on Earth.

Could tardigrades survive on icy worlds like Enceladus?

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Tardigrades are microscopic organisms that have gained importance in astrobiology in recent years, and today are considered one of the most extreme organisms on the planet. They are also denominated water bears, due to its general appearance and its slowness when moving. These organisms have extreme survival ability, they can enter into a state of latency for several years called cryptobiosis and this mechanism can be of different types, anhydrobiosis (lack of water), anoxybiosis (lack of oxygen), osmobiosis (low pressure), and cryobiosis (freezing temperatures) (Nelson and Marley 2010), making them to survive to different extreme changing conditions, even ionizing radiation. In the recent years it has been said that life could emerge in Enceladus, Saturn's icy moon, this is because Cassini probe has confirmed the existence of a long-lived global ocean laced with organic compounds and biologically available nitrogen (Deamer, 2017). One of the hypotheses of this work is that these organisms survive to the extreme environmental conditions in Enceladus. We know that these organisms can live and survive in extreme conditions on Earth, some inhabit the Arctic Ocean like genera Halobiotus, Pseudechiniscus, and Styraconyx. Some were found recently in cryoconite holes which are water-filled reservoirs on a glacier's surface (Zawierucha, 2017). The species Hypsibius dujardini, Pilatobius recamieri, the genera Ramazzottiidae, as well as other micro-invertebrates, were found. The strategy to tolerate and/or survive these temperatures is accumulating sugars like trehalose and polyols. This action protects membranes and proteins against phase transition and controls the ice fraction and minimum cell volume resulting from freeze concentration and osmotic dehydration. Could they survive on Enceladus? maybe, but there is still some work to do on understanding the genes that trigger these protection strategies against the freezing temperatures.

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POSTERS SESSION 4

Stellar and planetary characterization of two Kepler multi-planet systems from high-quality Gemini/GRACES spectra

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Our understanding of exoplanets structure, composition, formation, and evolution is strongly linked to our knowledge of a series of fundamental parameters of their host stars. On the one hand, stellar composition and mass have a major influence on the formation and evolution of planetary systems. On the other hand, models of planetary structure and composition rely on accurate estimations of their masses and radii, which for transiting planets, depend critically on the mass and radius of the parent star. These stellar properties, in turn, depend on the atmospheric parameters of the star, which can be derived from high-quality spectra. However, this kind of spectra is not commonly available for faint planet host stars such as those in the Kepler field. In this context, we present a detailed stellar and planetary characterization of two Kepler multi-planet systems based on GEMINI-GRACES high-quality spectra.

A search for orbital decay in southern transiting planets

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So far, among the more than 3900 confirmed exoplanets there are ~ 150 exhibiting very short orbital periods (P < 1.5 days). Particularly, these extreme systems with giant planets have raised several questions about their formation and orbital stability. Due to the close proximity to their hosts, star-planet tidal interactions play a key role in the final fate of these systems and it is expected that many of these planets eventually spiral in toward their host-stars. This systematic decreasing in the semimajor axis is called ""orbital decay"" and can be detected through the long-term photometric follow-up of transiting exoplanets.
In this contribution, we will briefly describe the project that we are carrying out to search for orbital decay in southern transiting planets and also present preliminary results for one of the monitored objects.

Atmospheric characterization of Saturn-like planets through multi-band photometry

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Nowadays, we know it is possible to obtain information about the atmospheric composition of a planet by analyzing the variation of the depth of its planetary transits as a function of wavelength. Until now, several studies of this kind have been made for Jupiter-like planets, compared to that, the number of published papers with Saturn-type planets is small. Having this in mind, in this work, we present preliminary results of my Master's degree thesis, which has the goal of studying the atmospheric composition of a sample of Saturn-type exoplanets by using lightcurves of their planetary transits obtained in different filters.

The Relation UV activity – Rotation

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One of the best methods to calculate the age of field stars is the Gyrochronology, however this method requires reliable determinations of the rotational period. To determine the rotational period we use the emission of the Mg II lines h (2803.53 Å) and k (2796.35 Å). We use a sample of 271 stars F, G and K with high resolution UV spectra for this work. Using 91 stars with rotational period already measured, we obtained a reliable activity – rotation relation for F and K type stars. We also obtained good results for G stars, in agreement with Olmedo et al. (2013).

Thursday 4th of April 2019

Session 5: Habitability of exo-worlds and Exoplanetary theoretical models

TALKS SESSION 5

After the Habitable Zone

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The habitable zone (HZ), the region around a star in which the Earth could retain surface water, has served scientists well in the search for potentially habitable terrestrial exoplanets. However, as we move into the era of targeting exoplanets for life detection, the simplifications inherent to the HZ present hurdles to progress. Numerous physical processes affect planetary habitability, such as planet formation, stellar evolution, internal properties, ocean behavior, tidal effects, atmosphere loss, orbital oscillations, and even galactic perturbations, but are left out of the classic HZ formulation. With targets now in hand and powerful telescopes on the horizon, ranking targets for habitability has become an immediate priority. A new approach is needed – one in which the outcomes of planet formation and evolutionary simulations are used to calculate the probability that a planet has surface water today. This approach will generate an "exoplanet habitability index" that quantifies the likelihood that a given planet is currently habitable and can be used to prioritize precious telescope time in the search for habitable and inhabited worlds. This new approach will require a massive and collaborative effort between scientists across a range of disciplines, including leveraging new insights from data science to analyze high-dimensional data sets. Developing this framework that connects formation and evolutionary models to observations is a grand scientific challenge of the 21st century, but the successful discovery of life beyond the Solar System is contingent upon its creation and implementation.

Coronal Mass Ejections in Low-Mass Stars and Their Influence on Habitability

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Stellar magnetic fields completely dominate the environment around late-type stars. They are responsible for driving the coronal high-energy radiation (e.g. EUV/X-rays), the development of stellar winds, and the generation transient events such as flares and coronal mass ejections (CMEs). While considerable progress has been made for the first two processes, our understanding on the eruptive behavior of active stars is still very limited. This information is critical as these phenomena can have a very strong or even catastrophic impact on exoplanet atmospheres. Of particular importance are M-dwarf planetary systems, as they are prime targets for current and upcoming exoplanet searches, yet their period of enhanced magnetic activity is much longer than in any other spectral type. I will present the results of a numerical project aimed at studying the properties of eruptive phenomena in low-mass stars, and determine their impact on the habitability conditions around these systems. We consider state-of-the-art 3D magneto-hydrodynamic simulations of CMEs, developed using one of the latest models employed for space weather forecast in the solar system. These results will be discussed in the general solar-stellar context, taking into account the observed properties of the magnetic fields in which they develop.

Poly-extremophiles: exploring the limits of habitability

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One of the main areas of interest in Astrobiology is the study of extremophiles, organisms that can adapt, or even thrive, in extreme conditions. One of the main reasons for this interest is that the concept of habitability, which refers to the potential of a cellestial body to harbour life, is central to Astrobiology. Since the only life forms we know are the ones that can be found on Earth, it becomes fundamental to enlarge our knowledge about extreme life forms inside our own planet, in order to accurately understand which are the limits in physical or geochemical conditions that can sustain life.

On the other hand, this study is central to the hypothesis of panspermia, which proposes that certain life forms can survive space travel, and therefore propagate life across different planets. These organisms should be able to survive to high-vacuum conditions, high levels of radiation and extreme temperatures. These studies are also central to prevent contamination of extraterrestrial environments with terrestrial microorganisms during space missions.

Studies of extremophiles cover organisms that can survive in very high concentrations of salt (halophiles) or heavy metals, in very high or low temperatures (thermophiles or psychrophiles), in acid or alkaline environments (acidophilea or alkaliphiles), to extremely dry conditions (xerophiles), to high level of radiations (radioresistants), etc.

However, conditions in extraterrestrial habitats are most certainly extreme in many aspects. For example, strong evidence of the existance of salt hidrates and brine on Mars has been found in the last years, and it was proposed that these brines could provide a habitable environment. Of course, any form of life capable of living in brines should be halophilic, but a high concentration of salt is not the only extreme conditions in that environment: microorganisms there should be anoxigenic, and should be able to endure at least low temperatures and high levels of radiation.

Therefore, the next step to understand the real limits of habitability should be to study organisms that can survive under several extreme conditions, polyextremophiles. In this paper we study Brevibacterium linens AE038-8, a bacterial strain isolated from arsenic-rich groundwater in Tucumán, Argentina. We investigate its tolerance to multiple stress factors relevant for astrobiology studies, such as tolerance to heavy metals, to extreme pH values, different temperatures and to high salt concentrations, conditions which might be present in planets of our Solar System and in exoplanets.

Implications of non-standard physics on the future evolution of the Sun and exo-planets orbiting red giant stars

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We describe how the simultaneous production of axions and neutrinos with a nonzero magnetic dipole moment will enlarge the solar radius and luminosity during the red and asymptotic giant phases and affect the physical state of the planets within the solar system. We compare the predictions of canonical stellar evolution against solar models that include an enhanced energy loss within their core induced by the production of axions and neutrinos, considering the current most restrictive limits for the coupling constant between axions and electrons and the magnetic dipole moment of neutrinos and explore the consequences for known exo-planets currently orbiting red giant stars.

Planetary habitability around M dwarfs: lessons from Proxima and Trappist-1

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Main sequence M stars (red dwarfs or M dwarfs) are the most abundant stars in our solar neighborhood and their planets are more likely to be detected using transits or radial velocity techniques, particularly low mass/radius planets (<10 Earth masses/2 Earth radius). Then, planets around M dwarfs seem to be good targets for habitability studies, but these stars have characteristics that may be harmful for life. Numerical models have been used to calculate the effects of tidal locking, XUV radiation and near UV radiation on the habitability potential of planets around M dwarfs. Two planetary systems may help to understand what happens to planets in the habitable zone of these type of stars. In my talk I will present the definitions of planetary habitability and the habitable zone and the characteristics of M dwarfs relevant for planetary habitability to follow with the characteristics of the exoplanets around Proxima and Trappist-1 and what we have learn about a habitability from these systems.

The afterlife: Exploring the possibility of hosting life in evolved planetary systems

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The end of the lifes of low and intermediate mass stars is slow (not explosive) and rich in complex chemistry. The planetary orbit relocation that the planetary systems experience can provide new renovated conditions for the development of life. On the other hand, the process of heavy mass-loss is rich in complex chemistry that could trigger new evolution. I will discuss all these processes and their timescales with the aim of establishing the prospects that these stars have of sustaining, destroying previously existing life or simply developing it from scratch.

Computer simulation of the UV irradiation of different spectral types of stars on potentially habitable planets: Its impact in prebiotic chemistry

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One of the most important topics about of origin of life studies, is the search for plausible routes of synthesis of biomolecules under prebiotic conditions. Numerous experiments have shown that amino acids, nucleotides, carbohydrates and other essential components in cells are formed under simulated conditions. These compounds are hydrocarbons, HCN, amino acids, aldehydes and ketones and others (Roy et al., 2007). Some conditions are necessary for the synthesis of those organic molecules of prebiotic importance. For instance, a source of energy (temperature, electrical discharges, ionizing radiation, etc) is a necessity to trigger the reactions for the synthesis of these compounds.
Stars that stay long enough in the main sequence to allow the origin and evolution of life in their planets, emit UV radiation, being young stars, F and active M dwarfs the ones that have more flux in this wavelength range. Assuming that the UV radiation reaches the surface of a potentially habitable planet orbiting this star, it might thus change the potential chemical reactivity and synthesis of some organic compounds. UV as a source of prebiotic chemistry has been simulated using lamps that do not reproduce the UV environment of early Earth (Ranjan and Sasselov, 2016) while no experiments to reproduce the planetary UV environment for planets around M dwarfs have been conducted (Rajan et al. 2017). The terrestrial atmosphere during the Archean period (3.8 Ga), and in general the atmospheres of terrestrial type planets are composed of CO_2.
Here, we explore the importance of UV light on the surface of the Earth to trigger reactions of prebiotic relevance, and consequently determine whether UV light as an energy source would be more or less efficient in planets around M dwarfs than in a planet around the Sun. Because the terrestrial atmosphere during the Archean period (3.8 Ga), and in general the atmospheres of terrestrial type planets are composed of CO_2 we use CO_2 rich atmospheres for our numerical simulations. The screening of the UV radiation is studied by means of the ATMOS photochemical model and the possible synthesis by using Hyperchem software. ATMOS is used to determine the amount of possible UV light in the surface of a potentially habitable planet with an atmosphere composed of CO_2, N_2 and H_2O around a young star, similar to the Sun and stars of the dwarf type M with different levels of chromospheric activity. Our preliminary results for molecular synthesis, indicate that under UV irradiation conditions both, HCN and HNC in the presence of water, form more feasibly towards diaminomaleonitrile (intermediate molecule in a possible route that leads to the synthesis of adenine). These results agree with other published results (Barks, et al 2010). Currently, we are working in computer simulations regarding the phosphate-rich apatite surfaces to concentrate the genetic code-related molecules to do an insight in their possible catalytic properties under the UV irradiation.

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The role of the host star: Astrophysical constraints on planetary habitability

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Planetary habitability is, to a large extent, driven and constrained by the astrophysical environment of the host star. This in particular includes the stellar high-energy radiation output, stellar winds and high-energy particles. But what is perhaps even more important is understanding the long-term evolution of the astrophysical environment, including the presence and fate of massive stars, the initial rotation period of the host star, and the timescales of of stellar spin-down and activity evolution. They are all fundamentally important for the development and evolution of atmospheres on planets. I will discuss a number of these dependencies and will also address open issues.

Impact rate and water delivery to the terrestrial planets from a dwindling asteroid belt

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Collisions of extraterrestrial bodies have played a key role in the origin and development of life on Earth as suppliers of volatile and organic material. On the other hand, collisions with massive bodies (say, 10-km size or larger) might have caused severe disruptions in the climate and triggered mass giannextinctions. It is very likely that the asteroid belt has been by far the main source of water-rich material, and that most of the ocean water has an asteroidal origin. The D/H ratio in carbonaceous meteorites (very likely of asteroidal origin) is in good match with the terrestrial value (Robert 2001). We have computed the loss rate of bodies from the asteroid belt by means of numerical integrations of the population of observed asteroids (near-Earth asteroids, Mars-crossers and Jupiter-crossers or approachers) that are in their way of leaving the asteroid belt. From these computations we derive the current impact rate of asteroids with Venus, the Earth and Mars. The frequency of collisions with the Earth is found to be of about one asteroid with diameter D > 1 km every 0.4 Myr, with a similar frequency for Venus, and about a half for Mars. For climate-disrupting massive bodies (D > 10 km) the frequency of collisions with the Earth is of about one every 130 Myr. We also find that the asteroid belt is losing a fraction of about 7×10^{-5} Myr^{-1} of its mass. The early asteroid belt might have been three orders of magnitude more massive than at present, but it quickly emptied as the most dynamically unstable bodies were scattered to planet-crossing orbits causing a heavy bombardment on the surfaces of the terrestrial planets but at the same time providing a outer veneer of water and organic material. It is possible that the so-called "Late Heavy Bombardment" at about 3.8 Gyr ago is an artifact (e.g. Zellner 2019), and that in fact it corresponds to a period of 600-700 Myr after the Earth formation when the asteroid belt lost most of its mass, a fraction of which ended colliding with the terrestrial planets and the Moon. Early Venus might have had an outer veneer of water and habitable conditions similar to the Earth, but its water was entirely lost as its climate evolved to a extremely hot one. These results will be discussed in this presentation.

Exploring the habitability of exoplanets with climate models

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The quest for inhabited worlds beyond the Solar System is focussed on rocky exoplanets, many of which will be soon detected by transit and radial-velocity surveys. Follow-up searches of atmospheric biomarkers with spectroscopic methods will require a preliminary selection of cases with optimal conditions of habitability. The main subject of this presentation concerns the assessment of the habitability of rocky exoplanets by means of climate models. Classic studies of the habitable zone (HZ) provide the limits of insolation that allow liquid water to exist on the surface of planets orbiting main-sequence stars. The edges of the classic HZ are calculated using 1D climate models that simulate the surface conditions at critical levels of atmospheric CO_2 and H_2O. Besides the insolation, stellar type and atmospheric composition considered in classic studies of the HZ, planetary habitability is influenced by many other factors, such as the presence of alternative greenhouse gases (e.g. CH_4, H_2) or variations of surface gravity, atmospheric pressure, rotation period, axis tilt, magnetic field and surface geography (e.g., ocean and desert worlds). Many of these factors are unconstrained by observations, but their effects on the exoplanet surface and atmosphere can be parametrized in climate models of intermediate complexity. By modeling the surface one can quantify the habitability from the predicted surface distribution of physical quantities that affect the presence of life, such as the temperature and ionizing radiation. Modeling the atmosphere is essential because the external, gaseous layers of exoplanets are the only regions that we can probe with observations. Ambient conditions that maximize the production and detectability of atmospheric biomarkers should be preferred in the choice of habitability criteria. Other topics that will be addressed in this presentation include the habitability of planets around binary stars and the effects of the luminosity evolution of the central star. Finally, some remarks will be given on the viability of biochemistries based on solvents alternative to water and the potential implications in terms of habitability.

<u>Session 6:</u> Historical, societal aspects and education in astrobiology

TALKS SESSION 6

Societal Aspects of Astrobiology and the Impact of Discovering Life Beyond Earth

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The discoveries of thousands of planets around stars, including some in habitable zones, plus the existence of ocean worlds in our own solar system, make more urgent the question of the impact on society if microbial or intelligent life is actually discovered beyond Earth. It is a subject whose time has come. In the United States and other countries a series of interdisciplinary meetings continue to be held on the issue, most recently at the SETI Institute and the Breakthrough Listen Project. A new Society for Social and Conceptual Issues in Astrobiology (SoCIA) has been founded and has sponsored their second meeting. NASA has established the Baruch S. Blumberg NASA/Library of Congress Chair in Astrobiology specifically to focus on the humanistic aspects of astrobiology. And the latest NASA Astrobiology Strategy document (2015) recognizes a societal interest in its endeavors. In Europe astrobiology and society is a foundational theme for the proposed European Astrobiology Institute (EAI), with a plan of action summarized in the publication Astrobiology and Society in Europe Today (Kapova and Persson, 2018). A worldwide research community continues to form composed of interdisciplinary scholars from the social sciences and humanities (Race et al, 2012).
In this presentation, I will summarize possible approaches to this problem, the need to think out of the box, and possible societal impacts, especially in the areas of theology, ethics, and worldviews. I argue that in examining societal impact, as well as astrobiology's underlying assumptions, not only the natural sciences but also the social sciences and humanities must become an integral part of astrobiology. Concepts such as astrocognition, astroethics, and astrotheology become immediately relevant when we find life, and indeed insights from these fields might be essential to finding extraterrestrial life at all. These ideas are elaborated in more detail in my book Astrobiology, Discovery, and Societal Impact (Dick, 2018).

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POSTERS SESSION 5

Dynamical evolution of two-planet systems and the WD atmospheric pollution

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We present preliminary results on the investigation of the dynamical evolution of two-planet systems, aimed at exploring if planet engulfment at very late stellar evolutionary stages can be invoked as the origin of the metallic pollution of WD atmospheres. The results so far indicate that only one such a case is obtained after 3650 simulated systems. Therefore, other plausible scenarios have to be analyzed in view of the 25% observed pollution prevalence. Among others, the evolution of systems with three or more planets and/or the effects of planetesimal rings such as the main asteroid and the Edgeworth-Kuiper of our solar system.

Stellar UV Excess in the Kepler Field

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The stars in the Kepler field have been observed from the infrared to ultraviolet, by surveys like 2MASS, SDSS and GALEX. This multi-wavelength observations enabled the calculation of stellar properties, allowing to put our solar system in an evolutionary context with respect to similar systems. Age is fundamental to establish the evolutionary state of a star; which in turn is correlated to stellar activity and rotation. Stellar activity encompasses phenomena that determine the space weather, eg. starspots, flares, faculae, etc., in the solar case has obvious relevance due to influence in the earth atmosphere; which also occurs in the case of extrasolar systems, studying both is required to comprehend each one.

To study the activity-rotation-age relation we have created a deep photometric catalog in the near ultraviolet in the Kepler field (GALEX CAUSE Kepler Catalog, GCK). Which is based in the co-adding of observations conducted over a period of 45 days, composed in average of ~17 visits. The catalog has ~660000 sources, from which 475000 has counterparts in the Kepler Input Catalog, ~140000 counterparts in the Kepler targets and 1117 counterparts of host stars with planets confirmed by the Kepler Mission. We have also have crossmatched the observations in visible and infrared surveys.

The difference between the observed (our catalog) and theoretical (photospheric) NUV emission provides an estimation of ultraviolet excess, which is an indicator of stellar activity. In order to measure the ultraviolet excess, we elaborate a library of synthetic photometry of NUV (and other auxiliary bands) for main sequence stars which stands for the photospheric contribution. We will present the GCK catalog and the first findings in the analysis of the activity-rotation-age relation.

POSTERS SESSION 6

Experiences on teaching Astrobiology in Baja California: from classical lectures to MOOCs

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Teaching Astrobiology at the undergraduate level in Mexico has represented a very interesting challenge for our workgroup for more than a decade. Our course, taught at the University of Baja California, has been a pioneer in the teaching of Astrobiology at that level. We present a review of initial motivation, contents of the course, statistics of students, as well as resources that have been implemented to cover all the topics. During the development of the courses, we detected that the practical teaching of the subjects through exercises and laboratory experiments qualitatively improved the school performance. Therefore, we decided to work on collecting and/or designing a set of exercises and experiments and compile a student's manual to improve learning in our course. We also have used some of these experiments in undergraduate summer schools, high-school summer workshops, and even in outreach activities. Finally, motivated by the work done by colleagues from overseas, as well as Mexican colleagues and students, who demand courses at their locations, we decided to give a try to the "flipped" modality for our course, making an Astrobiology MOOC (Massive Open Online Course) in Spanish. We have conceived this new project as a consequence of our previous work. The general structure of the MOOC, as well as a description of its aims and expectations, is presented.
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Astrobiology as a didactic strategy to develop compentences

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Astrobiology, as a discipline, seeks to scientifically understand the origin, evolution, distribution, and destiny of life in the Universe. To achieve these goals the coordinated efforts of specialists from different fields, geographic locations, and academic backgrounds are of prime importance. Since a decade ago or so, some Universities in different countries have proposed academic curricula to prepare young astrobiologists either by providing a specialized degree oriented to help in one of the major topics important to Astrobiology, or by preparing students eager to tackle any of the problems faced in Astrobiology, either academic or technological.
In Mexico, academics interested in Astrobiology, most of whom also carried out research into topics touching a variety of Astrobiology related fields, have been grouped in the Sociedad Mexicana de Astrobiología (SOMA, in Spanish), a non-profit, self-sustained organization, that for the past 18 years has been interested in popularizing Astrobiology among young students in order to motivate them to initiate a scientific career, among other activities. As part of these efforts, a course in Astrobiology has been included in the undergraduate programs of different Universities in Mexico (UNAM, UAEM, UANL, UABC). For the particular case of the University of the State of Morelos (UAEM), this course has adopted the format of a workshop providing the opportunity of not only discussing the central topics common to other astrobiology courses, but also of encouraging the construction of academic competences and skills needed by an astrobiology professional when he/she is integrated into the field, either in the academic, technological, or administrative area. The experience accumulated in almost a decade is going to be shared in order to contrast it with experiences in different contexts.

Friday 5th of April 2019

Session 7: Space exploration and observations from the ground of solar system objects of astrobiologial interest

TALKS SESSION 7

Status of the Large Millimeter Telescope "Alfonso Serrano"

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The Large Millimeter Telescope (LMT) is a bi-national collaboration between Mexico and the USA, led by the Instituto Nacional de Astrofisica, Optica y Electronica (INAOE) and the University of Massachusetts at Amherst (UMASS), to construct, commission and operate the largest millimeter-wave radio telescope, a 50m-diameter dish located on the summit (~4600m) of Volcan Sierra Negra, an extinct volcano in the Mexican state of Puebla. The LMT has been successfully operating since 2014, until 2017 with its inner 32m and currently with its full 50m aperture. Scientific results so far have shown that the telescope and its initial suite of instrumentation already conform a very competitive infrastructure for studying the formation of structures across the Universe and for testing the most fundamental laws in physics. In this talk I will provide a summary of the LMT status, including short descriptions of the instruments to be commissioned in the short term.

Observations of Comets with the Large Millimeter Telescope

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The study of comets using millimeter-wave observations provides a well established way to learn about the composition of the cometary nucleus as well as important physical processes at work in the cometary coma. In this paper I will describe the ways that the Large Millimeter Telescope (LMT) will be used to pursue cometary observations. New LMT results from the recent apparition of comet 46P/Wirtanen will be presented to illustrate the potential of the LMT to contribute to this field.

Status of World Space Observatory-UV

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The World Space Observatory--Ultraviolet (WSO--UV) is a space mission with 2-meter class telescope onboard fully devoted to UV observations in the spectral domain of 115—310 nm. The WSO-UV project is a multipurpose orbital observatory for high and low resolution spectroscopy, high sensitivity imaging and slitless spectroscopy in the ultraviolet. The imaging instrument FCU onboard WSO-UV will be the first UV camera to be flown to a geosynchronous orbit. The WUVS spectrographs will deliver spectroscopic performance on a range of astronomical sources, combining high sensitivity, low background and high resolution at FUV and NUV wavelengths. The observatory is planned to operate for at least five years and perhaps longer. WSO-UV will open new opportunities in planetary science, stellar astrophysics, extragalactic astronomy, cosmology and exoplanets.
Main participants of the observatory are Russia and Spain with potential participation of Japan and Mexico. Here we provide information on instrumentation update and the project status in 2019.

The Dragonfly Mission Proposal: Prebiotic Chemistry and a Search for Biosignatures on Saturn's Moon Titan

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The only moon with a thick atmosphere, Titan's carbon and water make it a a top target for exploring the origin of life and searching for extant life in the solar system. If life requires energy, water, and carbon, then sunlight could provide power at Titan. Titan's surface is made of water ice; and 100 km below the surface lies a liquid water ocean. Unlike other icy moons, methane in Titan's atmosphere provides a plentiful source of carbon. Photolysis of methane drives the production of complex hydrocarbons that amalgamate into atmospheric hazes, eventually building up on the surface. When these carbon molecules mix with liquid water, as they would in impact melt or cryovolcanic flows, the resulting conditions might resemble those before the formation on life on Earth. We formulated a Titan mission that we call Dragonfly to explore the prebiotic chemistry on the surface. Dragonfly is a lander with a surface sampling system and a gas chromatograph mass spectrometer to measure surface composition. We will sample both organic sediments and water ice. To get between them, we will fly -- the lander is a quadcopter that uses the thick atmosphere and low gravity at Titan to achieve mobility. I will describe the mission proposal presently under consideration by NASA's New Frontiers program. If selected, we would land on Titan in 2034 to measure how far prebiotic chemistry has progressed there.

POSTER SESSION 7

Exploring the Enceladus Molecular Environment with the LMT

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Based on the discoveries of the Cassini spacecraft, the Saturnine moon Enceladus has been identified as a prime target for life search and for astrobiology studies. The plumes of water vapor and ice grains discovered on Enceladus by the Cassini Mission, provide evidence that there is a liquid water reservoir beneath the Enceladus frozen surface. The material ejected into space from the warm fractures of the surface revealed an elaborated chemistry: in addition to water (95%), other molecules have been found including ammonia and methane, and noticeable quantities of salts in the ice grains. Cassini's results have placed Enceladus as the best candidate to find life as we know it, as this satellite meets the three most important requirements for life to develop: life related chemical species, liquid water and a source of energy. Cassini´s detections have been complemented by HERSCHEL space observations that confirmed the presence of water in the torus of neutral material along the Enceladus orbit, and from the ground with the discovery of large amounts of methanol by the 30m telescope IRAM at 1.2mm.
We plan to observe Enceladus with the Large Millimeter Telescope (LMT) and the available high resolution spectrometers; 1.3mm receiver, B4R and SEQUOIA to search for emission of molecular species that will complement the in situ measurements of Cassini and that of methanol. The richness of the millimeter wave band in molecular transitions and the large LMT collecting area with its 50m aperture ensures detection and a great potential of discovery.

Study of the Effect of Ionizing Radiation in the Decomposition and Detection of Organic Material in One Mars Analog Soil

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The martian environment is currently a desert with dunes and dust storms. However, the surface morphology and mineralogy of soil of planet suggests that in the past had a favorable environment for development and sustainment of life. The search for organic material is of great importance to identifying life in Mars. Unfortunately, we have not been able to find organic compounds that are part of present or past life. Such observations may be due to the interaction of these materials with ionizing and ultraviolet radiation impinging upon the martian surface. In this paper, the effect of ionizing radiation upon the decomposition of organic matter in soil analogous to Mars was assessed, such as that of the Mojave Desert, USA. The results show that the main decomposition compounds are carbon dioxide, carbon monoxide and hydrocarbons (saturated, unsaturated and aromatic). Irradiated soil was analyzed with the analytical Py-GC-MS technique. The results show that the rates of decomposition of organic material is -0.1411 MGy^{-1}, and therefore, it is believed that these materials could have been wiped from the martian surface more than 2.76 billion years ago, suggesting that the best approach would be to search in deep layers of the soil.

Comparative analysis of impacts of similar ICMEs on near-Mars environment during solar minimum and solar maximum

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We present preliminary results of our study in which we compare the impacts of two interplanetary coronal mass ejections (ICME) on near-Mars environment. The two ICMEs exhibit similar maximum B-field magnitude, velocities, densities and durations at 1AU. They were both followed by fast solar wind streams. The first ICME was observed by the ACE mission in November 2007, so during the most recent minimum of the solar activity. The second was detected by ACE in March 2012 when the Sun was near the maximum of its activity. During these periods, Earth and Mars were almost aligned meaning that ICMEs that hit Earth also hit Mars. Wile the ACE mission served as the solar wind monitor, we use Mars Express (MEX) data in order to study the processes in the near Mars environment. At times when the two ICMEs arrived to Mars, the MEX orbits were similar in the sense that they were practically in the terminator plane of Mars. The motivation behind this study is that during its maximum, the Sun emits more photoionising light than during its minimum. This means that during solar maximum the Martian ionosphere, which represents an obstacle that the SW cannot penetrate, is more ionized and therefore more rigid.

POSTER GENERAL SESSION

TolTEC: Unveiling the Hidden Universe

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TolTEC1 (P.I. G. Wilson) is a new millimeter-wavelength camera being built to take maximal advantage of the 50 meter Large Millimeter Telescope (LMT2). It will have 6,300 Lumped Element Kinetic Inductance Detectors (LEKIDs), spread across three different bands (1.1, 1.4, and 2.0 mm), and sensitive to a single linear polarization of the incoming light. Each TolTEC observation will therefore result in nine different images of the sky - one for each of the Stokes parameters I, Q, and U, for each of TolTEC's three spectral bands.

Recombination Lines and Molecular Gas around Young Massive Stars in W51A

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We investigate the nature of compact sources within the high-mass star forming region W51A. A search for new source detections of radio recombination lines $H77alpha$ and $H30alpha$ allows determination of the line-broadening components and electronic density, and along with the associated kinematics, reveals the presence of wind, infall, ionized disks, or jets. We also search, through molecular line tracers, for the presence, or lack thereof, of hot molecular gas associated with the sources to resolve whether they are Ultra/Hyper compact HII regions or candidate Colliding Wind Binaries. Finally, an observational comparison between the number of Hot Molecular Cores with or without free-free counterparts, and between free-free sources not associated with dense molecular gas yields a statistical estimate of hot core evolution into compact HII regions.

Near-Earth Object detection using synthetic tracking technique and the astrographs equipped with sCMOS cameras.

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Near-Earth Objects (NEOs) are intrinsically faint and move rapidly in the sky (even a few degrees per day), therefore its detection is challenging. We report on the progress of our implementation of a new observational technique to detect and subsequently characterize NEOs called synthetic tracking (ST). ST's main goal is to mitigate trailing loss caused by smearing object's image through field of view (FOV) during long exposures. The idea is to acquire a large number of short exposure frames, then shift and add them to simulate telescope tracking of the object. The powerfulness of this method depends on modern technologies like sCMOS detectors and wide FOV telescopes (astrographs). The sCMOS cameras are a new generation of CMOS technology called scientific CMOS. They are characterized by high-speed and low noise read-out. On the other hand, astrographs are capable of capturing a bigger piece of the sky during a single exposure and so allow covering a large area of the sky during one night. A new generation of high quality off the shelf astrographs is becoming available. In this context, we will present two telescopes of the Solaris global network owned by Nicolaus Copernicus Astronomical Center of Polish Academy of Sciences: (1) Solaris-3B, located at the Siding Spring Observatory, Australia is an 8inch f/2.8 ASA Astrosysteme H-series astrograph, equipped with sCMOS Andor Zyla 5.5 camera that provides 1.7◦ × 1.4◦ FOV and (2) Solaris-2, located at the South African Astronomical Observatory, South Africa a Ritchey-Chretien 0.5 m f/15 telescope, which soon will be equipped with a Kepler KL4040 FLI sCMOS camera and will offer 17′× 17′ FOV; and one telescope owned by the Research Foundation Baltic Institute of Technology: Panoptes-1AB that will be initially installed at the Pomeranian Science and Technology Park's area in Gdynia, Poland for R&D purposes, and later relocated to most likely Western Australia. Panoptes-1A is a unique catadioptric TEC300VT-7DEG 0.3 m f/1.44 astrograph that will be equipped with a Kepler KL4040 FLI sCMOS and offer an impressive 5◦ × 5◦ FOV.

Spatial structure of the Galactic ISM obtained with the analysis of prominent DIBs.

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Diffuse interstellar bands (DIBs) can trace different conditions of the interstellar medium along the line-of-sight between us and the observed star. We use spectra from the GALAH survey to measure profiles of around a dozen DIBs towards 100,000s stars - hot and cool alike. Our study includes mostly lines-of-sight in the thin (70%) and thick (20%) disks at distances up to 5 kpc. Combined with Gaia's excellent distances we can observe interstellar gas structures at a ~10 kpc scale by measuring correlations between nearby lines-of-sight.