Final program

18:00	**TUESDAY, July 16: Welcome Cocktail & Registration, salle des Voûtes**

NW2SD international conference, July 17th - 19th, Palais du Pharo, Marseille France

WEDNESDAY, JULY 17

08:00	**Registration, Hémicycle**	
08:45	**Opening Session Hémicycle** Dr. **Annette Calisti and** Prof. **Jean-Marc Layet** Introduction Talk : Prof. **Pierre Chiappetta**, vice-President of Aix-Marseille Université	
09:00	**Session 1, Hémicycle** **Chairs:** Profs. **Patrick Soukiassian and Jean-Luc Beuzit** Plenary Talk: Prof. **Gérard Mourou**, Nobel Laureate in Physics (2018), Ecole Polytechnique, Palaiseau, France “Passion Extreme Light”	
09:45	Invited Talk : Prof. **Hidemi Shigekawa** “Sub-cycle transient scanning tunneling spectroscopy and its applications”	
10:15	**A. Bétourné**: “High-Resolution Single-Shot Surface Shape and in-situ Measurements using Quadriwave Lateral Shearing Interferometry”	
10:35	**Coffee Break, Hémicycle**	
10:55	**Session 2 A Hémicycle** **Chairs:** Profs. **Christoph Gerber and Thierry Angot**	**Session 2 B Amphithéâtre Gastaut** **Chairs:** Profs. **Ewine van Dishoek and Auguste Le Van Suu**
	C. Liu: “Comprehensive Experimental Studies of Ultrathin Superconducting Films with a Self-Developed Multi-Functional Scanning Tunneling Microscope”	Invited Talk : Dr **Luc Blanchet** “Gravitational Waves: A New Astronomy”
11:25	**F. Flores**: “Inelastic tunneling excitation of transition metal atoms, the Hund rule and Kondo resonances”	Invited talk: Prof. **Jose Cernicharo** “From Molecules to Dust in Carbon Rich Astrophysical Environments”
11:55	**G. Le Lay**: “A Journey through Architecture, Black Holes, and NanoArchitectonics”	**S. Cristallo:** “From nano-scale to tera-scale: dust formation in AGB stars”
12:15	**Lunch Break, Hémicycle**	

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13:40	**Session 3, Hémicycle** **Chairs:** Profs. **Hidemi Shigekawa and Guy Le Lay** Plenary Talk : Prof. **Charles Kane**, Laureate of the 2019 Breakthrough Prize in Fundamental Physics, University of Pennsylvania, Philadelphia, USA “The Emergence of Topological Quantum Matter”	
14:25	Plenary Talk: Prof. **Ewine van Dishoeck**, Kavli Prize Laureate in Astrophysics (2018), Leiden Univ., The Netherlands “Building Stars, Planets and the Ingredients for Life in Space”	
15:10	**Posters session & Coffee Break, Salle des Voûtes**	
15:50	**Session 4 A, Hémicycle** **Chairs :** Profs. **Fernando Flores and Ulf Karlsson** Invited Talk: Prof. **Patrick Soukiassian** “Nano-Objects and Selective Nanochemistry at Advanced Materials”	**Session 4 B, Amphithéâtre Gastaut** **Chairs:** Profs **Ingrid Mann and Philippe Boduch** Invited Talk : Dr. **Jean-Luc Beuzit** “Direct Imaging of Extrasolar Planets”
16:20	**Y. Sassa**: “Kagome silicene: a novel exotic form of two-dimensional epitaxial silicon”	**C. Grisolia**: “Experimental determination of adhesion force of Lunar and Tokamak dust: a common approach”
16:40	**M.E. Davila**: “Novel 1D pentagonal silicon nanoforms”	**M. Minissale**: “The catalytic role of dust grains and gas-dust coupling processes in the Interstellar Medium”
17:00	**K. Wu**: “Tuning the atomic structure of 2D boron sheets”	**E.R. Micelotta**: “New results about the survival of PAHs under extreme astrophysical conditions”
17:20	**L.C. Lew Yan Voon**: “Why monolayer galliene and thalliene have not been synthesized: Ab initio DFT insights”	**A. Nanni**: “Constraining the optical properties of carbon dust around carbon-rich stars”
17:40	**A. Dimoulas**: “Topological type III Dirac nodes in 2D materials: a solid-state analogue of black hole event horizon”	**M. Mikikian**: “Nanoparticle formation and dynamics in laboratory hydrocarbon plasmas”

THURSDAY, JULY 18

08:30 **Registration, amphithéâtre Gastaut**

09:00 **Session 5, Amphithéâtre Gastaut**

Chairs: Profs **James Gimzewski and François Roman**

Plenary Talk : Prof. **Christoph Gerber**, Kavli Prize Laureate in Nanosciences (2016), Univ. of Basel, Switzerland

"From Nanobio to Precision Medicine Based on Nanomechanics"

09:45 Plenary Talk : Prof. **Francisco Mojica**, Albany Medical Center Prize (2017), pioneer of CRISPR (molecular biology), Univ. of Alicante, Spain

"CRISPR Systems: the Advent of a New Scenario in Biological Research"

10:30 **Posters session & Coffee Break, Salle des Voûtes**

11:00 **Session 6, Amphithéâtre Gastaut**

Chairs: Profs **Francisco Mojica and Andrew Wee**

Invited Talk : Prof**. James K Gimzewski**

"The Radical Atom: Mechanosynthetic 3D Printing for Atomically Precise Manufacture"

11:30 Invited Talk : Prof. **Yeukuang Hwu**

"Brain Mapping with X-ray"

12:00 **Lunch Break, Salle des Voûtes**

NW2SD international conference, July 17th - 19th, Palais du Pharo, Marseille France

13:30	**Session 7, Amphithéâtre Gastaut** **Chairs:** Profs **Charles Kane and Lok Lew Yan Voon** Plenary Talk : Prof. **Qi-Kun Xue**, Laureate of the 2016 Future Science Prize-Physical Science Prize in Fundamental Physics, Tsinghua University, China "Atomic-Level Control of High Temperature Superconductivity"
14:15	**Session 8, Amphithéâtre Gastaut** **Chairs:** Profs **Kehui Wu and Thanasis Dimoulas** Invited Talk : Prof. **Andrew Wee** "The Molecule-2D Interface"
14:45	**A. Verdini**: "Study of stability of Ruthenocene on Ag(111) and Cu(111)"
15:05	**M. Göthelid**: "Temperature dependent dehydrogenation of naphthalene on Ni(111)"
15:25	**S. Clair**: "Controlling a Chemical Coupling Reaction on a Surface: Tools and Strategies for On-Surface Synthesis"
15:45	**F. Schulz**: "High-resolution atomic force microscopy for analysis of complex molecular mixtures"
16:05	**T. Djenizian**: "From All-solid-state to flexible Li-ion microbatteries using self-organized titania nanotubes"
16:25	**Posters session & Coffee Break, Salle des Voûtes**
16:45	**Session 9, Amphithéâtre Gastaut** **Chairs:** Profs. **Maria E. Davila and Ying Jiang** Invited Talk : Prof. **Ingrid Mann** "Nanodust and nanoparticle interactions in ionospheric and solar wind plasma"
17:15	**J. A. Martin-Gago**: "Mimicking cosmic dust: The STARDUST machine and surface science"
19:30	**Gala Dinner, Palais du Pharo, salle Eugénie**

NW2SD international conference, July 17th - 19th, Palais du Pharo, Marseille France

FRIDAY, JULY 19

08:15 **Registration, amphithéâtre Gastaut**

08:30 **Session 10, Amphithéâtre Gastaut**
Chairs: Profs. **José Angel Martin Gago and Eric Salomon**
Invited Talk: Dr. **Antonio Tejeda**
"Graphene Growth on Different SiC Crystallographic Orientations: Consequences on Electronic Properties and Surface Reactivity"

09:00 **L. Vattuone**: "Graphene chemistry under UHV conditions"

09:20 Invited Talk: Dr. **Philippe Boduch**
"Swift Heavy Ions, Ices and Astrophysics"

09:50 Invited talk: Prof. **Ying Jiang**
"Peering into the nanostructured water/ice"

10:20 **L. L. S. d'Hendecourt**: "Cosmic Ices: from astrochemistry to astrobiology?"

10:40 **D. Hagebaum-Reignier: "**Polyoxymethylene formation in interstellar ice analogs: a combined experimental and quantum chemical study"

11:00 **Posters session & Coffee Break, Salle des Voûtes**

11:20 **Session 11, Amphithéâtre Gastaut**
Chairs: Dr **Hubertus Thomas and** Dr **Annette Calisti**
Plenary Talk : Prof. **Bernard Bigot**, Director-General, ITER Organization, Cadarache, France
"ITER Project: let the stars inspire us towards a sustainable world energy supply"

12:05 **Lunch Break, Salle des Voûtes**

13:30 **Session 12, Amphithéâtre Gastaut**
Chairs: Dr. **Christian Grisolia and** Prof. **Jean-Marc Layet**
Plenary Talk: Dr. **Hubertus Thomas**, Deutsches Zentrum für Luft- und Raumfahrt, Wessling, Germany
"Complex/Dusty Plasma Physics – from Laboratory to Space"

14:15 **C. Arnas**: "Origin of dust in tokamaks"

14:35 **L. Vignitchouk**: "Metallic dust-plasma interaction in fusion plasma environments"

14:55 **L. Tahri**: "Negative ions surface production in low pressure H_2/D_2 plasmas for nuclear fusion applications"

15:15 **A. Michau**: "Particle behavior in DC discharge: Influence of the Charging process"

15:35 **Concluding Remarks**

18:00 **Commemorative event for the first step of a Man on the Moon**
"De Sahelanthropus à Starman"

Three internationally renowned personalities will present their vision of the evolution of Mankind and his place in the universe.

Plenary Speakers :

Prof. **Henry de Lumley**, President of the Institut de Paléontologie Humaine, Fondation Scientifique Albert 1er Prince de Monaco, Paris,
"Les grandes étapes de l'évolution morphologique et culturelle de l'Homme. Emergence de l'Être Humain"

Prof. **Etienne Klein**, CEA Université Paris-Saclay et Ecole Centrale, Paris,
"Peut-on penser contre son cerveau?"

Prof. **Michel Mayor**, Wolf Prize Laureate (2017), discoverer of the first exoplanet at the OHP in 1995, Univ. de Genève, Suisse,
"Autres Mondes dans le Cosmos : Rêve de l'Antiquité - Réalité de l'Astrophysique d'Aujourd'hui"

Musics: Jazz Band du CNRS de Marseille

Origin of dust in tokamaks

C. Martin [1], C. Pardanaud [1], P. Roubin [1], S. Peillon [2], F. Gensdarmes [2], C. Arnas [1], G. De Temmerman [3], C. Grisolia [4]

[1]Aix-Marseille université, PIIM, France, [2]IRSN Saclay, France, [3]ITER Organization, France, [4]IRFM/CEA Cadarache, France

The accumulation of dust in a fusion device represents both a safety concern and a threat to plasma operation. The dust formation mechanisms depend on the materials used to face the plasma.

- For carbon materials, chemical and physical erosion lead to the formation of layers in remote areas of the tokamak which eventually delaminate. When the electron temperature is low enough (near the wall), eroded species can participate to specific collisions/reactions giving rise to ionic molecules up to the appearance of nanoparticles.
- For metallic materials (tungsten, molybdenum), the chemical erosion disappears and the physical erosion is reduced to a very low level. Off normal events give rise to dust of other categories. Arcing, runaway electrons, disruptions … produce local melting often followed by an emission of molten material droplets.

The different mechanisms of dust production will be discussed based also on dedicated studies performed with controlled parameters in laboratory plasmas experiments.

High-Resolution Single-Shot Surface Shape and *in-situ* Measurements using Quadriwave Lateral Shearing Interferometry

Sherazade Aknoun[1], Anaïs Saintoyant[1], Antoine Federici[1], Aurélie Bétourné[1], William Boucher[1] & Benoit Wattellier[1]

[1] *Phasics S.A., Espace tech. de Saint Aubin, Route de l'Orme des Merisiers, 91190 Saint Aubin, France*

In this paper, we present a high-sensitive single-arm interferometry technology, called quadriwave lateral shearing interferometry, applied to surface shape and *in-situ* refractive index variation measurements. This full-field technology enables single-shot measurements of the optical path difference (OPD) of samples over a large field of view with a phase resolution of 0.5nm. QWLSI provides accurate and sensitive roughness measurement of surfaces and can be well adapted to *in-situ* measurements since only one image is acquired to reconstruct the OPD map of the sample. Examples of surfaces imaging of metamaterials as well as characterization and measurement of induced refractive index variation will be presented.

References:

1) J. Primot, L. Sogno, "Achromatic three-wave (or more) lateral shearing interferometer", *J. Opt. Soc. Am. A*, *12*, 2679 (1995)

BACK

ITER Project: let the stars inspire us towards a sustainable world energy supply

Bernard Bigot
ITER organization, Cadarache, France

Hydrogen fusion is the most abundant energy source in the universe—it is the energy that powers the Sun and the stars. Reproducing fusion reactions in a man-made machine would provide mankind with a safe, virtually inexhaustible and environmentally benign energy option. This is what the international collaboration, ITER, is aiming at.
In 2007, seven partners representing 35 countries—China, the European Union, India, Japan, Korea, Russia, and the United States—have agreed to pool their human, scientific, technical and industrial resource to demonstrate that fusion power can generate massive quantities of energy for commercial use in the decades to come.
To create a largely self-heating plasma—producer of net energy—requires building an industrial-scale research facility.
The origin and current status of the ITER Project under construction in France and the challenges it is facing will be presented, along with the machines's key component, the Tokamak reactor: a large magnetic cage made of superconducting coils requiring the development of innovative conductors able to sustain a current intensity of over 70 000 Amp at a temperature of 4 K with very stringent geometrical specifications.

BACK

Gravitational Waves: A New Astronomy

Luc Blanchet [1]

[1] *Institut d'Astrophysique de Paris, CNRS et Sorbonne Université, France*

The gravitational wave detectors LIGO and Virgo have observed the signals generated by the orbital motion and the final merger of binary systems of massive black holes at large astronomical distances. This major discovery has opened up the way to the new astronomy of gravitational waves, radically different from and complementary to the traditional astronomy based essentially on electromagnetic waves. More recently the detection of gravitational waves emitted by the merger of two neutron stars has been followed by electromagnetic counterparts observed by g and X-ray satellites, and by optical telescopes on ground. In this talk we shall review the spectacular advances of gravitational astronomy, notably the "multi-messenger" aspect with joint observations of gravitational and electromagnetic waves. We shall also emphasize the crucial role played by theory in these detections, i.e. the problems of motion and gravitational wave emission in general relativity, and the new possibilities offered by gravitational waves for testing alternative theories of gravity.

BACK

Swift heavy ions, Ices and Astrophysics

Philippe Boduch[1], Hermann Rothard[1], Alicja Domaracka[1]

[1]*Centre de Recherche sur les Ions, les Matériaux et la Photonique, CEA/CNRS UMR6252/ENSICAEN/UNICAEN, CIMAP-CIRIL-Ganil, BP 5133, 14070 Caen Cedex 05, France.*

Ices are ubiquitous in space. They are mainly composed of simple molecules such as H2O, CO, CO2, NH3 ... They are present on comets, satellites of certain planets (Jovian moons for example) and on the grains the dense clouds in ISM. These ices can be irradiated in space by stellar winds or cosmic rays. Proton and UV irradiations have been the subject of numerous studies. With heavy ions, only a few studies have been carried out at low energy. It seemed therefore important to simulate in the laboratory the interactions between fast heavy ions and the ice present in space in order to understand the role of cosmic rays in the evolution of these ices. These ions deposit locally a very large amount of energy. They can then generate unobservable effects with lighter particles. In this framework, I will present the study of simple ice and mixtures at 15 K irradiated by heavy ions produced at GANIL facilities (Grand Accélérateur National d'Ions Lourds, Caen, France). The effects of irradiation are analyzed in situ by photon spectroscopy (infrared (FTIR) and UV-Visible domain). The results presented at this conference will deal with the effects induced on the structure of the ice, the chemical modifications and the role of the implantation. A particular attention will be focused on complex organic molecules (mainly nucleobases) irradiation.

BACK

From Molecules to Dust in Carbon Rich Astrophysical Environments

José Cernicharo[1,] José Angel Martín-Gago[2], and Christine Joblin[3]

[1] *CSIC, IFF, Spain;* [2] *CSIC, ICMM, Spain;* [3] *CNRS Toulouse, France*

We will present the chemistry of carbon in C-rich evolved stars. The characterization of the molecular content of the ejecta of these objects has been obtained through sensitive optical, infrared and millimeter and submillimeter wave spectroscopic observations using the largest telescopes at all wavelengths (see Figure 1). A view of the chemical content of these objects derived from these objects will be presented.

The data gathered from these astronomical observations are the basic input for novel laboratory experiments within the framework of the Nanocosmos synergy project of the ERC. In these experimental setups, in particular in the stardust machine, we simulate at the best the physical and chemical conditions prevailing in the photosphere of evolved stars. The first experiments that we are going to present in this conference are related to the formation of carbon clusters and hydrocarbons as a first step to the formation of dust grains.

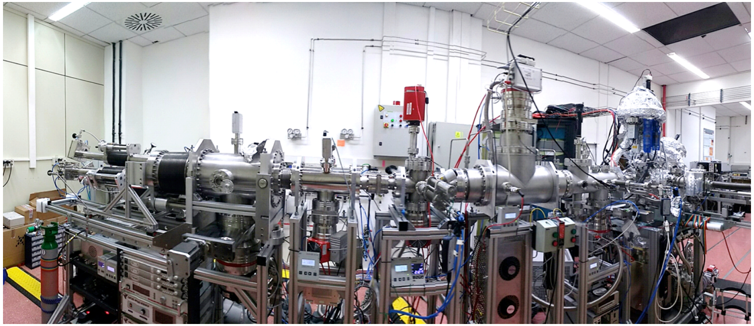


Figure 1: The stardust experimental Setup of the Nanocosmos project. Three different magnetrons are used to produce clouds to atoms that react between them, and with injected gases, to produce clusters and large molecules.. The goal is to simulate the chemistry of C-rich AGB stars.

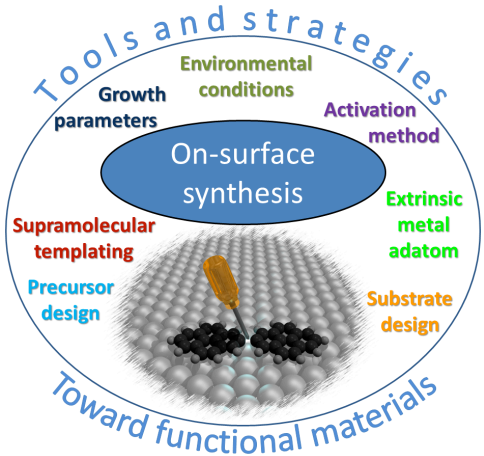
BACK

Controlling a Chemical Coupling Reaction on a Surface: Tools and Strategies for On-Surface Synthesis

Sylvain Clair [1]

[1] *Aix Marseille Univ, Univ Toulon, CNRS, IM2NP, Marseille, France*

The concepts of supramolecular chemistry have been successfully applied in the last decades to create well-organized structures on surfaces. More recently, a fundamental progress has been made with the demonstration that covalent linkages between organic molecules can be created directly on a metal surface, leading to the emergence of the field of *on-surface synthesis*. In some cases the reaction conditions can be properly tuned to steer the formation of the reaction products. It is thus possible to control the initiation step of the reaction and its degree of advancement, the nature of the reaction products, as well as the structure and the quality of the as-formed networks.[1) 2) 3)]



References:

1) Clair, S.; De Oteyza, D. G., *Chem. Rev.* 2019, **119**, 4717-4776.

2) Clair, S.; et al., *Chem. Commun*. 2014, **50**, 9627-9635.

3) Kalashnyk, N.; et al., *Nat. Commun*. 2017, **8**, 14735.

From nano-scale to tera-scale: dust formation in AGB stars

S. Cristallo[1,2], D. Gobrecht[3], L. Crivellari[4]

Affiliation [1]INAF – Osservatorio Astronomico d'Abruzzo, Italy, [2]INFN – Sezione di Perugia, Italy, [3]KU Leuven, Belgium, [4,2]Instituto de Astrofisica de Canarias, Spain

Low mass Asymptotic Giant Branch (AGB) stars are the most efficient dust producers in the Universe. Their circumstellar envelopes, extending for hundredths of solar radii, are recurrently crossed by strong shocks driving a rich molecular chemistry. The latter provides seeds for more complex dust structures, which drive the stellar mass-loss. The modelling of dust formation is a complex task, heavily connected with many branches of astrophysics and chemistry: stellar evolution[1)], radiative transfer[2)], kinetic non-equilibrium chemistry and density functional theory[3)]. I will describe the current status of our project on dust formation in AGB stars.

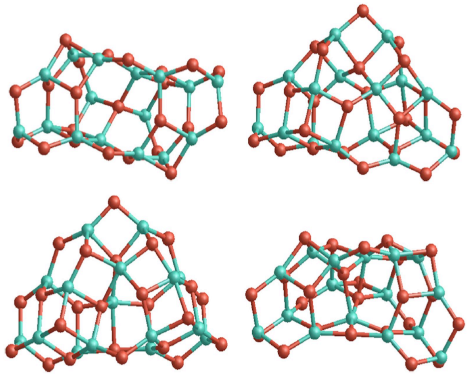


Figure: Low-lying isomers of $(Al_2O_3)_8$

References:

[1)] Cristallo S. et al., ApJS, 219, 21, (2015).

[2)] Crivellari. L. et al., ApJ, 429, 331, (1994).

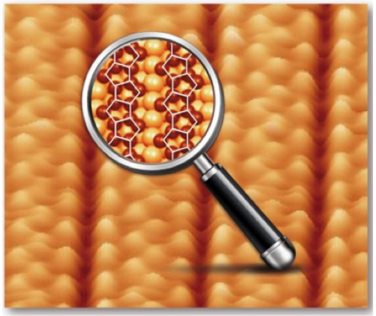
[2)] Gobrecht. D. et al., CPL, 711, 138, (2018).

Novel 1D pentagonal silicon nanoforms

J. I. Cerdá[1], J. Sławinska[1], G. Le Lay[2], A.C. Marele[3], J. M. Gómez-Rodríguez[3,4,5] and M. E. Dávila[1]

[1]Instituto de Ciencia de Materiales de Madrid, ICMM-CSIC, Cantoblanco, 28049, Madrid, Spain, [2]Aix Marseille Université, CNRS, PIIM UMR 7345, 13397, Marseille, France, [3]Departamento de Física de la Materia Condensada, Universidad Autónoma de Madrid, E-28049 Madrid, Spain, [4]Condensed Matter Physics Center (IFIMAC), Universidad Autónoma de Madrid, E-28049 Madrid, Spain, [5]Instituto Nicolás Cabrera, Universidad Autónoma de Madrid, E-28049 Madrid, Spain

Our group has revealed an unprecedented one-dimensional (1D) Si atomic arrangement solely comprising highly perfect alternating pentagons residing in the missing row troughs of the reconstructed surface Ag (110) [1]. It is the first pure pentagonal phase ever found for silicon low-dimensional structures, initially theoretically supported by DFT calculations compared to Scanning Tunneling Microscopy observations [1], further rapidly confirmed by Surface X-ray Diffraction measurements [2]. In fact, until now such a structure has only been obtained synthetically as one-dimensional nanoribbons (1D-NRs) grown on a silver (110) substrate. These NRs adopt a highly ordered chiral arrangement in single- and/or double-strands (SNRs and DNRs, respectively).



STM image of the 1D DNRs of silicon grown on a silver (110) substrate. The structure reveals that Si arrange as perfect alternating pentagons residing in the missing row troughs of the reconstructed surface Ag (110).

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We thus simultaneously demonstrate the existence of penta-silicene, a recently conjectured novel pentagonal silicon allotrope, which remained unveiled for more than one decade [3], and which materializes a paradigmatic shift from normal hexagonal silicene.

The discovery of 1D-Penta-silicene NRs increases the chances of the future isolation of this new low dimensional Si allotrope, provided these epitaxial NRs can be detached from the silver surface.

Acknowledgements:

This work has been funded by the Spanish MINECO under contract Nos. MAT2013-47878-C2-R, MAT2015-66888-C3-1R, CSD2010-00024, MAT2013-41636-P, AYA2012-39832-C02-01 and ESP2015-67842-P.

References:

1) J. I. Cerdá, Jagoda Sławinska, G.Le Lay, A.C. Marele, J. M. Gómez-Rodríguez and M. E. Dávila. "Unveiling the pentagonal nature of perfectly aligned single-and double-strand Si nano-ribbons on Ag(110) ", Nature Communications , 2016, 7:13076 | DOI: 10.1038/ncomms13076.

2) G. Prévot, C. Hogan, T. Leoni, R. Bernard, E. Moyen, and L. Masson. "Si Nanoribbons on Ag(110) Studied by Grazing-Incidence X-Ray Diffraction, Scanning Tunneling Microscopy, and Density-Functional Theory: Evidence of a Pentamer Chain Structure", Phys. Rev. Lett., 2016, 117, 276102.

3) C. Leandri, G. Le Lay, B. Aufray, C. Girardeaux, J. Avila, María E. Dávila, M.C. Asensio, C. Ottaviani and A. Cricenti. "Self-aligned silicon quantum wires on Ag(110)". Surf. Sci., 2005, 574, L9-L15.

BACK

Topological type III Dirac nodes in 2D materials: a solid state analogue of black hole event horizon

A. Dimoulas [1], S. Fragkos[1], P. Tsipas[1], C. Alvarez[2], R. Sant[2,3], H. Okuno[2], G. Renaud[2]
[1]NCSR DEMOKRITOS, Greece, [2] CEA-INAC, France, [3] Institute Neel CNRS, France

Topological Weyl and Dirac semimetals (DSM) show exotic particle physics and cosmology analogies. Type I and type II DSM with slightly tilted and overtilted Dirac cones, respectively, have been experimentally confirmed. Yet a new, **type III** DSM, emerges as a theoretical possibility exactly at the borders between type I and type II (see **Figure**). Research is motivated by the spectacular predictions[1)] that type III DSM could be the solid state analogue of the black hole event horizon. We will show [2)], by a combination of ARPES and DFT, that epitaxial thin films of $HfTe_2$ and $ZrTe_2$ are type I and type II DSM, respectively, so, $Hf_{1-x}Zr_xO_2$ can be tuned to be a type III Dirac semimetal.

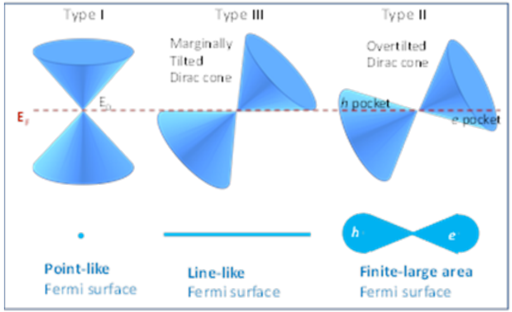

Figure: Type III DSM shows a unique line-like Fermi surface and a flat dispersion in one of the bands

References:

1) G. E Volovik, *JETP Letters* **104**, 645 (2016).
2) S Aminalragia-Giamini et al., *2D Mater*. **4**, 015001 (2017); P. Tsipas et al., *ACS Nano* **2**, 1696 (2018)

BACK

From All-solid-state to flexible Li-ion microbatteries using self-organized titania nanotubes

Thierry Djenizian
Department of Flexible Electronics, Ecole des Mines de Saint-Etienne, France,

Lithium-ion batteries (LIBs) are widely used to power portable devices, microelectronics, vehicles, etc. With many advantages such as high surface area and improved charge transport, self-supported 3-D nanostructured metal oxides such as titania nanotubes (TiO_2nts) are promising electrode materials for LIBs and their impact is particularly significant when considering the miniaturization of energy storage systems and the development of 3D microbatteries.

This talk will review the concept and fabrication of all-solid-state Li-ion microbatteries using TiO_2nts as negative electrode[1-3]. The fabrication of a full 3D microcell showing high electrochemical performance will be presented and the development of the next generation of 3D microbatteries will be discussed.

References:

[1-3)] B.L. Ellis, P. Knauth, T. Djenizian, *Adv. Mater.*, **26**, 3368 (2014); G. Salian, C. Lebouin, A. Demoulin, S. Maria, P. Knauth, M. Lepihin, A. Galeyeva, A. Kurbatov, and T. Djenizian, *J. Power Sources*, **340,** 242 (2017) ; G. Salian, B. M. Koo, C. Lefevre, T. Cottineau, C. Lebouin, A. T. Tesfaye, P. Knauth, V. Keller, T. Djenizian, *Adv. Mater. Technol.*, **3**, 1700274 (2018).

BACK

Inelastic tunneling excitation of transition metal atoms, the Hund rule and Kondo resonances

F. Flores[1] and E.C. Goldberg[2]

[1]Departamento de Física Teórica de la Materia Condensada. UAM. 28049-Madrid. Spain.[2] Instituto de Desarrollo Tecnológico para la Industria Química, and Departamento de Materiales. Facultad de Ingeniería Química. CONICET. UNL. Santa Fe. Argentina

An ionic Hamiltonian based on the first Hund rule applied to transition metal atoms will be reviewed and discussed in detail[1,2)]. The tunneling current between a STM-tip and a transition metal atom[3,4)] will be analyzed by means of that Hamiltonian combined with an effective crystal-field effect[3)]. We use an equation of motion (EOM) method to calculate that inelastic tunneling current as well as the Kondo resonance appearing at the Fermi level[4)] .

We present results for Co (with spin S=3/2) on a Cu2N(100)-surface[4,1)] and show how an accurate description of its Kondo resonance can be achieved by extending the EOM-calculation up to fourth-order in the atom/metal interaction that defines the parameter of expansion in the EOM-equations. These results allow us to calculate also the inelastic tunneling excitation of the atom and the dynamical fluctuations of the atomic spin from S=3/2 to S=2.

References

[1)] E.C. Goldberg and F. Flores, J of Physics: Condensed Matter 25, 225001, 2013

[2)] E.C. Goldberg and F. Flores, Phys. Rev. B **96**, 115439, 2017; Phys. Rev. B **77**, 125121, 2008.

[3)] C. F. Hirjibehedin et al, Science 317, 1199, 2007

[4)] A. F. Otte et al, Phys. Rev. Lett. 103, 107203, 2009

BACK

Mimicking cosmic dust: The STARDUST machine and surface science

Lidia Martínez[1], Gonzalo Santoro[1], Pablo Merino[1], Mario Accolla[1], Guillermo Tajuelo[1], Christine Joblin[2], José Cernicharo[1] and José A. Martín-Gago[1]

[1]*ICMM, CSIC , Spain;* [2]*IFF, CSIC , Spain;* [3]*IRAP, CNRS, France*

Evolved stars are a factory of chemical complexity, gas and dust, which contribute to the building blocks of planets and life. However, the dust formation process remains poorly understood Different laboratory techniques are used to produce analogs of cosmic dust being based the majority of them on uncontrolled combustion or plasma decomposition of molecular precursors in conditions far removed from those in star photospheres.

We have designed and built an unprecedented ultra-high vacuum machine combining gas aggregation sources with in-situ advanced surface science characterization techniques (as STM, XPS or IRAS) and mass spectroscopy. Differently to most of the previously reported experiments we show that the collected dust consists of amorphous C nanograins together with small C-clusters, which can exhibit a low degree of hydrogenation. We show efficient formation of aliphatic species and ineffective of aromatic species.

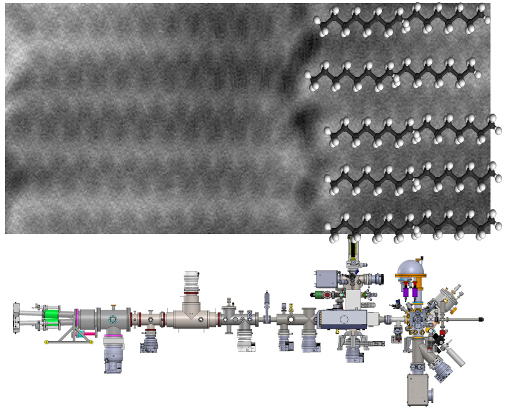

Figure: Alkanes seen by STM formed in the Stardust machine

References: 1 L. Martínez, *et al*., Sci. Rep. 8 (2018) 7250 / 2 Merino et al. Nat comm. 5, 3054 (2014)

BACK

From Bio to Precision Medicine based on Nanomechanics

Christoph Gerber

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The emergence of Atomic Force Microscopy more than 30 years ago in the then fledgling field of nanotechnology led to a shift of paradigm in the understanding and perception of matter at its most fundamental level. It undoubtedly has opened new avenues in physics, chemistry, biology and medicine and still is inspiring researchers around the world . The high flexibility of AFM to image, probe and manipulate materials with unprecedented resolution and to be combined with other technologies made it the most powerful and versatile toolkit in nanoscience and – technology of today. As a consequence, new revolutionary concepts stimulated a number of new technologies. Applications in biology and precision medicine will be discussed.

BACK

The Radical Atom: Mechanosynthetic 3D Printing for Atomically Precise Manufacture

James K Gimzewski

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Achieving the long-term objective of scalable Atomically Precise Manufacturing (APM) is one which has civilization altering consequences. To place individual atoms into a specified location is a seminal aspiration of researchers and engineers in the many fields which have arisen from Feynman's vision of 'nanotechnology'. Applying mechanochemistry modification is conceptually straightforward: One prototype approach builds the reactive molecule by photolytically generating radicals[1]. We discuss this process which is a pathway to 3d-printing at the ultimate limits of fabrication in an atom-by-atom manner.

References

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BACK

Temperature dependent dehydrogenation of naphthalene on Ni(111)

Mats Göthelid [1], K. Marks[2], M.G. Yazdi[1], W. Piskorz[3], T. Hansson[2], A. Kotarba[3], D.J. Harding[4], H. Öström[2], K. Engvall[4]

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Biomass gasification for production of renewable energy is one very promising route to a fossil free society. Presence of heavier hydrocarbons prevent the full utilization of the gas product. We present a multi-experimental and theoretical study of the temperature dependent dehydrogenation of naphthalene on Ni(111), using SFG, STM, TPD and DFT. Naphthalene chemisorbs in the di-bridge-7 geometry. Upon heating to 360 K the molecule tilts and replaces two C-H bonds by C-Ni and forms H_2. Increasing the temperature leads to further dehydrogenation and production of H_2 gas as well as the formation of surface carbon that deactivates the catalyst. We present a full energy diagram for the reaction leading to H_2 and graphene [1, 2].

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BACK

Experimental determination of adhesion force of Lunar and Tokamak dust: a common approach

Pauline Oudayer[1], Samuel Peillon[2], Christian Grisolia[3], Jean-Charles Matéo-Vélez[1], and François Gensdarmes[2]
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Hydrogen fusion is the most abundant energy source in the universe—it is the energy that powers the Sun and the stars. Reproducing fusion reactions in a man-made machine would provide mankind with a safe, virtually inexhaustible and environmentally benign energy option. This is what the international collaboration, ITER, is aiming at.

In 2007, seven partners representing 35 countries—China, the European Union, India, Japan, Korea, Russia, and the United States—have agreed to pool their human, scientific, technical and industrial resource to demonstrate that fusion power can generate massive quantities of energy for commercial use in the decades to come.

To create a largely self-heating plasma—producer of net energy—requires building an industrial-scale research facility.

The origin and current status of the ITER Project under construction in France and the challenges it is facing will be presented, along with the machines's key component, the Tokamak reactor: a large magnetic cage made of superconducting coils requiring the development of innovative conductors able to sustain a current intensity of over 70 000 Amp at a temperature of 4 K with very stringent geometrical specifications.

BACK

Polyoxymethylene formation in interstellar ice analogs: a combined experimental and quantum chemical study

T. Butscher[1], F. Duvernay[1*], G. Danger[1], R. Torro[2], G. Lucas[2], Y. Carissan[2], D. Hagebaum-Reignier[2] and T. Chiavassa[1]

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From new laboratory experiments and quantum chemical calculations on the low-temperature formation of Complex Organic Molecules, we elaborate a formation pathway for radical-assisted formaldehyde polymerisation leading to the formation of polyoxymethylene (POM)[1)]. We show the ability of free radicals ($HCO^\bullet$, $^\bullet CH_2OH$) to react at low temperature, and highly accurate quantum calculations predict a lower reaction barrier with the $^\bullet CH_2OH$ radical for the polymerisation initiation step. This formation mechanism is likely to occur in interstellar or cometary environments. Fragmentation patterns of the short chain-length POM observed with mass spectrometry are consistent with data collected by the Ptolemy instrument of the Rosetta mission[2)].

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[1)] T. Butscher, F. Duvernay, G. Danger, R. Torro, G. Lucas, Y. Carissan, D. Hagebaum-Reignier, and T. Chiavassa, Mon. Not. R. Astron. Soc. **486**, 1953 (2019).

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Brain Mapping with X-rays

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The new capability of high spatial and temporal resolution by the integration of micro- and nano-tomography is best for neurobiology. The complexity of the complete neural networks is beyond the current technology to describe, analyze and understand. Comprehensive mapping of neural networks in the brain is therefore a formidable but very exciting challenge. One of the essential step towards understanding brain functions is to construct a basic circuit map – a connectome – showing the neural network at the level of single neurons and connections. Could x-ray techniques be the tool of choice to challenge the animal brain connectome mapping? Is the overall performance adequate, however? Our positive results show that there are two additional directions need to be further improved: an even better spatial resolution and higher probe depth, both are relevant to the high brightness synchrotron radiation and new nanofabrication facilities. As one of the six "high priority challenges" in the US BRAIN Initiative: "Maps at multiple scales: Generate circuit diagrams that vary in resolution from synapses to the whole brain", we believe x-ray imaging will transform this vision into reality with these improvements. We present an effective strategy based on recent advances in synchrotron x-ray tomography. The approach reaches three critical objectives: (1) three-dimensional (3D) imaging with high and isotropic spatial resolution; (2) fast image taking and processing, as required for comprehensive whole-brain mapping within a reasonable time, and (3) multi-scale resolution, to zoom into specific regions of interest. We tested the strategy by mapping large populations of metal-labeled neurons and their connections in two animal models, Drosophila and mouse. Its speed notably allowed full 3D mapping of the Drosophila brain in a few days. Further improvements are underway, increasing the speed and opening the door to comprehensive sub-cellular mapping of large animal brains.

BACK

Peering into the nanostructured water/ice

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Nanostructured water/ice is ubiquitous in nature and plays an essential role in a broad spectrum of physics, chemistry, biology, energy and material sciences. However, our molecular-level understanding is still far from complete due to the lack of high-resolution experimental methods. In this talk, I will present our recent progress on the development of new-generation scanning probe microscopy/spectroscopy (SPM/S) with the ultrahigh sensitivity to H atoms[1,2], and its application to nanostructured water/ice at surfaces, ranging from water clusters, ion hydrates to two-dimensional ice layers. Some important issues, including H-bonding topology[3], proton dynamics[4], nuclear quantum effects (NQEs)[5], and ion transport[6] will be addressed.

References:

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6) Nature 557, 701 (2018).

BACK

Symmetry, Topology and Electronic Phases of Matter

Charles L. Kane

Department of Physics and Astronomy, University of Pennsylvania, USA

Symmetry and topology are two of the conceptual pillars that underlie our understanding of matter. While both ideas are old, over the past several years a new appreciation of their interplay has led to dramatic progress in our understanding of topological electronic phases. A paradigm that has emerged is that insulating electronic states with an energy gap fall into distinct topological classes. Interfaces between different topological phases exhibit gapless conducting states that are protected and are impossible to get rid of. In this talk we will discuss the application of this idea to the quantum Hall effect, topological insulators, topological semimetals and topological superconductors. The latter case has led to the quest for observing Majorana fermions in condensed matter, which opens the door to proposals for topological quantum computation. We will close by surveying the frontier of topological phases in the presence of strong interactions.

A Journey through Architecture, the Black Forest, and NanoArchitectonics

Guy Le Lay

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The Atomium, designed from the bcc unit cell of iron, was built for Expo 58 in Brussels. Later, the geodesic dome built for Expo 67 in Montreal by architect Buckminster Füller, was the inspiration for the C60 molecule. A Black Forest of carbon nanotubes makes Vantablack, the world's darkest material blacker than black, the favorite paint of British artist Anish Kapoor, who designed the Black Holes of Art. The "Water Cube" built for the 2008 Beijing Olympics, was designed based on the Weaire-Phelan solution to the Kelvin Problem, a way of partitioning space using a foam of equal-volume cells with minimum contact surface areas.

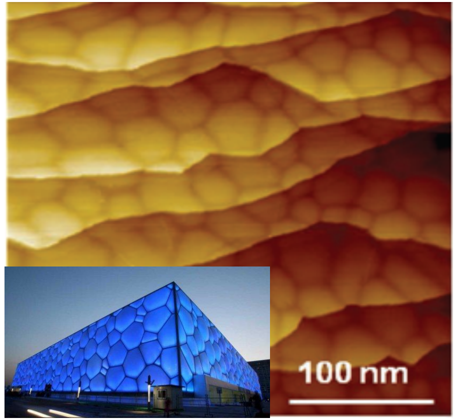

Figure: Plumbene on a "Nano WaterCube"

In this talk, I will stroll among such architectures from Montreal to Nagoya, where graphene's latest cousin was recently discovered, overlaying a "Nano WaterCube"[1].

References:

1) J. Yuhara, B. He, N. Matsunami, M. Nakatake, and G. Le Lay, Adv. Mater. 2019, 1901017.

BACK

Cosmic Ices: from astrochemistry to astrobiology?

Louis L. S. d'Hendecourt [1], Grégoire Danger[2], Robert Pascal[1]
Team ASTRO, PIIM, CNRS[1], AMU[2], Marseille, France

"Dirty" ices are observed in collapsing molecular clouds out of which stars and planetary systems form. Debris from the formation of planets such as small bodies in the Solar System may constitute the original supply of organic materials that has been imported on the primitive Earth[1]. This hypothesis, called the *exogeneous delivery of organic matter*, is currently discussed in the astrochemical community. It is the subject of many experimental studies that involve the photo- and thermo- chemistry of ices. In this process, currently at work in our laboratory at PIIM, we decipher the organic content generated in the form of organic residues present after the ice sublimation, at room temperature. Many diverse and complex molecules have been identified.. Although these molecular "bricks of life" are interesting by themselves, their purpose must be included in a tentative scenario leading to consider them as valid candidates for prebiotic chemistry. We are thus building-up a new experiment that will allow us to study the evolution of this organic matter following a far from equilibrium chemistry path toward self-organized molecular systems, a requirement for minimal life. This scenario will pre presented in this talk.

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BACK

Comprehensive Experimental Studies of Ultrathin Superconducting Films with a Self-Developed Multi-Functional Scanning Tunneling Microscope

Canhua Liu

School of Physics and Astronomy, Shanghai Jiao Tong University, China

Recently, researchers have made efforts to search for new superconducting materials in various ultrathin films, aiming at novel physical phenomena including 2D superconductivity, topological superconductivity, and interface enhanced superconductivity. To define a superconductor, one needs to observe its zero resistance and Meissner effect. For an ultrathin superconducting film with a thickness of only one- or two-atomic layer, however, the experimental techniques are not easily available since the film may be extremely vulnerable to air and thus requires *in situ* measurements. Alternatively, researchers usually search for superconductors firstly by using scanning tunneling microscope (STM) to measure superconducting energy gaps. Recently, we developed a multi-functional STM (STM+) that enables not only general STM measurement but also *in situ* four-point electrical transport and two-coil mutual inductance measurements. With the STM+, we can thus make comprehensive investigations of superconductivity in an ultrathin film by observing not only its superconducting energy gap but also its zero resistance and Meissner effect. Such studies of superconductivity in an indium and a FeSe ultrathin film will be exemplified in the talk.

BACK

Why monolayer galliene and thalliene have not been synthesized: *Ab initio* DFT insights

L. C. Lew Yan Voon [1], C. N. M. Ouma [2], L. Rhyman[3,4], P. Ramasami[3,4]

[1]*University of West Georgia, USA,* [2]*North-West University, South Africa,* [3]*University of Mauritius, Mauritius,* [4]*University of Johannesburg, South Africa*

The shift in dimensionality from three-dimensional (3D) to two-dimensional (2D) has resulted from 2D materials (systems) exhibiting novel structural and electronic properties that are superior to their 3D counterparts. With the discovery of graphene (Gr), focus has shifted towards the search for systems that are not only structurally analogous to Gr but also with superior properties to graphene. This is because the applicability domain of Gr is limited by its lack of a finite gap desired for nanoelectronic applications. In this study, with the use of density functional theory calculations, we systematically investigate the energetics, structural and electronic properties of buckled, planar and puckered allotropes of 2D Ga (galliene) and Tl (thalliene). The calculated formation and cleavage energies were in range of other 2D analogues already realized experimentally hence the possibility of exfoliating monolayer galliene and thalliene. However, all the investigated allotropes of galliene and thalliene were found not to be dynamically stable and this may account for these 2D structures not yet synthesized.

BACK

Nanodust and nanoparticle interactions in ionospheric and solar wind plasma

Ingrid Mann

Department of Physics and Technology, UiT in Tromsø, the Arctic University of Norway

Nanodust and nanoparticles form in the solar system by fragmentation of larger objects, by condensation and by coagulation. Nanodust exists e.g. in the Earth ionosphere in the meteor ablation zone. It also forms as impact ejecta particles at the surface of atmosphere-less solar system objects and it forms by the mutual collisions of larger dust in the solar wind. Key issues for understanding the interactions of the nanodust are the charging rates and light scattering properties. The nanodust influences the charge balance in the ionosphere which in many cases can be considered a dusty plasma where the dust participates and gives rise to plasma collective effects. This is observed in the Earth's ionosphere and also in the ionospheres of other solar system objects. The solar wind in contrast, is a medium where dust densities are small in comparison to the number densities of the ambient high temperature plasma. Charged nano dust trajectories are governed by electromagnetic forces as can be seen in the vicinity of atmosphere-less solar system objects. This can also be seen in the vicinity of the Sun where charged dust is strongly influenced by the Lorentz force and picked up by the solar wind.

This work is funded by Research Council of Norway, NFR 275503.

New results about the survival of PAHs under extreme astrophysical conditions

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Polycyclic Aromatic Hydrocarbons (PAHs) have been proposed as possible carriers of the dominant astronomical emission features observed in the mid-infrared. In the interstellar medium, PAHs are processed by energetic ions and electrons accelerated in shocked plasmas typically produced by supernova explosions. It is therefore important to quantify the capability of PAHs to survive under these extreme conditions and to determine the structural modifications induced by such energetic collisions. I will summarise the first studies on this topic[1,2)] which have shown that PAHs are surprisingly fragile when facing ions and electrons bombardment under interstellar conditions. I will then present a re-evaluation of the lifetime of PAHs in shocks[3)], based on newly determined values of the dissociation parameters[4)], highlighting the mutual gain resulting from the synergy between astrophysicists and atomic, molecular and plasma physicists.

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BACK

Particle behavior in Dc discharge : Influence of the Charging process

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In this presentation, we analyze the particles behavior in plasmas using detailed aerosol modeling in DC discharge combined with theoretical models for charge and thermal fluctuations. We showed that taking into account the discrete nature of the charge distribution is of prime importance to estimate the fraction of non-negatively charged particles. This results in the appearance of several particle generations, i.e. modes, and lower density and slightly larger diameter of the core distribution.

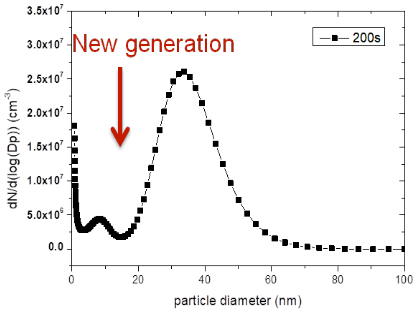

Figure: Multi-mode particle size distribution obtained in DC discharge

BACK

Nanoparticle formation and dynamics in laboratory hydrocarbon plasmas

M. Mikikian[1], E. von Wahl[1,2], T. Lecas[1], S. Labidi[1], T. Gibert[1], H. Kersten[2], I. Géraud-Grenier[3], V. Massereau-Guilbaud[3]

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Nanoparticles can easily be grown in typical low-pressure laboratory plasmas containing hydrocarbon precursors coming from injected gases or sputtered films. In this presentation, the formation and dynamics of dense nanoparticle clouds are studied, in particular the interaction between the charged nanoparticles and the plasma that leads to complex nanoparticle cloud structures and to low frequency instabilities[1)].

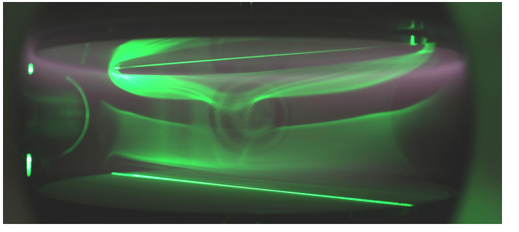

Figure: Nanoparticle cloud trapped in a low-pressure plasma

References:

[1)] M. Mikikian, S. Labidi, E. von Wahl, J.-F. Lagrange, T. Lecas, V. Massereau-Guilbaud, I. Géraud-Grenier, E. Kovacevic, J. Berndt, H. Kersten, T. Gibert, Plasma Phys. Control. Fusion **59**, 014034 (2017)

This work was partly supported by the French National Research Agency (ANR) through the MONA project (ANR-18-CE30-0016)

BACK

The catalytic role of dust grains and gas-dust coupling processes in the Interstellar Medium

Marco Minissale[1], Emanuele Congiu[2], Thanh Nguyen[2], Stephanie Cazaux[3], François Dulieu[2]

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It is well recognized that dust grains, due to their catalytic role, strongly influence the chemical composition of molecular clouds in the interstellar medium. Astronomical observations prove that many molecular species formed on interstellar grains populate the gas phase. Nevertheless, the mechanisms of gas-dust coupling still remains obscure and unclear. The focus of this talk is the experimental investigation of two key processes to better understand gas-dust coupling: thermal and chemical desorption. We present experimental results used to derive desorption and diffusion barriers of highly chemically reactive species, i.e., N and O atoms, on amorphous solid water ice and oxidized graphite. We also discuss the role of chemical desorption, which links the solid and gas phases without the intervention of external agents such as photons, electrons, or other energetic particles. This process allows the prompt return of molecules, formed on dust surfaces, into the gas phase.

BACK

CRISPR systems: the advent of a new scenario in biological research

Francisco J. M. Mojica, Jesús García-Martínez, Noemí M. Guzmán, Raúl Ruiz, Belén Esquerrà-Ruvira
University of Alicante, Spain

The great advancements in scientific knowledge usually come hand in hand with technological developments that facilitate experimentation and allow researchers to tackle previously unattainable challenges. A recent example of this alliance is the CRISPR technology, a laboratory toolkit that has revolutionized biotechnology, agriculture and medicine during the present decade, generating enormous expectations to solve major societal, economic and health issues. This biological revolution has its origin in the CRISPR adaptive immune systems, utilized by bacteria for billions of years to cope with alien genetic invaders that compromise their fitness and put their life at risk. The manipulation of native CRISPR systems in the natural hosts has resulted in remarkable uses within microbiology, such as vaccination of bacteria against viruses, storage of information in living cells or specific killing of pathogens. Likewise, CRISPR components can be engineered to function in almost any organism, ranging from fungi to humans, where they are being repurposed to achieve precise genome modification, fine-tuned control of gene expression or temporal recording of cellular events. Furthermore, with CRISPR technology user-friendly diagnostics tools endowed with extraordinary sensitivity have been implemented and, more recently, cells have been turned into biological computers. A new era in molecular biology has just begun, where the kind of experiments that can be performed appears to be only limited by the imagination of the researcher.

BACK

Passion extreme light

Gérard Mourou
Ecole Polytechnique, Palaiseau, France

Extreme-light laser is a universal source providing a vast range of high energy radiations and particles along with the highest field, highest pressure, temperature and acceleration. It offers the possibility to shed light on some of the remaining unanswered questions in fundamental physics like the genesis of cosmic rays with energies in excess of 1020 eV or the loss of information in black-holes. Using wake-field acceleration some of these fundamental questions could be studied in the laboratory. In addition extreme-light makes possible the study of the structure of vacuum and particle production in "empty" space which is one of the field’s ultimate goal, reaching into the fundamental QED and possibly QCD regimes.
Looking beyond today’s intensity horizon, we will introduce a new concept that could make possible the generation of attosecond-zeptosecond high energy coherent pulse, de facto in x-ray domain, opening at the Schwinger level, the zettawatt, and PeV regime; the next chapter of laser-matter interaction.

BACK

Constraining the optical properties of carbon dust around carbon-rich stars

Ambra Nanni[1]

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In galaxies characterized by metallicities lower than solar, a large fraction of the thermally pulsing asymptotic giant branch (TP-AGB) stars evolves through a C-rich phase (C-stars). Studying the C-stars in the Magellanic Clouds (MCs) allows us to understand the properties of the carbon dust formed around these evolved stars.

To achieve this goal, I apply a model of dust growth and wind dynamics to the circumstellar envelope of C-stars evolving along the TP-AGB, for which the theoretical spectra and photometry are computed. The theoretical photometry is calculated for different combinations of grain sizes and optical constants available in the literature, and compared with the observed one. Only 2 combinations out of ~50 initially considered are able to simultaneously reproduce the infrared and *Gaia* DR2 photometry of the C-stars[1),2)]. Observations are best reproduced by dust grains with sizes between 0.04 - 0.1 μm, rather than by large ones (>0.2 μm) for all the optical data sets. The deviation between the theoretical and observed photometry tends to increase for larger grains.

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BACK

Metallic dust- plasma interaction in fusion plasma environments

S. Ratynskaia[1], L. Vignitchouk[1], P. Tolias[1]

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Dust poses a safety problem for future fusion devices such as ITER, since during the nuclear phases of operation it will be tritiated, chemically reactive and toxic. Prediction of dust transport and life time in fusion devices involves solving coupled charging and heating equations along with an equation of motion[1,2)] and a contact mechanics model describing dust-vessel collisions[3)]. Here we focus on how such a problem is addressed in the context of metal droplet survival and droplet conversion to solid dust in ITER disruption scenarios[4)]. Particular attention is paid to the multitude of surface processes relevant for W and Be exposed to high energy electrons and highly charged impurity ions as well as microphysics of plasma particle absorption contributing to the heat budget[4,5)].

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BACK

Kagome silicene: a novel exotic form of two-dimensional epitaxial silicon

Y. Sassa[1], F.O.L. Johansson[1], A. Lindblad[1], M.G. Yazdi[2], K. Simonov[1], J. Weissenrieder[2], M. Muntwiler[3], F. Iyikanat[4], H. Sahin[5], T. Angot[6], E. Salomon[6], and G. Le Lay[6]

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Since the discovery of graphene, intensive efforts have been made in search of novel 2D materials. Decreasing the materials dimensionality to their ultimate thinness is a promising route to unveil new physical phenomena, and potentially improve the performance of devices. Among recent 2D materials, analogs of graphene, the group IV elements have attracted much attention for their unexpected and tunable physical properties. Depending on the growth conditions and substrates, several structures of silicene, germanene, and stanene can be formed. Here, we report the synthesis of a Kagome lattice of silicene on AL (111) substrate. We provide evidence of such 2D Si allotrope through STM observations, high-resolution core-level and ARPES measurements, along with DFT calculations. The formation of a Kagome silicene opens up the possibility of realizing high temperature quantum Hall states, which is of broad relevance for the investigation of modern quantum materials and the fabrication of cheaper devices.

BACK

High-resolution atomic force microscopy for analysis of complex molecular mixtures

Fabian Schulz [1], Julien Maillard[2,3], Katharina Kaiser[1], Shadi Fatayer[1], Isabelle Schmitz-Afonso[2], Thomas Gautier[3], Carlos Afonso[2], Nathalie Carrasco[3], Leo Gross[1]

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High-resolution atomic force microscopy (AFM) allows the chemical structure of single molecules to be imaged in real space.[1)] In recent years, this technique has been increasingly employed to analyze complex molecular mixtures of various natural origins, e.g., asphaltenes, marine dissolved organic carbon and soot molecules.[2-4)] Here, we use AFM to shed light onto the chemical structure of tholins, which are analogues of the aerosols present in the atmosphere of Saturn's moon Titan and can be produced on earth.[5)]

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Sub-cycle transient scanning tunneling spectroscopy and its applications

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For further advances in nanoscale science and technology, the development of a method for exploring the transient dynamics of local quantum functions in organized small structures is essential. Since the invention of scanning tunneling microscopy (STM), the addition of high time-resolution to STM has been one of the most challenging issues[1]. Recently, new laser technologies have become applicable, where the carrier-envelope phase (CEP) is the same and locked in the subsequent monocycle pulses. Furthermore, the CEP can be controlled. On the basis of such CEP technologies, a new microscopy technique, THz-STM, has been developed. The tip-enhanced THz monocycle pulses have enabled taking a snapshot of ultrafast dynamics. The transient electronic state excited by an optical pulse can be evaluated using the THz-STM, and the ultrafast carrier dynamics excited by an optical pulse was reproducibly probed with visualization of enhanced THz near field[2]. Future applications will be discussed at the conference[3].

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Nano-Objects and Selective Nanochemistry at Advanced Materials

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Silicon carbide (SiC) & Graphene are advanced semiconductors having figures of merit scaling well above those of well-established ones. Understanding/mediating SiC and graphene surfaces & interfaces properties are of central importance. The 1st case of hydrogen/deuterium (H,D) inducing the metallization of a semiconductor surface has been shown for a cubic 3C-SiC(001)3x2 surface. Here, investigations based on advanced experimental techniques such as i) atom resolved scanning tunneling microscopy (STM) and spectroscopy (STS), ii) vibrational spectroscopies using infrared absorption spectroscopy (IRAS) & high-resolution electron energy losses spectroscopies (HREELS), iii) synchrotron radiation-based photoemission spectroscopies (SR-PES) and iv) state-of-art theoretical ab-initio VASP calculations within MedeA® environment. The results shows i) the 1st evidence of H/D-induced nanotunnel opening at a semiconductor sub-surface that could either be metallic or semiconducting depending on the coverage. Dangling bonds generated inside the nanotunnel offer a very promising template to capture atoms or molecules, an interesting feature to selectively functionalize i.e. graphene epitaxially grown on SiC. It opens nano-tailoring capabilities towards advanced applications in electronics, chemistry, storage, sensors or biotechnology with routes towards selective surface/interface functionalization. Finally, H interaction with graphene on SiC dust grains leads to the formation of polycyclic aromatic hydrocarbons (PAH) in the interstellar medium, envisioning a possible route toward prebiotic roots of life in the universe.

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Negative ions surface production in low pressure H_2/D_2 plasmas for nuclear fusion applications.

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In order to ignite and control fusion reactions between hydrogen nuclei in a tokamak plasma, efficient and powerful heating techniques are needed, such as neutral beam injectors (NBI). NBI injects a high-energy neutral beam (1 MeV for the ITER project) which will heat up the plasma by collisions. Such neutral beams are produced thanks to the creation, the acceleration and the neutralization of a D^- negative-ions (NI) beam. D^- ions are produced in a low pressure-high density-low temperature plasma column from the interaction of the plasma particles with metal surfaces with low work function. Within this framework, the aim of our study is to characterize the NI production of carbon-based surfaces (instead of metals) in hydrogenous plasmas[1,2]. To this aim, we studied a Magnetized Retarding Field Energy Analyzer (MRFEA) which allows to make both positive ions and NI current measurements. From the measured NI current, it is possible to estimate the produced NI current at the sample thanks to a model that will be presented, along with experimental results.

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Graphene growth on different SiC crystallographic orientations: consequences on electronic properties

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Dust grains are preferred catalytical sites for the formation of the most abundant molecule, H2. [1,2] Some constituents of spatial dust are SiC and even graphene, as it was observed by Spitzer Space Telescope in planetary nebulae [3]. The interface of graphene on SiC and its reactivity (and therefore the band structure close to the Fermi level) deserves particular attention. These states strongly depend on the SiC facet under graphene, as we demonstrate in this work. Our complementary studies of scanning tunneling microscope (STM), cross sectional transmission electron microscope (TEM) and Angle-resolved Photoemission Spectroscopy (ARPES) show that graphene is metallic and undoped when growing on the (1-10n) facets of SiC [4-6], while it is semiconducting when a honeycomb carbon layer is attached to (0001) facets [7-9].

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Complex/Dusty Plasma Physics – from Laboratory to Space

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Complex/dusty plasmas are ubiquitous in space, including interstellar clouds, circumstellar and protoplanetary accretion disks, nova ejecta, and planetary magnetospheres. But there are also manmade plasmas where solid particles grow in the plasma or are injected by purpose. This laboratory research is very interdisciplinary and covers all fields of matter, from plasma physics, gas dynamics, and fluid to solid state physics. Solid nanoparticles can grow by gas phase polymerization in the plasma. Their size can increase to tens of micrometers by accretion and agglomeration. Depending on the molecules in the plasma they can form e.g. ice, carbon, or silica particles.

Monodisperse micrometer sized particles can form Coulomb liquids or solids, due to their high charges gained in the plasma environment. Such liquids and solids can be seen as classical condensed matter systems with the special property that the dynamics of the “proxy atoms” (the microparticles) can be observed on the most fundamental level of individual particles allowing new insights into processes like crystallization or melting, defect motion, shear flow, waves and solitons, just to mention only a few topics.

A review of complex/dusty plasma research in the laboratory under gravity and microgravity (on the International Space Station) is presented covering the fields from the nanoworld 2 stardust.

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The role of stardust in building molecules in space

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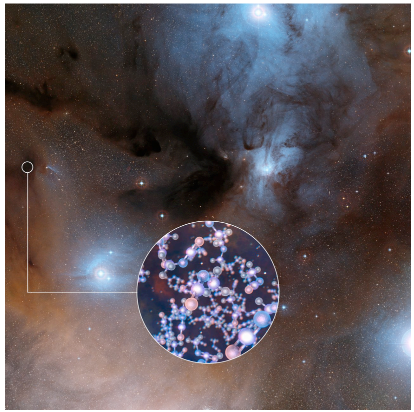
Chemistry starts in the cold and tenuous clouds between the stars. In spite of extremely low temperatures and densities, these clouds contain a surprisingly rich and interesting chemistry, as evidenced by the detection of more than 200 different molecules, from simple to complex[1]. Chemistry takes place both in the gas and on the surfaces of nano-sized interstellar dust grains.[1,2] New facilities such as ALMA allow us to zoom in on the formation sites of new stars and planets with unprecedented sharpness and sensitivity. Spectral scans of young protoplanetary disks contain tens of thousands of rotational lines[3], revealing water and a surprisingly rich variety of organic materials, including simple sugars[3], molecules with peptide bonds[4] and high abundances of deuterated species[3]. What are the dominant chemical processes at work? How common are they? What material is available to build new exo-cometary and planetary systems?



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Graphene chemistry under UHV conditions

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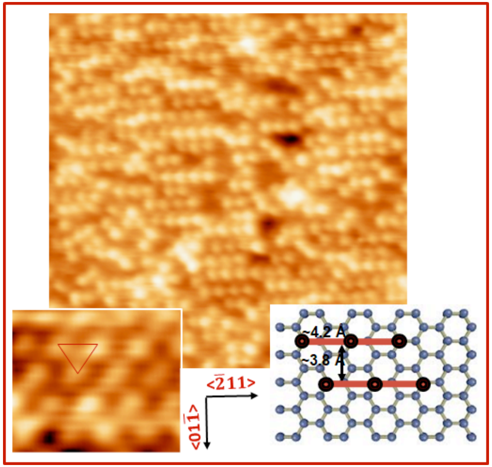

Both the interstellar medium (ISM) and the circumstellar envelope (CSE) have been suggested to be the stage for a rich chemistry involving simple molecules like H2 and CO 1). In these environments, graphenic materials have been recently suggested to play a relevant role in the formation of polycyclic aromatic hydrocarbons 2). On the other hand, the pressure and temperature conditions present in ISM and CSE can be well simulated by experiments performed under the Ultra High Vacuum conditions traditionally employed in surface science.
Since one of the most common substrates in ISM and CSE is graphene (G), we report here on the experimental investigation of its interaction with CO with attention to the material on which graphene is supported and to the presence of vacancies and dopants. In order to provide models for both strongly and weakly interacting support, we have studied G/Ni(111) and G/Cu, respectively.
High Resolution Electron Energy Loss Spectroscopy has been used to check the presence and the nature of

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the adsorbed species while Low Temperature STM has been employed to monitor the surface morphology. The formation of G and its doping has been tested by X ray Photoelectron Spectroscopy.
No signature of adsorbed CO was found after exposure both at RT and at 100 K for G/Cu, while chemisorbed CO was observed after just a few L at 100 K for G supported on Ni(111). In the Figure, we show an STM image of CO adsorbed on G/Ni(111). The bottom-left inset reports an atomically resolved image of the clean G layer, the bottom-right one an empiric model for CO adsorption.
This result indicates that the nature of the substrate plays an essential role in the adsorption process 3) 4). The heat of adsorption is estimated to be ~0.58 eV/molecule at low coverage. The top-bridge configuration is identified as the most reactive 5).

Doping G/Ni(111) by N2+ ion bombardment allows for the formation of a second, more strongly bound moiety, characterized by a CO stretch energy of 236 meV and by an initial heat of adsorption of 0.85 eV/molecule. The presence of N (in pyridinic or substitutional sites) enhances therefore significantly the chemical reactivity of G/Ni(111) towards CO 6).
We also investigated the role of isolated defects, which were created by low energy Ne+ ion bombardment on single layer graphene supported on the same substrates 4). We find that no CO adsorption occurs for defected Graphene (G*)/Cu, while vibrational signatures of the presence of CO are observed for G*/Ni(111). Two moieties, desorbing just above 350 K, are then present after exposure at room temperature. The frequency and the relative intensity of the observed vibrational features indicate that CO chemisorbs at the

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G/Ni(111) interface close to the vacancies rather than at the defected G* layer. The red-shift of the C1s binding energy suggests that in such regions detachment of the G layer from the substrate occurs.
Surprisingly, when performing subsequent cycles of CO adsorption at defected G*/Ni followed by annealing we observe a reduction of the amount of adsorbed CO and Low Temperature-STM confirms that mending of vacancies has occurred. We suggest that a Boudouard reaction involving two intercalated CO molecules takes place under graphene cover, producing CO2, which desorbs, and C, which repairs the vacancy.
In conclusion, we have demonstrated that the interaction of the graphenic layer with the support and the presence of defect play a fundamental role in determining its chemical reactivity with CO under conditions of astrochemical interest.

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Study of stability of Ruthenocene on Ag(111) and Cu(111)

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Metallocenes show a “sandwich structure”, which doesn’t exist in nature, with two ring-shaped carbon compounds enclosing a metallic atom. An increasing interest on metallocene molecules has been raised recently, mainly due to the possibility to exploit spin dependent-effects of the magnetic metal atoms and for the production of metal-molecule layers in molecular electronics. Almost no experimental data is available for the Ruthenocene, and, in order to fill this lack of data, we decided to study the desorption of Ruthenocene deposited on Cu(111) and Ag(111) as a function of the temperature by means of X-ray Photoemission Spectroscopy (XPS) and Near edge X-ray absorption Fine Structure (NEXAFS). By exploiting the fast- XPS measurement capability at the ALOISA beamline (Elettra Synchrotron Facility), we followed the evolution of the C 1s and Ru 3d core level peaks by raising the temperature from 220K up to room temperature. We observe a similar behavior for both substrates, with a desorption temperature of 250 K for Ag(111) and 280 K for Cu(111). Nevertheless, while for the Ag(111) case XPS indicates an almost complete desorption at room temperature, for the Cu(111) case data show clearly still presence of molecules on the surface. This is a clear indication of a stronger interaction between Ruthenocene/Cu rather than Ruthenocene/Ag. Moreover, the dichroism obtained from the NEXAFS data clearly shows that the pristine film is much more ordered than the submonolayer remaining after the annealing. In the case of Ruthenocene/Cu(111), we extended the study by means of Scanning Tunneling Microscope, revealing large and ordered islands after deposition at 210K.

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The Molecule-2D Interface

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The van der Waals interactions of molecules with two dimensional (2D) materials is of interest in both fundamental understanding and nanoscience applications. We use high resolution scanning tunneling microscopy/spectroscopy (STM/STS) and density functional theory (DFT) calculations to show that a monolayer transition metal dichalcogenide (TMD) can effectively screen an organic-inorganic heterointerface[1)]. We elucidate the electronic properties of a lateral doped/intrinsic heterojunction in 2D WSe_2, partially covered with a molecular acceptor $C_{60}F_{48}$[2)]. We also demonstrate the self-assembly of DAP molecules into a hexagonal porous network on a monolayer $MoSe_2$ surface, as a result of the different electron affinities of the inversion domain boundaries and the pristine $MoSe_2$ domains[3)].

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Tuning the atomic structure of 2D boron sheets

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Elemental 2D materials formed by C, B, Si, Ge, Sn, P are interesting due to their simple structure combined with unique electronic and mechanical properties. Unlike carbon that has only one 2D allotrope – honeycomb graphene, 2D boron sheets, namely borophene, possesses enormous polymorphs arising from periodic hole patterns in a triangular lattice. In this talk, I will discuss our experimental works in the epitaxial growth 2D boron sheets. We found that the structure of 2D boron sheets can be tuned by the interaction and charge transfer between the film and the substrate. And even a honeycomb 2D boron sheet can be achieved by using Al(111) as the substrate. The electronic and vibrational properties of 2D boron sheets were studied by ARPES and tip-enhanced Raman spectroscopy, revealing the existence of Dirac fermions in 2D boron.

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Atomic-level control of high temperature superconductor materials for unveiling their pairing mechanism

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We investigate the pairing mechanism of high Tc superconductivity in cuprates and iron-pnictides by using state-of-the-art molecular beam epitaxy (MBE)-scanning tunneling microscopy (STM), angle-resolved photoemission spectroscopy and Josephson tunneling experiment. By MBE growth, we are able to prepare superconducting CuO_2 planes in BSCCO and LSCO and FeSe planes in Fe-based pnictides, which provides an unprecedented opportunity to investigate the pairing mechanism in well-controlled manner. We show that the pairing symmetry in both systems is rather conventional. We propose a model for understanding the complicated phase diagram and mechanism of unconventional high temperature superconductivity in the two systems.

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Posters session

- M. Minissale, A. Dunand, J.-B. Faure, T. Angot, G. De Temmerman, R. Bisson: “*Ammonia sticking on materials relevant to fusion reactors: tungsten and 316L stainless steel*”
- N. Chan , A. Betourne: *“Quadriwave lateral shearing interferometry: Applications of a high-resolution wavefront sensing technique”*
- A. Czechowski, I. Mann: *“Nanodust in the solar wind and in the inner planetary debris disks”*
- M. Ialovega, E. Bernard, R. Bisson, R. Sakamoto, A. Kreter, T. Angot, C. Grisolia: *“Helium irradiation effects and their impact on deuterium retention in tungsten”*
- C. Louis de Canonville, M. Minissale, R. Bisson, L. Gallais: *“Optical properties of metallic surfaces submitted to fusion reactor conditions”*
- I. Mann, T. Gunnarsdottir, H. Trollvik, Å. Fredriksen, T. Antonsen, O. Havnes: *“Nanoparticles in Earth's ionosphere – detection from rockets”*
- M. Mikikian, E. von Wahl, T. Lecas, J.-L. Le Garrec, J.B. Mitchell: *“Rapid nanoparticle nucleation by dimethylamine injection in an argon plasma”*

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- N.Moussa, H.Dellali, M.Benfriha, M.Belhakem : "*Comparative etude by Fourier transform infrared spectroscopy of functional structures of activated carbon derived from brown algae and activated carbon from green algae chemically activated by CaCl2 agent.*"
- P. Parent, C. Laffon, D. Ferry, O. Grauby: *"Molecular interactions with carbon nanoparticles: a laboratory study"*
- D. Beato Medina, E. Salomon, G. Le Lay, T. Angot: *"Reactivity of silicene towards atoms and molecules"*
- L. Tahri, A. Aanesland, D. Rafalskyi, A. Simonin, J.-M. Layet, G. Cartry: *"Surface production of negative ions in low pressure H2/D2 plasmas: measurement of the absolute negative ion flux"*
- J. Yuhara, H. Shimazu, K. Ito, A. Ohta, M. Araidai, M. Kurosawa, M. Nakatake, G. Le Lay: *"Germanene epitaxial growth by a segregation method on Ag(111) thin films"*
- J. Yuhara, B. He, N. Matsunami, M. Nakatake, G. Le Lay: *"Plumbene Epitaxial Growth on a "Nano WaterCube""*
- J. Yuhara, Y. Fujii, K. Nishino, N. Isobe, M. Nakatake, L. Xian, A. Rubio, G. Le Lay: *"Formation of planar stanene epitaxially grown on a Ag2Sn surface alloy"*

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Ammonia sticking on materials relevant to fusion reactors: tungsten and 316L stainless steel

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Harnessing nuclear fusion's power is the goal of the ITER tokamak, an experimental project involving 35 nations. In a tokamak, a magnetically confined plasma of hydrogen isotopes (deuterium and radioactive tritium) is heated to millions of Kelvin. During high-power operations in ITER, it will be necessary to seed impurities into the edge of the fusion plasma to dissipate part of the plasma exhaust power through radiation and maintain the power fluxes to the plasma-facing components within tolerable limits. Nitrogen (N) is one of the leading impurity candidates. Ammonia production has, however, been observed in the all-metal ASDEX-U and JET tokamaks during N-seeded plasma [1,2)]. The formation of large quantities of tritiated ammonia has consequences for several aspects of the ITER plant operation in terms of tritium retention, gas reprocessing and duty cycle. In this contribution, we address the following question: what is the sticking probability of ammonia molecules on ITER-relevant material (tungsten and 316L stainless steel)?

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Quadriwave lateral shearing interferometry: Applications of a high-resolution wavefront sensing technique

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Quadriwave lateral shearing interferometry (QWLSI) is an established measurement technique in the nanoworld: phase-shifts introduced by a sample are directly measured by acquiring the transmitted light wave front. The technology is based on the analysis of an interferogram created by four replicas of the initial wave front diffracted by an optical grating set few millimeters in front of the sensor.
The wavefront data have multiple applications, from label-free quantitative phase imaging for cell substrates to the characterization of large diameter telescopes for astronomy.
We present this technique in multiple contexts: laser-gas interactions in high-power experiments, metasurfaces characterization and materials imaging at the nanometric scale.

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Nanodust in the solar wind and in the inner planetary debris disks

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The dust in the interplanetary medium is electrically charged as a result of photo ionization and interactions with solar wind and high energy particles. The ratio of surface charge to mass typically increases with decreasing size of particles and as a result the trajectories of the nm-sized dust is determined by interplay between the gravity and the electromagnetic forces. The nanodust forms by collisional fragmentation of larger dust and depending on the conditions at their origin, the nanodust particles can either be trapped in a non-Keplerian orbit, or escape away from the Sun. Similar conditions occur around other stars that are surrounded by planetary debris disks and under different conditions for the stellar wind and stellar radiation. In the vicinity of the star, the motion of the coronal and stellar wind plasma must include some amount of corotation. We here discuss the influence of corotation on the dynamics of nanodust in the inner regions of planetary debris disks and in the vicinity of the Sun. - IM's work is funded by Research Council of Norway, NFR 262941.Gunnarsdottir, T., Master Thesis, UiT The Arctic University of Norway, 2019.

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Helium irradiation effects and their impact on deuterium retention in tungsten

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Investigations of helium irradiation effects on hydrogen isotopes (HI) retention in tungsten (W) plasma-facing components are very important for future fusion reactors such as ITER. Pre-irradiation by 75eV (3×10^{23}) He m^{-2} helium ions resulted in formation of craters on the polycrystalline W surface and created helium bubbles of different size above the helium implantation range up to 110nm in the bulk of the W samples. Thermal treatment revealed the coalescence of small helium bubbles into larger ones and annealing of the near-surface region.
Sequences of 250eV deuterium (D) implantation and thermodesorption experiments showed remarkable changes of D retention in presence of helium in W. D retention is 3 to 8-fold higher than in non-irradiated samples. The change of D desorption spectra intensity and the appearance of additional desorption peak can be associated with the change of helium bubbles size and density. Although the samples were heated up to 1350K, the total helium release was less than 0.02% of the incident fluence. This suggests that some amount of helium is still present in the samples and might be trapped inside the bubbles. These results indicate the importance of taking into account the helium irradiation effects for the correct estimation of HI inventory in tokamak wall materials.

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Optical properties of metallic surfaces submitted to fusion reactor conditions

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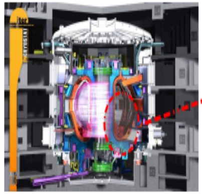

ITER, TOKAMAK

ITER, Divertor

Divertor is a very important piece of ITER. Situated at the bottom of the vacuum vessel the divertor extracts heat and ash produced by the fusion reaction, minimizes plasma contamination, and protects the surrounding walls from thermal and neutronic loads. This involve the study of optical properties of the W samples and their evolution with the near surface properties (implanted ions, oxidation, micro-structure, roughness...) and applied heat loads (temperature gradients).

The aim of this thesis is to study the optical properties of metals used in fusion devices. For this purpose, we are currently building an experimental development that perform ellipsometry measurement on laser heated samples from 120K to 2000K in well-controlled conditions (ultra-vacuum) and on a variety of W samples, from model (single crystal) to realistic tokamak materials. The experiments analysis is associated with modelling for the description of optical properties dependencies with intrinsic material properties and surface state.

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Nanoparticles in Earth's ionosphere – detection from rockets

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The upper atmosphere at the transition to space contains small nanometer-sized dust particles. The particles originate from the entry of the cosmic dust into the atmosphere, a process where a large fraction of material evaporates and then re-condenses. A fraction of the dust particles is electrically charged and the dust interacts with the other charged components of the atmosphere at this altitude[1]. The dust can be observed from sounding rockets and the detection with Faraday cup instruments during summer when the dust particles have sizes of up to several 10 nm is well developped[2]. We here discuss the challenges of detecting nanoparticles in winter conditions when their sizes are few nm and smaller and present results from a student rocket campaign made in January 2019[3,4]. This work is funded by Research Council of Norway, NFR 275503.

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Rapid nanoparticle nucleation by dimethylamine injection in an argon plasma

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While only present as a trace in the atmosphere, dimethylamine (DMA) is considered to play an important role in the aerosol formation by stabilizing sulfuric acid-water clusters[1)]. In these preliminary tests, the ability of DMA to produce nanoparticles is studied in low-pressure plasma conditions. It appears that immediately after DMA injection in an argon plasma, a huge density of nanoparticles is produced.

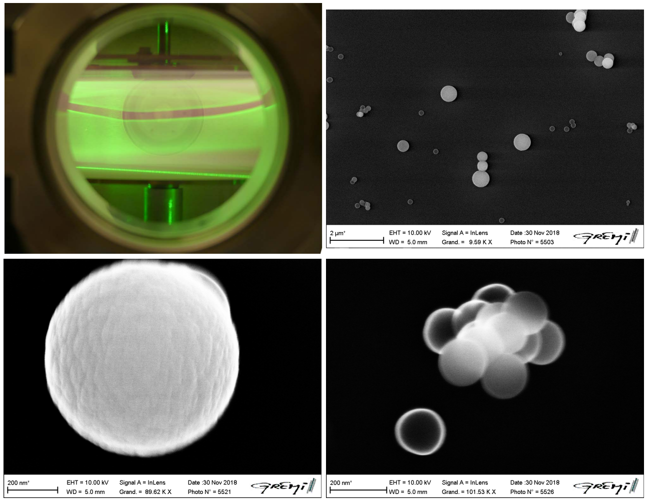

Figure: Nanoparticle cloud grown from DMA and trapped in the plasma. SEM images of some collected nanoparticles.

References:

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BACK

Etude comparative par la spectroscopie infrarouge à transformée de Fourier des structures fonctionnelles des charbons actifs issus des algues brunes et des charbons actifs issus des algues vertes activé chimiquement par l'agent $CaCl_2$

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Activated carbon is an adsorbent product with an extremely porous structure with a large specific surface inlaid with several chemical functions. To understand the adsorption mechanisms involved, it is necessary to study the functional structure of this active surface and the influence of the diverse parameters. At the SEA2M laboratory, we develop carbon from plant biomass such as brown algae and green algae (marine biomass) existing on the coast of Mostaganem, two types of carbon were made from these two types of algae and treated with the chemical agent $CaCl_2$.The spectroscopy infrared etude of the functional structure developed in these two types of activated carbon has shown a remarkable differentiation, this differentiation is mainly in the concentration of the functional groups as well as the types of functions etched on this active surface.

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BACK

Molecular interactions with carbon nanoparticles: a laboratory study

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Cosmic dust grains range from large molecules (PAHs) to submicronic particles and aggregates of silicate and carbon, depending on their location1. Heterogeneous reactions at their surface is one important source of molecules in space2. Although laboratory studies can provide the energy barriers for such gas-grain reactions to feed astrochemical models, gas temperature, timescales, coverages, composition, size, and morphology of surfaces used as laboratory models can be far from the interstellar conditions3. Especially, although cosmic grains' radiative properties indicate that they are of nanometer size3, laboratory experiments are usually carried out on large and flat surfaces (graphite, silicates, etc.), but not on nanoparticles. To address this issue, the interactions of some species of astrophysical interest with carbon nanoparticles have been studied, and preliminary results will be presented in this communication.

BACK

Reactivity of silicene towards atoms and molecules

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Silicene is a “2D” material which consists of one or a few silicon layers similar to the well-known graphene. It is an interesting material because of its possible compatibility with the existing technology in microelectronics and its foreseeable impressive properties, such as: the quantum spin hall effect, a tunable band gap and the presence of Dirac electrons.

In this work, the reactivity of such a material towards two different chemical species, namely hydrogen and the strong acceptor molecule F_4TCNQ, has been studied.

BACK

Surface production of negative ions in low pressure H_2/D_2 plasmas: measurement of the absolute negative ion flux

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In order to ignite and control fusion reactions between hydrogen nuclei in a tokamak plasma, efficient and powerful heating techniques are needed, such as neutral beam injectors (NBI). NBI injects a high-energy neutral beam (1 MeV for the ITER project) which will heat up the plasma by collisions. Such neutral beams are produced thanks to the creation, the acceleration and the neutralization of a D^- negative-ions (NI) beam. D^- ions are produced in a low pressure-high density-low temperature plasma column from the interaction of the plasma particles with metal surfaces with low work function. Within this framework, the aim of our study is to characterize the NI production of carbon-based surfaces (instead of metals) in hydrogenous plasmas[1,2]. To this aim, we studied a Magnetized Retarding Field Energy Analyzer (MRFEA) which allows to make both positive ions and NI current measurements. From the measured NI current, it is possible to estimate the produced NI current at the sample thanks to a model that will be presented, along with experimental results.

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1) Cartry G et a.l 2017 New Journal of Physics **19** 025010

2) Kogut D et a.l 2017 Plasma Sources Science and Technology **26** 045006

Germanene epitaxial growth by a segregation method on Ag(111) thin films

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The heavy group 14 elements have received great attention as candidates of post-graphene materials[1,2)] In the present study, germanene has been epitaxially prepared on the surface upon annealing an Ag(111) thin film grown on Ge(111)[3)]. Low-energy electron diffraction clearly shows incommensurate "(1.3×1.3)"R30° spots, corresponding to a lattice constant of 0.39 nm, in perfect accord with close-up scanning tunneling microscopy (STM) images, which clearly reveal an internal honeycomb arrangement with low buckling within 0.01 nm. From the STM images, two types of protrusions, named hexagon and line, form a (7√7×7√7)R19.1° supercell with respect to Ag(111).

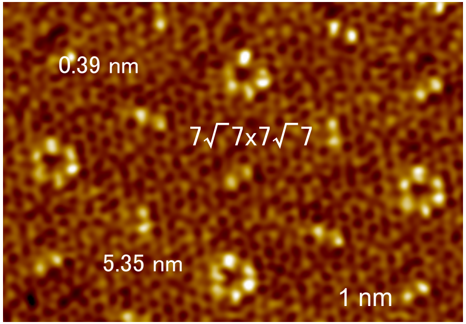

Figure: STM image of germanene on Ag(111) thin film on Ge(111)

References:

1) P. Vogt et al, *Phys. Rev. Lett.* **108** (2012) 155501.
2) M. E. Dávila et al, *New J. Phys.* **2014**, *16*, 095002.
3) J. Yuhara et al, *ACS Nano* **12** (2018) 11632.

Plumbene Epitaxial Growth on a “Nano WaterCube”

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While theoretical studies predicted the stability and exotic properties of plumbene, the last group 14 cousin of graphene, its realization has remained a challenging quest. Here, it is shown with compelling evidence that plumbene is epitaxially grown by segregation on a $Pd_{1-x}Pb_x(111)$ surface alloy. It exhibits in scanning tunneling microscopy (STM) a unique surface morphology resembling the famous Weaire-Phelan bubble structure of the Olympic “WaterCube” in Beijing. The “soap bubbles” of this “Nano WaterCube” are adjustable with their average sizes related to the Pb concentration ($x<0.2$) dependence of the lattice parameter of the $Pd_{1-x}Pb_x(111)$ alloy surface. Angle-resolved core-level measurements demonstrate that a lead sheet overlays the $Pd_{1-x}Pb_x(111)$ alloy. Atomic-scale STM images show a planar honeycomb structure with a unit cell of ranging from 0.48 nm to 0.49 nm corresponding to that of the standalone 2D topological insulator plumbene[1].

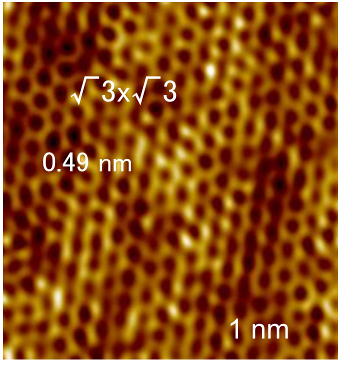

Figure: STM image of plumbene on a Pd-Pb alloy thin film on Pd(111)

References:

1) J. Yuhara *et al.*, Adv. Mater. 2019, 1901017

Formation of planar stanene epitaxially grown on a Ag_2Sn surface alloy

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2D sheets of heavy group 14 elements are receiving great attention as candidates of post-graphene materials[1)]. Recently, the synthesis of high buckled stanene on Bi_2Te_3(111) has been reported[2)]. In the present study, we examine the submonolayer Sn films on Ag(111). The high-resolution STM images clearly exhibit large area planar stanene with honeycomb structure[3)]. From the combined results of LEED-RBS-STM-PES-ARPES and *ab initio* calculations based on DFT theory, it is concluded that planar stanene is formed on a Ag_2Sn surface alloy on the Ag(111) substrate.

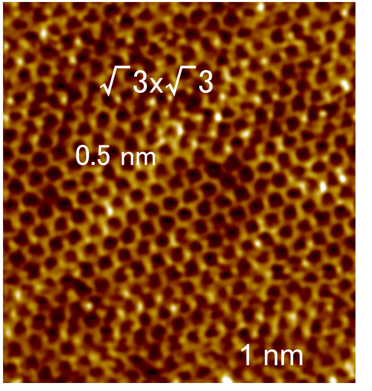

Figure: STM image of stanene on a Ag_2Sn surface alloy on Ag(111)

References:

1) P. Vogt et al, *Phys. Rev. Lett.* **108** (2012) 155501.
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3) J. Yuhara et al, *2D Mater.* **5** (2018) 025002.