

## **BELGIAN PHYSICAL SOCIETY**

## **General Scientific Meeting**

KU Leuven, Belgium Leuven, May 28, 2014



Programme & Abstracts of oral and poster contributions

## VENUE

Main location Auditorium Max Weber Parkstraat 51 3000 Leuven



**Poster session & Drink** Jubilee Hall Naamsestraat 22 3000 Leuven



### Lunch

Alma 2 Edward van Evenstraat 2C 3000 Leuven



## FOREWORD

Dear Members of the Belgian Physical Society,

In the name of the BPS Board, the Department of Physics and Astronomy of the KU Leuven, and all colleagues involved in the organization, I welcome you at this year's General Scientific Meeting of the BPS.

The invited lectures this year focus on intriguing topics in particle and condensed matter physics and their links with astrophysics. The first lecture deals with the science of the Icecube project, a neutrino detector consisting of  $1 \text{ km}^3$  of very transparent ice deep in the Antarctic ice sheet. It is able to detect neutrinos up to the PeV range and should provide important information on cataclysmic events in the universe where such high energy neutrinos are generated. The second invited talk will inform you about the Majorana fermions, possible candidate particles for the mysterious "cold dark matter" in the universe.

The high quality of the candidates turned the preselection for the Young Scientist Oral Contest this year again into a very difficult task for the jury. It proved to be nearly impossible to select only three candidates for the final contest at the Annual Meeting. We wish the three nominees all the best and the audience a didactic session that should teach about but a few of the very interesting research projects that are being undertaken in Belgium and the Netherlands.

Finally, the poster session and parallel sessions in the afternoon will provide you with a broad overview of physics research in Belgium.

I wish you all a successful and interesting conference!

Jef Ongena BPS President

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## PROGRAMME

- 8:30 Registration and coffee
- 9:00 Welcome by BPS President
- 9:10 Plenary lecture 1: Francis Halzen (University of Wisconsin, Madison) IceCube and the discovery of high-energy cosmic neutrinos
- 10:00 Plenary lecture 2: **Carlo W. Beenakker** (Leiden University) *The search for Majorana fermions in superconductors*
- 10:50 Coffee break
- 11:15 Young scientist oral presentation contest (11:15-12:30)
  - 11:15 Introduction and presentation by Springer Verlag
  - 11:30 YS1: Kasper Eersels (UHasselt) Structural imprinting as a tool for the selective detection of mammalian cells
  - 11:50 YS2: Vinzenz Koning (Leiden University) Doughnut-shaped droplets of liquid crystals
  - 12:10 YS3: Emmanuel Chané (KU Leuven) The day the Earth's magnetosphere lost its bow-shock
- 12:30 Lunch (Alma 2)
- 13:30 Parallel sessions (topics and conveners see next pages)
- 16:00 Poster session (in Jubilee Hall)
- 18:00 Reception and closing ceremony (in Jubilee Hall)

## Parallel Session on PHYSICS AND EDUCATION

Chair: Mieke De Cock Room: AV 91.20

- 13:30 EDUo1 (INVITED): **Henk J. Pol** (Universiteit Twente) *How could a speed course QM look like?*
- 14:30 EDUo2 (INVITED): Laura Tamassia (KHLim) CERN in the classroom
- 15:30 EDUo3 (INVITED): **Philippe Leonard** (Experimentarium) Some ideas to teach modern physics
- 16:15 EDUo4 (INVITED): **Rita Van Peteghem** (CNO, UAntwerpen) *Ideas on professional development*

# Parallel session on FUNDAMENTAL INTERACTIONS, PARTICLE & NUCLEAR PHYSICS

Chair: Nathal Severijns Room: SW 02.25

at PSI

13:30 FPNo1 (INVITED): Steven Lowette (VUB) Achievements and prospects of the CMS experiment at the TeV energy scale 14:30 FPNo2: Cécile Caillol (ULB) and Lucia Perrini (UCL) Evidence for the 125 GeV Higgs boson decaying to a pair of  $\tau$ leptons with the CMS experiment 15:00 FPNo3: Ivan Budincevic (KU Leuven) Collinear resonance ionization spectroscopy of 202-206, 218m, 219, 229, 231 Fr isotopes FPNo4: Thomas Reis (IIHE-Brussels) 15:20 Search for massive resonances in dilepton mass spectra at CMS FPNo5: Elise Wursten (KU Leuven) 15:40Probing beyond the Standard Model: the neutron EDM experiment

# Parallel session on CONDENSED MATTER & NANOSTRUCTURE PHYSICS

Chair: Francois Peeters Room: AV 91.21

graphene

13:30	CMNo1 (INVITED): Hasan Sahin (UA)
	Two-dimensional atomic crystals
14:10	CMNo2: Thomas Picot (KU Leuven)
	Violation of Leggett-Garg inequality and observation of
	non-classical weak values in a superconducting circuit
14:30	CMNo3: Matthieu Verstraete (ULG)
	First principles calculation of the Seebeck effect
14:50	CMNo4: Kelly Houben (KU Leuven)
	Probing the atomic vibrations in nanostructured tin superconductors
	with synchrotron light
15:10	CMNo5: Dimpy Sharma (UNamur)
	First-principles studies of charge transfer in nitrogen doped

# Parallel session on BIOPHYSICS, MEDICAL, STATISTICAL & MATHEMATICAL PHYSICS

Chairs: Patrick Wagner, Carmen Bartic, Joseph Indekeu Room: SW 02.05

13:30	BMSMo1(INVITED): Enrico Carlon (KU Leuven)
	Anomalous dynamics of DNA hairpin folding
14:00	BMSMo2: Bruno Lannoo (KU Leuven & Lille 1)
	Oscillatory gene regulatory network modules
14:15	BMSMo3: Marcel Boix-Alberich (UMons)
	Protein adsorption on inert ceramics
14:30	BMSMo4: Olivier Deschaume (KU Leuven)
	Protein fiber-mediated self-assembly of gold nanoparticle arrays

- 14:45 BMSMo5: **Thijs Becker** (UHasselt) Diffusion of interacting particles
- 15:00 BMSMo6: Marloes Peeters (UHasselt) Thermal detection of histamine with a graphene oxide based molecularly imprinted polymer platform prepared by reversible addition-fragmentation chain transfer polymerization
- 15:15 BMSMo7: **Patricia Losada-Pérez** (UHasselt) *Phase transitions in lipid vesicles detected by a complementary set of methods: heat-transfer measurements, adiabatic scanning calorimetry and dissipation-mode quartz crystal microbalance*
- 15:30 BMSMo8: Luana De Freitas Nascimento (SCK-CEN, UGent, VUB)

Medical dosimetry with a RL/OSL prototype: 6 MV photon beams

## Parallel session on ATOMS, MOLECULES, OPTICS & PHOTONICS

Chairs: Xavier Urbain, Pascal Quinet Room: SW 02.27

13:30	AMOo1 (INVITED): Holger Kreckel (Max-Planck-Institut für
	Kernphysik, Heidelberg, Germany)
	Imaging of a chiral molecule in the gas phase
14:15	AMOo2: Yejun Li (KU Leuven)
	The geometric structure of transition metal doped silicon clusters
14:40	AMOo3: Michaël Lobet (UNamur)
	Plasmon hybridization in pyramidal metamaterials for ultra-
	broadband absorption
15:05	AMOo4: Mirko Cormann (UNamur)
	The role of weak values in quantum state reconstruction
15:30	AMOo5: Kamel Mallat (UCL)
	Nonlinear interferometry and enhancing of the contrast using
	femtosecond gate

## Parallel session on ASTROPHYSICS, GEOPHYSICS & PLASMA PHYSICS

Chair: Giovanni Lapenta Room: SW 02.07

- 13:30 AGPo1 (INVITED): **Enrico Camporeale** (Centrum Wiskunde & Informatica, Amsterdam, NI) A spectral discretization of a kinetic plasma model: comparison with the Particle-in-Cell method
- 14:00 AGPo2: **Sven Van Loo** (Harvard, USA) Core and filament formation in magnetised, self-gravitating layers
- 14:20 AGPo3: Michael Pieters (BIRA-IASB) Solar wind modeling
- 14:40 AGPo4: **Koen Kemel** (KU Leuven) *The Kelvin-Helmholtz instability as a source for kinetic turbulence*
- 15:00 AGPo5: Yevgen Kazakov (RMA) Progress in the ion cyclotron resonance heating of (3He)-H tokamak plasmas in support of ITER
- 15:20 AGPo6: **Vyacheslav Olshevsky** (KU Leuven) Magnetic reconnection in turbulent space plasmas: null-points or pinches?
- 15:40 AGPo7: Lukas Maes (BIRA-IASB) Effects of solar illumination on ionospheric outflows in field-aligned acceleration regions above the polar caps

## **BEST POSTER CONTEST**

Room: Jubilee Hall 16:00 – 18:00

### Section Fundamental interactions, Particle & Nuclear Physics

- BP1 **Tom Cornelis** (UAntwerpen) Electroweak (VBF) production of a Z boson in association with forward/backward jets at CMS
- BP2 **Gwendolyn Lacroix** (UMons) Glueballs and the Yang-Mills plasma
- BP3 Elisa Pinat (KU Leuven) New signalling techniques for an upgraded IceCube detector

### Section Condensed Matter & Nanostructure Physics

- BP4 Angeline Akelo Kasina (KU Leuven) Ultra-stable glass properties revealed by simultaneous dielectric and ac calorimetric measurements
- BP5 **Troy Munro** (KU Leuven, Utah State University) Thermal properties of synthetic spider silk by photothermal fluorescence
- BP6 Ahmet Yasin Atalay (UHasselt) Annealing effect of sol-gel deposited ZnO film
- BP7 William Armando Munoz (UAntwerpen) Disordered graphene Josephson junctions
- BP8 **Bert Braeckman** (UGent) Sputter deposition of multi-component alloy thin films by using powder targets

- BP9 Ariel Adorno de Sousa (UAntwerpen) Braess paradox at the mesoscopic scale
- BP10 **Zhe Li** (KU Leuven) Self-doping of ultrathin insulating films by transition metal atoms
- BP11 Lien D'Olieslaeger (UHasselt) PCDTBT:[70]PCBM blend nanoparticles for opto-electronic applications
- BP12 **Tsveta Ivanova** (KU Leuven) Formation and STM characterization of nanoporous DBA molecular networks
- BP13 Valérie Augustyns (KU Leuven) Lattice site and thermal stability of implanted transition metals in germanium
- BP14 **Diego Rabelo da Costa** (Univ. Federal do Ceará, UAntwerpen) Valley filtering by electrostatic potentials in bilayer graphene
- BP15 Hanna Paddubrouskaya (KU Leuven) Ring-shaped ferromagnetic nanowires for current-induced domain wall motion studies

### BP16 Andreas Gaulke (UHasselt) Area-selected deposition of graphene oxide using dielectrophoresis in a top down approach

- BP17 **Koen van Stiphout** (KU Leuven) Modifying the reaction of thin Ni films with Si by Si implantation
- BP18
   Victor Leonardo Fernandez Becerr (UAntwerpen)

   Stable half quantum vortices in mesoscopic p-wave superconductors
- BP19
   Daniel Perez (KU Leuven)

   One dimensional superconductivity in Sn nanowires
- BP20 **Nuno Santos** (KU Leuven) Metal germanide formation on  $Ge_{1-x}Sn_x$

- BP21 **Hiwa Modarresi** (KU Leuven) Enhanced ferromagnetism in BiFeO<sub>3</sub> by Co ion implantation
- BP22 Johanna Jochum (KU Leuven) Growth and characterization of metastable alpha-Sn films
- BP23 Anmin Yin (KU Leuven) Angular dependence of Rayleigh-wave velocity in steel plates
- BP24 **Corentin Guyot** (UMons) How does the film thickness influence the optical behavior of plasmonic nanocomposites?
- BP25 **Mathieu Stock** (UMons) Applications of k-means and hierarchical clustering in the analysis of the optical properties of materials: the case of spectroscopic imaging ellipsometry
- BP26 Jan Sermeus (KU Leuven) Elastic characterization of porous MnO2
- BP27 **Matias Timmermans** (KU Leuven) Dynamic visualization of nanoscale vortex orbits
- BP28 **David Debruyne** (KU Leuven) *PH-sensitive quantum dots and rods*
- BP29 Jonas J. Joos (UGent) Designing phosphors for brighter LEDs

### Section Biophysics, Medical, Statistical & Mathematical Physics

- BP30 **Patricia Losada-Pérez** (UHasselt) *Phase coexistence of phospholipid mixtures determined by quartz crystal microbalance with dissipation and adiabatic scanning calorimetry*
- BP31 **Kathia Lorena Jiménez-Monroy** (UHasselt) DNA electrical behavior at room temperature: I-V measurements on single molecules

- BP32 **Stijn Duchateau** (UHasselt) Arduino based impedance measurement platform
- BP33 **Mehran Khorshid** (UHasselt) Affinity and specificity studies of novel selected 17β-estradiol (E2) aptamers via Surface Plasmon Resonance (SPR)
- BP34 **Yovan de Coene** (KU Leuven) Probing the mechanical properties of living neurons by Atomic Force Microscopy
- BP35 Wahyu Wijaya Hadiwikarta (VITO, KU Leuven) Thermodynamics of DNA hybridization: theory and applications for molecular diagnostics

### Section Atoms, Molecules, Optics & Photonics

- BP36 **Matthieu Génévriez** (UCL) Experimental and theoretical study of 3-photon ionization of He  $(1s2s^{3}S)$  and He  $(1s2p^{3}P)$
- BP37 **Julien Dujardin** (ULG) Many-body quantum transport of Bose-Einstein Condensates: a truncated Wigner approach
- BP38 Nguyen Thi Hien (KU Leuven) Metamaterial hybridization
- BP39 **Yejun Li** (KU Leuven) The geometric structure of transition metal doped silicon clusters

### Section Astrophysics, Geophysics & Plasma Physics

- BP40 Sofia Paraskevi Moschou (KU Leuven) Potential Magnetic Field Extrapolation
- BP41 **Emanuele Cazzola** (KU Leuven) Electromagnetic particle-in-cell simulations of the solar wind interaction with lunar magnetic anomalies

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- BP42 Anastasiya Boiko (KU Leuven) Methods of the search for the radio emission from M-dwarf star AD Leonis with the radio telescope UTR-2
- BP43 **Graciela López Rosson** (BIRA-IASB) Energetic particle telescope, first results
- BP44 **Kris Borremans** (BIRA-IASB) Test particle simulations of electrons and protons in Earth's radiation belts during storms
- BP45 **Tom Hendrix** (KU Leuven) Dust in Kelvin Helmhotz instabilities

### **REGULAR POSTERS**

Room: Jubilee Hall 16:00 – 18:00

### Section Fundamental interactions, Particle & Nuclear Physics

- FPNp1 Jian Wang (ULB) Constraints on the Higgs boson width from off-shell production and decay to  $ZZ \rightarrow 4l$  or 2l2v
- FPNp2 **Tomica Porobic** (KU Leuven) Space-charge effects in WITCH, a penning trap experiment for weak interaction studies
- FPNp3 Gergely Soti (KU Leuven) Measurement of the beta-asymmetry parameter in search for physics beyond the Standard Model

### Section Condensed Matter & Nanostructure Physics

CMNp1 **Serghei Klimin** (UAntwerpen) Superconductivity in a LaAlO<sub>3</sub>-SrTiO<sub>3</sub> heterostructure

#### CMNp2 Enric Menéndez Dalmau (KU Leuven)

*Tuning the ferromagnetic-antiferromagnetic interfaces of granular Co-CoO exchange bias systems by annealing* 

CMNp3 Maarten Van De Put (UAntwerpen, IMEC)

Spectral force approach to solve the time-dependent Wigner-Boltzmann transport equation

CMNp4 Nasrin Sarmadian (UAntwerpen)

*High throughput first-principles calculations of bixbyite oxides for TCO applications* 

### CMNp5 Kristof Moors (KU Leuven)

Resistivity scaling in ultra-thin metallic nano-wires

### CMNp6 Serghei Klimin (UAntwerpen)

Effective field theory for a two-band ultracold Fermi gas

### CMNp7 Koen Schouteden (KU Leuven)

*Engineering the band structure of nanoparticles by an incommensurate cover layer* 

### Section Biophysics, Medical, Statistical & Mathematical Physics

### BMSMp1 Evelien Kellens (UHasselt)

Molecularly imprinted nano and micro particles for the detection of testosterone

### BMSMp2 Tobias Peissker (KU Leuven)

*Vacuum-deposited metallic nanoparticles on a protein-repellent background for site-selective protein adsorption* 

### Section Atoms, Molecules, Optics & Photonics

### AMOPp1 Arnaud Dochain (UCL)

*Rovibrational distribution of*  $O_2^+$  *produced by solar wind interaction and REMPI* 

### AMOPp2 Vladimir Kaydashev (KU Leuven)

*Tolerance of platinum clusters to CO poisoning induced by molybdenum doping* 

### AMOPp3 Liwang Liu (KU Leuven)

Fluorescence spectra shape based dynamic thermometry

### Section Astrophysics, Geophysics & Plasma Physics

### AGPp1 Jens Pomoell (KU Leuven)

*The evolution of the global coronal shock in the June 7, 2011 event: An MHD simulation study* 

### AGPp2 Yevgen Kazakov (RMA)

*Tunneling and mode conversion of fast magnetosonic waves in the planetary magnetospheres* 

### AGPp3 Dirk Van Eester (RMA)

Minority ion cyclotron resonance heating in H-mode in presence of the ITER-like wall in JET

### AGPp4 Wei Jiang (KU Leuven)

Numerical simulations of solar-wind comet interactions based on implicit particle-in cell/Monte Carlo method

### AGPp5 Emanuele Cazzola (KU Leuven)

Asymmetric reconnection: a breakthrough to more realistic reconnection events in space

### AGPp6 Lorenzo Siddi (KU Leuven) Mesh-free formulation of two dimensional Darwin model

AGPp7 Johan De Keyser (BIRA-IASB) The DFMS sensor of ROSINA onboard Rosetta: Mission to comet

### AGPp8 Maria Elena Innocenti (KU Leuven) Realistic mass ratio simulations of magnetic reconnection with the Multi Level Multi Domain method

### AGPp9 Dirk Van Eester (RMA)

Antenna near-field wave studies in magnetized plasmas as part of the optimization of auxiliary heating in fusion devicesAntenna nearfield wave studies in magnetized plasmas as part of the optimization of auxiliary heating in fusion devices

### AGPp10 Yana Maneva (KU Leuven)

*Wave-particle interactions in collisionless plasmas – Landau damping vs. cyclotron resonance* 

## **ABSTRACTS PLENARY LECTURES**

### PL1 IceCube and the discovery of high-energy cosmic neutrinos

Francis Halzen

Wisconsin IceCube Particle Astrophysics Center and Department of Physics, University of Wisconsin, Madison

The IceCube project has transformed one cubic kilometer of natural Antarctic ice into a neutrino detector. The instrument detects 100,000 neutrinos per year in the GeV to PeV energy range. Among those, we have recently isolated a flux of high-energy cosmic neutrinos. I will discuss the instrument, the analysis of the data, and the significance of the discovery of cosmic neutrinos.

#### PL2 The search for Majorana fermions in superconductors

Carlo W. Beenakker Leiden University

Majorana fermions (particles which are own antiparticle) may or may not exist in Nature as fundamental building blocks, but in the solid state they can be constructed out of electron and hole excitations. What is needed is a superconductor to hide the charge difference, and a topological phase to eliminate the zero-point motion that would cause an energy difference. A qubit encoded in a pair of Majorana fermions is expected to have an unusually long coherence time. We will discuss strategies to detect Majorana fermions in a topological superconductor, as well as possible applications in a quantum computer.

## ABSTRACTS YOUNG SCIENTIST ORAL PRESENTATION CONTEST

## YS1 Structural imprinting as a tool for the selective detection of mammalian cells

### Kasper Eersels Hasselt University

Various diseases are associated with changes in the morphology and membrane composition of human cells. For example, the shape of erythrocytes can be indicative for the presence of certain diseases such as sickle cell anemia. In addition, it was shown that blood monocytes display a different phenotype in early stages of atherosclerosis and cancer cells display a different glycosylation pattern in comparison to normal cells. Therefore, a biosensor that would be able to detect small differences between similar cell types would be of great value in modern health care. Previous research has shown that is possible to detect a wide variety of cell types (e.g. mammalian red blood cells) by means of surface-imprinted polyurethane layers. In our work, rebinding of animal and human cells to the imprinted layer is detected by the novel heat-transfer method (HTM) that was previously developed for the detection of point mutations in DNA. To this extent, a home-made polydimethylsiloxane (PDMS) stamp is covered with a monolayer of template cells. The stamp is pressed into a semi-cured polyurethane layer, which is then cured overnight. After removal of the stamp and the cells, a surface-imprinted polymer (SIP) is left behind with binding sites that are functionally complementary to the templating cells. The rebinding of cells to the SIP is detected by analyzing the heattransport through the layer. The increase in thermal resistance, associated with rebinding of the cells to the receptor, can be measured by the HTM set-up in a sensitive, specific and fast manner. In addition, the method is very low cost as it consists only of a thermistor (used as an adjustable heat source), two thermocouples, a proportional-integral-derivative controller (acting as a thermostat) and a data acquisition unit. The read-out is easy to interpret, using an automated Labview program, running on a laptop. These characteristics imply that the proposed biomimetic sensor platform could be a valuable tool in handling various diseases including cancer and atherosclerosis in the future.

### YS2 Doughnut-shaped droplets of liquid crystals

### Vinzenz Koning Leiden University

Nematic liquid crystals are a remarkable phase of matter, sharing properties with both liquids and crystals. Like crystals they are ordered: in a liquid crystal rodlike molecules tend to align along a common axis. It is this order that is responsible for the ability of liquid crystals to modulate light. Indeed, switching your liquid crystal display (LCD) on and off relies on untwisting and twisting this nematic molecular arrangement. We are looking for ways to create and control exotic nematic organisations geometrically rather than electrically. To do this, we exploit a characteristic that nematic liquid crystals share with liquids: they both can form droplets. However, by utilising special properties of the outer medium, we generate stable toroidal droplets rather than the well-studied spherical droplets. The shape of this droplet turns out give rise to a coupling between the local average molecular orientation and the curvature of the boundary of the droplet that favours a `double twist'. Interestingly, this director configuration is chiral, despite the achiral nature of nematics. We compare the twist angle measured in the experiments with the theory.

#### YS3 The day the Earth's magnetosphere lost its bow-shock

### Emmanuel Chané *KU Leuven*

During 24 and 25 May 2002 the solar wind density around the Earth was so low (below 0.1 particle per cubic centimetre) that the Alfvén Mach number dropped below 1. Due to these unusual solar wind conditions, the Earth's bow-shock disappeared and two Alfvén wings formed on the flanks of the magnetosphere. These Alfvén wings are two long structures (estimated extension of 600 Earth radii), where the solar wind plasma is decelerated and the magnetic field direction changes (estimated deceleration of 30% in one wing and 60% in the other wing). During this presentation, we first analyse in situ measurements and show: 1) how the Alfvén Mach number dropped below 1 (data from ACE and WIND) and 2) how the measurements are consistent with the formation of Alfvén wings (the spacecraft Geotail crossed one of the Alfvén wings several times), we then present results of our global numerical simulations for such incoming solar wind conditions. The simulations show how the magnetosphere configuration dramatically changes when

the sub-Alfvénic solar wind reaches the magnetosphere: Whereas the day side magnetopause expends up to 20 Earth radii, the position of the last closed field line on the night side diminishes to 20 Earth radii. As a result the closed magnetic field line region becomes very symmetric. The open field line configuration also changes drastically: while the field lines emanating from the northern hemisphere all point in the direction of the dawn Alfvén wing (around 8:00 local time), the field lines from the southern hemisphere all point in the other wing (around 22:00 local time). During the formation of the Alfvén wings, the lobes completely disappeared and the auroral activity greatly diminished.

## **ABSTRACTS ORAL SESSION**

### PHYSICS AND EDUCATION

### EDUo1 How could a speed course QM look like?

### Henk J. Pol

### Universiteit Twente

'Everybody should know about Quantum Mechanics!' This is easier said than done... By giving QM a place in the secondary school curriculum, we get the opportunity to reveal to our students some of the magic of the quantum world.

In this talk we will argue not to fill these lectures with the usual quantum mechanical 'calculations'. An alternative can be found in the for education necessary connections of physics with the real world, that is by putting QM in contexts and practical's.

#### EDUo2 CERN in the classroom

### Laura Tamassia *KHLim*

An important goal of (physics) education is to create possibilities for young people to develop a deep interest in the world. Research in CERN is a topic with a great potential to trigger the interest of school students.

In this talk, I will present a set of modular learning activities meant for the last two years of secondary school and based on authentic learning materials and CERN digital tools. Some of these activities can be separately integrated in standard lessons as exercises for other physics topics, or they can all be combined to form a longer learning trajectory focused on the prediction and discovery of the Brout-Englert-Higgs boson. This second option offers the possibility to gradually evolve to more open inquiry activities and in this way to develop the research skills of students.

### EDUo3 Some ideas to teach modern physics

## Philippe Leonard *Experimentarium*

In art or in physics, the term 'modern' usually refers to the XX<sup>th</sup> century and not exactly to the contemporary field. Hesitating to teach modern physics today is just like skipping electricity in 1950! However some very contemporary tools allow us to keep modern physics simple, experimental and interesting as well.

### EDUo4 Ideas on professional development

Rita Van Peteghem *CNO*, *UAntwerpen* 

# FUNDAMENTAL INTERACTIONS, PARTICLE & NUCLEAR PHYSICS

## FPNo1 Achievements and prospects of the CMS experiment at the TeV energy scale

### Steven Lowette Vrije Universiteit Brussel

With the discovery of a new particle in 2012, the Large Hadron Collider (LHC) and its experiments already achieved one of their main goals. Detailed measurements of the properties of this particle have revealed that it behaves very much like the predicted H boson, the agent of electroweak symmetry breaking of the Standard Model of particle physics. At the same time, an extensive set of searches and precision measurements revealed no signs of new physics beyond the Standard Model in the new energy regime opened up by the LHC. In this talk, I will review the H boson property measurements and searches for new physics with the CMS experiment during LHC's 2010-2012 run, and discuss how the increase of the LHC collision energy and rate from 2015 onwards rekindles high expectations for discovery of new particles and deeper understanding of physics at the TeV energy scale.

## FPNo2 Evidence for the 125 GeV Higgs boson decaying to a pair of $\tau$ leptons, with the CMS experiment

Cécile Caillol<sup>1</sup> Lucia Perrini<sup>2</sup> CMS Collaboration <sup>1</sup>Université Libre de Bruxelles, <sup>2</sup>Université Catholique de Louvain, CERN

A search for the standard model Higgs boson decaying into a pair of tau leptons is performed using events recorded by the CMS experiment at the LHC in 2011 and 2012. The dataset corresponds to an integrated luminosity of 4.9 fb at a centre-of-mass energy of 7 TeV and 19.7 fb at 8 TeV. An excess of events is observed over the expected background contributions, with a local significance larger than 3 standard deviations for mH values between 115 and 130 GeV. The best fit of the observed H $\rightarrow \tau\tau$  signal cross section for m<sub>H</sub>=125 GeV is 0.78 +/- 0.27 times the standard model expectation. These observations constitute evidence for the 125 GeV Higgs boson decaying to a pair of tau leptons.

## FPNo3 Collinear resonance ionization spectroscopy of 202-206, 218m, 219, 229, 231 Fr isotopes

## Ivan Budincevic KU Leuven

Physics results will be presented on the <sup>202-206</sup>Fr and <sup>218m, 219, 229, 231</sup>Fr isotopes from the Collinear Resonance Ionization Spectroscopy (CRIS) experiment at the ISOLDE facility in CERN [1]. The neutron-deficient francium isotopes 202-206Fr present an interesting physics case, due to the presence of isomeric intruder states originating from the lowering of the  $(\pi 1i_{13/2})_{13/2+}$ ;  $(\pi 2f_{7/2})_{7/2+}$ ;  $(\nu 1i_{13/2})_{13/2+}$  and  $(\pi 3s_{1/2}^{-1})_{1/2+}$ states for neutron-deficient isotopes above Z = 82, with the  $(\pi 3s_{1/2}^{-1})_{1/2+}$  state predicted to be the ground state in <sup>199</sup>Fr [2]. The neutron-rich francium isotopes <sup>218m,219,229,231</sup>Fr are located on the borders of the actinide region in which nuclei are known to possess reflection-asymmetric shapes. <sup>218</sup>Fr exhibits an alternating parity band in its decay scheme [3], while <sup>219</sup>Fr possesses parity doublet bands [4], both of which are associated with reflection-asymmetric nuclear shapes. The magnetic dipole moments and relative mean-square charge radii of these isotopes were extracted from the measured hyper fine spectra. The magnetic dipole moments, along with previously known spin values, were used to determine the valence proton orbital occupation for the ground and isomeric states of <sup>202-206</sup>Fr and for the ground state of <sup>219</sup>Fr. The identification and separation of the ground and isomeric states in <sup>202-204</sup>Fr

was achieved using the technique of decay-assisted collinear laser spectroscopy [5,6]. The ( $^{229,231}$ Fr) results have implications on the spin values of these two isotopes. Analysis of the change in mean-square charge radii suggests an onset of collectivity in the studied neutron-deficient francium isotopes [1]. The relation of the mean-square charge radii odd-even staggering effect and presence of reflection-asymmetric shapes allows certain conclusions to be drawn on the nature of the deformations in  $^{220-228}$ Fr [7].

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### FPNo4 Search for massive resonances in dilepton mass spectra at CMS

### Thomas Reis

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A search for new massive resonances decaying to dileptons is presented. Such heavy resonances are predicted by several theories beyond the standard model, for example grand unified theories or theories with large extra dimensions. The analysis uses the full 2012 dataset recorded by the CMS experiment at the LHC, and corresponding to 20 fb from pp collisions at 8 TeV centre-of-mass energy. 95% confidence level upper limits on the ratio of the new resonances production cross section times branching fraction to the production cross section times branching fraction from the Z boson are calculated. A  $Z'_{SSM}$  from the sequential standard model lighter than 2960 GeV, and a  $Z'_{psi}$  from superstring-inspired theories lighter than 2600 GeV can be excluded at 95% confidence level. Projections for the discovery potential of new massive resonances that decay to dileptons for future runs of the LHC are shown.

## FPNo5 Probing beyond the Standard Model: the neutron EDM experiment at PSI

### Elise Wursten KU Leuven

The reason for our very existence hinges on a tiny asymmetry in matter and antimatter, a direct consequence of so-called CP-violation. The standard model of particle physics cannot explain this asymmetry and thus experimental observations are needed to guide us towards a better theoretical understanding of the universe. A powerful observable for this is the electric dipole moment of the neutron (nEDM). One of the experiments measuring the nEDM is stationed at the Paul Scherrer Institute, where a new ultra-cold neutron source has been built. The nEDM collaboration governing this setup is continuing the experimental effort of the RAL/Sussex/ILL collaboration which has measured the most stringent limit up to now. Their setup has undergone an extensive upgrade, which should enable us to decrease the limit on the neutron electric dipole moment by almost one order of magnitude within the coming years. In this talk, a general overview of the experimental method will be given. The current status of the apparatus at PSI will be presented and the goals for the future will be discussed.

### **CONDENSED MATTER & NANOSTRUCTURE PHYSICS**

### CMNo1 Two dimensional atomic crystals

Hasan Sahin

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Unusual properties of graphene, promising for a variety of novel applications, have also triggered significant interest in one or several atom-thick honeycomb structures of transition metal dichalcogenides (TMDs) [1-3] and binary compounds [4-6]. First I'll talk about TMDs. Atomically thin TMDs are a new class of two-dimensional materials with the chemical formula MX2, where M is a transition metal (Mo and W) and X is a chalcogen (S, Se and Te) element. Monolayer semiconductor TMDs are promising functional materials for next-generation flexible optoelectronics and photovoltaics. STMDs consist of monolayers held together by weak forces where the layers are electronically and vibrationally coupled. Isolated monolayers show changes in electronic structure and lattice vibration energies, including a transition from indirect to direct bandgap. In addition I'll also present a new member of the family, rhenium disulphide (ReS2), where such variation is absent and bulk behaves as electronically and vibrationally decoupled monolayers stacked together.

In the second part of my talk I'll discuss monolayers of III-V compounds and Group IV elements. Based on structure optimization and phonon-mode calculations, we determined that many different honeycomb-shaped monolayer crystals are stable. We also find that all the binary compounds containing one of the first row elements, B, C, or N have planar stable structures. On the other hand, in honeycomb structures of Si, Ge, and other binary compounds the alternating atoms of hexagons are buckled since the stability is maintained by puckering. For those honeycomb materials which were found stable, we calculated optimized structures, cohesive energies, phonon modes, electronic-band structures, effective cation and anion charges, and elastic constants. Si and Ge in honeycomb structure (Silicene and Germanene) are semimetal and have linear band crossing at the Fermi level which attributes massless Fermion character to charge carriers as in graphene. However, all binary compounds are found to be semiconducting with band gaps depending on the constituent atoms. Preliminary results show that the nearly lattice matched heterostructures of these compounds can offer alternatives for nanoscale electronic devices. Similar to those of the threedimensional group-IV and group III-V compound semiconductors, one deduces interesting correlations among the calculated properties of present honeycomb structures.

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### CMNo2 Violation of Leggett-Garg inequality and observation of nonclassical weak values in a superconducting circuit

<u>Thomas Picot<sup>1</sup></u>, Joost Groen<sup>2</sup>, Diego Riste<sup>2</sup>, Lars Tornberg<sup>3</sup>, Julia Cramer<sup>2</sup>, Peter De Groot<sup>4</sup>, Goran Johansson<sup>3</sup>, Leo Di Carlo<sup>2</sup> <sup>1</sup> Laboratory of Solid-State Physics and Magnetism, KU Leuven <sup>2</sup> Kavli Institute of Nanoscience, TU Delft, The Netherlands <sup>3</sup> Microtechnology and Nanoscience, MC2, Chalmers University of Technology, Gothenburg, Sweden <sup>4</sup> Max Planck Institute for Quantum Optics, Münich, Germany

The intrinsically undetermined nature of quantum information is a fundamentally new concept of quantum mechanics without equivalent in any classical deterministic theories. Creating and manipulating quantum systems of ever bigger dimensions is of considerable interest both from a fundamental point of view to test the law of quantum mechanics on macroscopic systems as well as for future revolutionary applications of quantum information processing such as quantum computing and quantum teleportation. To confront experimentally the validity of the law of quantum mechanics against classical deterministic theories at an arbitrary large macroscopic scale, Leggett and Garg have devised a fundamental inequality based on two general assumptions commonly accepted for any classical system [1].

(A1): The value of a physical quantity is well defined at every instant of time.

(A2): The value of this physical quantity can be measured with arbitrary high precision and infinitely small perturbation. A fundamental bound exists for particular correlation functions of any 'classical' system obeying these two assumptions, whereas quantum mechanics predicts that this bound can be exceeded in the case of a macroscopic quantum object. We present a recent experiment with superconducting qubits constituted of a macroscopic number of electrons. Using a novel high quantum efficiency detector, we violate the Leggett-Garg inequality and observe simultaneously non-classical weak values [2]. These results illustrate the pure quantum behavior of this macroscopic system and, in particular, the fundamental quantum back-action of the detector reaching a resolution at the ultimate limit of the Heisenberg uncertainty principle.

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### CMNo3 First principles calculation of the Seebeck effect

<u>Matthieu Verstraete<sup>1</sup></u>, Bin Xu<sup>2</sup> <sup>1</sup>Université de Liège <sup>2</sup>University of Arkansas

Lithium is one of the simplest metals, with negative charge carriers and a close reproduction of free electron dispersion. Experimentally, however, Li is one of a handful of elemental solids (along with Cu, Ag, Au etc.) where the sign of the Seebeck coefficient (S) is opposite to that of the carrier. This counterintuitive behavior still lacks a satisfactory interpretation. We calculate S fully from firstprinciples, within the framework of P.B. Allen's formulation of Boltzmann transport theory. Here it is crucial to avoid the constant relaxation time approximation, which gives a sign for S which is necessarily that of the carriers. Our calculated S are in excellent agreement with experimental data, up to the melting point. In comparison with another alkali metal Na, we demonstrate that within the simplest non-trivial model for the energy dependency of the electron lifetimes, the rapidly increasing density of states across the Fermi energy is related to the sign of S in Li. The exceptional energy dependence of the DOS is beyond the free-electron model, as the dispersion is distorted by the Brillouin Zone edge, a stronger effect in Li than other Aliki metals. The electron lifetime dependency on energy is central, but the details of the electron-phonon interaction are found to be less important, contrary to what has been believed for several decades. Band engineering combined with the mechanism exposed here may open the door to new "ambipolar" thermoelectric materials, with a tunable sign for the thermopower even if either n- or p-type doping is impossible.

### CMNo4 **Probing the atomic vibrations in nanostructured tin** superconductors with synchrotron light

<u>Kelly Houben<sup>1</sup></u>, Sebastien Couet<sup>2</sup>, Tobias Peissker<sup>1</sup>, Ruben Lieven<sup>1</sup>, Maarten Trekels<sup>2</sup>, Manisha Bisht<sup>2</sup>, Johanna Jochum<sup>1</sup>, Daniel Pérez<sup>2</sup>, Bastiaan Opperdoes<sup>1,2</sup>, Thomas Picot<sup>1</sup>, Daniel Géz Merkel<sup>3</sup>, Aleksandr Chumakov<sup>3</sup>, Rudolf Rüffer<sup>3</sup>, Michael Yu Hu<sup>4</sup>, Jiyong Zhao<sup>4</sup>, Esen Ercan Alp<sup>4</sup>, Sam Roelants<sup>5</sup>, Bart Partoens<sup>5</sup>, François Peeters<sup>5</sup>, André Vantomme<sup>2</sup>, Kristiaan Temst<sup>2</sup>, Margriet Van Bael<sup>1</sup>
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### <sup>3</sup>European Synchrotron Radiation Facility (ESRF), Grenoble, France <sup>4</sup>Advanced Photon Source (APS), Argonne National Laboratory, Illinois USA <sup>5</sup>Departement Fysica, Universiteit Antwerpen

Interatomic coupling in crystalline solids gives rise to collective vibrations of the atoms. The behavior of these atomic vibrations, i.e. phonons, influences many material properties, such as thermal and mechanical properties. Furthermore, the interaction of phonons with electrons is of crucial importance in conventional superconductivity. When reducing the system dimensions down to the nanometer scale, deviations in the phonon density of states (PDOS) with respect to the corresponding bulk PDOS are observed. These deviations are the result of phonon confinement effects and the appearance of surface phonon modes [1]. Tin is known as a superconducting material with a bulk superconducting transition temperature (TC) of 3.72 K. An increase in TC of up to 21% has been observed in Sn nanostructures [2]. These changes in TC are (partially) ascribed to changes in the phonon spectrum. While the phonon spectrum of bulk systems is well understood, considerably less is known about the vibrational behavior in nanostructures because of the difficulty of experimentally probing atomic vibrations at this scale. How can atomic vibrations be detected in nanoscale samples? To what extent are phonon effects responsible for the observed phenomena, next to other possible causes such as electron confinement effects? To measure the phonon spectrum, a special nuclear scattering technique using synchrotron radiation is used which probes specifically the <sup>119</sup>Sn isotope. This way, only the phonon contributions are probed allowing to disentangle phonon confinement effects from electron confinement effects. Furthermore, Sn is an interesting material because of a structural transition which is little understood. The  $\alpha$ - to  $\beta$ -Sn transition is very closely related to the atomic vibrations since it is mediated by the difference in vibrational entropy [3]. The Sn phase transition has been studied during an in situ experiment at the ESRF, which constitutes a very clean method of probing the PDOS since oxidation and capping layers can be avoided. Measuring the PDOS at different times during the transition allows to obtain a high level of understanding in the processes involved in the phase transition. The PDOS of  $\alpha$ -Sn layers,  $\beta$ -Sn islands and cluster-assembled films have been studied at the ESRF and at the APS.

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## CMNo5 First-principles studies of charge transfer in nitrogen doped graphene

### Dimpy Sharma, Luc Henrard University of Namur

Two dimensional crystals Graphene are prominent nanomaterials candidates for many applications including nanoelectronics, solar cells or biodevices due to its unique 2D structure, its abundance, its thermal stablity and its unique electronic properties. One of the route to tailor its optical, electronic properties, as well as its reactivity can be done by Chemical doping. We apply Density Functional Theory (DFT) to study the electronic properties and scanning tunneling microscopy (STM) of nitrogen-doped graphene for different doping (from 0.1% to 5%). The charge transfer from the nitrogen atom to the 2D carbon network and the energy of the localized donor states localized on the nitrogen atoms, for single and multilayer graphene have been investigated. We also studied the effects of the periodicity and disorder by supercell techniques. Finally, the consequences on the STM images are emphasized and compare with most recent experimental data [1].

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## **BIOPHYSICS, MEDICAL, STATISTICAL & MATHEMATICAL PHYSICS**

### BMSMo1 Anomalous dynamics of DNA hairpin folding

## Enrico Carlon Institute for Theoretical Physics, KU Leuven

DNA hairpins are single stranded nucleic acids forming at low temperatures a stemloop structure. Hairpin folding is a prototype example of secondary structure formation and shares some common features with the more complex case of protein folding. We present some recent results about the analysis of folding dynamics of DNA hairpins, focusing in particular on the rapid zippering which follows the formation of a stable nucleus of a few base pairs. By means of computer simulations of a coarse-grained DNA model we show that the DNA hairpin zippering dynamics is anomalous, i.e. the characteristic time scales non-linearly with N, the hairpin length. We show that this "anomalous" dynamics originates from an increase in the friction during zippering due to the tension built in the closing strands and introduce a simple model which explains the simulation data. We discuss transition path times data where such effects should be detected.

#### BSMSo2 Oscillatory gene regulatory network modules

### Bruno Lannoo KU Leuven & Lille1

Gene regulatory networks (GRN) are large networks interacting through complex feedback mechanisms [1]. As a first step towards understanding their complex behavior, a lot of eff ort has been devoted in studying the dynamics of smaller modules in the past decades [3]. Here we focus on modules in which a target protein oscillates in time. Oscillatory behavior is found in many processes in the cell. For instance the circadian rhythms which keep control over the daily processes of the cell are driven by genetic modules [3]. But there are also oscillations which are sub circadian like those in NF-kB, p53, Wnt. For the production of these modules we used an improved version of the evolutionary algorithm proposed by Fran cois and Hakim [2]. This algorithm is inspired by the dynamics of an evolving population. After running this algorithm we find a large number of small modules capable of showing oscillatory behavior. We will discuss the simplest ones and go a bit deeper on the characteristics of the heterodimer autorepression loop module, which shows some interesting characteristics not yet discussed in the literature.

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### BSMSo3 Protein adsorption on inert ceramics

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Zirconia and alumina are nowadays extensively used as implants because of their high strength, low corrosion, wear resistance and biocompatibility. Its usage avoids the major concern about the metal ion release. When bioceramics are implanted into the body, they are surrounded by body fluid. These fluids contain a high concentration of proteins that are spontaneously adsorbed on the surface. This layer of adsorbed proteins plays an important role during bone tissue regeneration because it interacts with cells modifying cellular attachment, proliferation and migration processes. Attenuated total reflectance Fourier transform infrared spectroscopy (ATR-FTIR) is a reliable method to obtain quantitative data about the amount of protein adsorbed on the surface and of protein conformation in aqueous condition, real time and in situ. The aim of this work is to use ATR-FTIR to quantify in situ protein adsorption on ceramic surfaces and understand the parameters that control the biocompatibility of these materials and how to promote their osseointegration. Thin films of alumina and zirconia of thickness of 60-80 nm were synthesized using a solgel process and deposited by spin-coating on ATR prisms. Then, the amount of albumin absorbed on the films and its conformation were studied. The observed phases corresponds to alumina and a mixture of zirconia monoclinic and tetragonal phases. We used amide II band area (from 1500 to 1600 cm<sup>-1</sup>) to monitor adsorbed albumin on each film. Signal increases the first 2500 seconds until reaching a saturation, which indicates a balance between adsorption/desorption rates. Then, a solvent rinsing step reduces the signal due to the release of weak-bonded proteins. Finally, a stable signal caused by strong-bonded proteins appeared. Alumina absorbed more albumin than zirconia. However, protein adsorption was an order of magnitude lower in contrast with bioactive ceramics (e.g. calcium phosphates). Amide I band (1600-1700 cm-1) was deconvoluted in 3 different Gaussian bands. 1636 cm<sup>-1</sup> band was assigned to random structures, 1656 cm<sup>-1</sup> to  $\alpha$ -helix and 1675 cm<sup>-1</sup> to turns4. The results for alumina were  $44\pm3\%$  of random structure,  $30\pm3\%$  of  $\alpha$ -helix and  $26\pm3\%$  of turns. The results for zirconia were  $44\pm3\%$  of random structure,  $30\pm3\%$  of  $\alpha$ -helix and  $26\pm3\%$  of turns. The differences in conformation are not significant, but there is a reduction of approx. 20% of  $\alpha$ -helix structures if compared with native albumin in aqueous dispersion.

#### BSMSo4Protein fiber-mediated self-assembly of gold nanoparticle arrays

<u>Olivier Deschaume</u>, Bert De Roo, Margriet Van Bael, Jean-Pierre Locquet, Chris Van Haesendonck, Carmen Bartic Laboratory of Solid State Physics and Magnetism, KU Leuven

Bioinspired and bioinorganic materials science offer unique opportunities to produce and manipulate structures at the nanometer scale, under mild conditions and from minimal amounts of precursors1. In particular, the soft and reversible interactions characteristic of natural systems allow a wide flexibility, but also a surprising specificity in design, leading to hybrid architectures made from building blocks with precisely defined grain sizes, shapes and crystal orientations2. Bioinspired materials science is therefore a perfect complement, and a potential alternative to traditional top-down nanofabrication techniques. Biomolecular templates including DNA3, protein scaffolds4 and living organisms such as virus capsids5 are actively investigated for the preparation of inorganic nanowires and nanoparticle arrays with tunable characteristics for optoelectronic applications. Owing to their hybrid nature and properties, bioinorganic materials can also be applied as efficient biosensing elements or as smart biomaterials for regenerative medicine. In this study, amyloid nanofibers prepared from hen egg white lysozyme are used to specifically mediate the assembly of gold nanoparticles into regular arrays from solutions to the silica surface of glass and silicon substrates. The effect of nanoparticle size and deposition conditions on the self-assembly process is investigated by means of atomic force microscopy (AFM) and UV-visible spectroscopy (UV-Vis). The periodic nanoparticle arrangement observed is mainly influenced by inter-particle interactions rather than by the presence of specific binding groups at the surface of the templates. For a fixed ionic strength and particle concentration, the distance between nanoparticles increases with particle diameter and this trend fits well with theoretical interparticle potential values. In turn, optical properties measured by UV-Vis on large surfaces are correlated with particle arrangements observed at the nanoscale.

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#### **BSMSo5 Diffusion of interacting particles**

## <u>Thijs Becker<sup>1</sup></u>, K. Nelissen<sup>2</sup>, B. Cleuren<sup>1</sup>, B. Partoens<sup>2</sup>, C. Van Den Broeck<sup>1</sup> <sup>1</sup>Universiteit Hasselt <sup>2</sup>Universiteit Antwerpen

Particle diffusion is a ubiquitous phenomenon in nature, with applications in many scientific disciplines. An important case is diffusion in nanoporous materials. Thanks to new techniques [1], a large amount of detailed experimental data is now available for these systems. In an experimental study [2], the self-diffusion (diffusion in equilibrium) and transport diffusion (nonequilibrium) were measured. It was found, for the first time, that the self-diffusion could exceed the transport diffusion. To explain this observation, we study the diffusion of interacting particles on a lattice model [3]. In particular, we investigate the effect of particle interactions on the self-and transport diffusion. This is done both numerically, using Monte Carlo simulations, and analytically, in a type of mean field approximation. The observation that self-diffusion can exceed transport diffusion is explained by a simple analytical argument. Moreover, our model is able to capture many of the general trends observed experimentally, and we obtain quantitative agreement with the experimental results from [2].

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## BSMSo6 Thermal detection of histamine with a graphene oxide based molecularly imprinted polymer platform prepared by reversible addition-fragmentation chain transfer polymerization

<u>Marloes Peeters</u>, Stephan Kobben, Kathia Jiménez-Monroy, Thijs Vandenryt, Andreas Gaulke, Bart Van Grinsven, Thomas Junkers, Patrick Wagner *Institute of Materials Research, Hasselt University* 

Graphene oxide (GO), with its small dimension and high surface-to-volume ratio, can enhance the binding capacity and sensitivity of molecularly imprinted polymers (MIPs) [1]. Therefore, a straightforward and fast method was developed to graft MIPs onto GO by reversible addition-fragmentation chain transfer (RAFT) polymerization [2]. First, the initiator was linked to the GO in a simple two-step process which was verified via UV-vis spectroscopy. Subsequently, a MIP layer for histamine was grown onto the functionalized surface by RAFT crosslinking polymerization, enabling control over the imprint structure. The formation of a hybrid GO-MIP structure, particles surrounded with a polymer network of  $\sim 2.4$  nm, was verified by atomic force microscopy (AFM). Classical batch rebinding experiments demonstrated the specificity of the MIP towards its original template histamine. Next, the heattransfer method (HTM) was applied, a novel sensing technique requiring only two thermocouples and an adjustable heat source. This method has been employed for the detection of small organic molecules with bulk MIPs, but never with a GO-hybrid structure. For proof-of-principle purposes, silicon substrates were functionalized with the GO-MIPs and sensing was performed on histamine in buffer solutions. The designed sensor platform could detect histamine in the nanomolar regime, similar to conventional techniques. In summary, we have developed a fast and straightforward method to prepare MIP-GO hybrids which were able to measure histamine in buffer solutions by thermal detection. Since GO exhibits excellent thermal properties, this opens the window to sensing of small organic molecules in relevant biological samples.

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## BSMSo7 Phase transitions in lipid vesicles detected by a complementary set of methods: heat-transfer measurements, adiabatic scanning calorimetry and dissipation-mode quartz crystal microbalance

Patricia Losada-Pérez<sup>1</sup>, Kathia Jiménez-Monroy<sup>1</sup>, Bart Van Grinsven<sup>1</sup>, Jan Leys<sup>2</sup>, Stoffel Janssens<sup>1</sup>, Christ Glorieux<sup>2</sup>, Jan Thoen<sup>2</sup>, Ken Haenen<sup>1</sup>, Ward De Ceuninck<sup>1</sup>, Patrick Wagner<sup>1</sup>

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The interest on lipid thermodynamics and phase transitions has grown over the last decades motivated by the need to link the phase behaviour of model membrane lipids to the lateral organization in the cell membrane and cell function [1]. In this work we report on the use of the heat transfer method, a novel surface-sensitive technique which is based on heat transfer through solid-liquid interfaces [2], to detect phase transitions of model lipid membranes. Small unilamellar vesicles SUVs were adsorbed on nanocrystalline diamond films known as a versatile platform material for biosensing experiments with outstanding heat-conduction properties. Complementary adiabatic scanning calorimetry and quartz-crystal microbalance measurements were carried out to monitor the phase transitions taking place in multilamellar and SUVs, respectively. The heat transfer measurements revealed reversible jumps upon heating and cooling in the thermal resistance Rth in the vicinity of the expected transition temperature. The results show the capability of the heat transfer method to detect the reversible main phase transition in DPPC, thus opening new perspectives for the study of more complex lipid systems and different solid platforms. This work also confirms quartz crystal microbalance with dissipation monitoring (QCM-D) as a useful tool for the assessment of the structural changes taking place upon the phase conversion and shows the capability of Peltier-element-based adiabatic scanning calorimetry to provide high-resolution thermodynamic information on biophysical systems.

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## BSMSo8 Medical dosimetry with a RL/OSL prototype: 6 MV photon beams

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Contemporary therapeutic radiation oncology treatments require the delivery of highly localized doses of radiation to well defined target regions inside the patient. The efficacy of the radiation treatment, however, requires knowledge of the absorbed dose in the organ of interest to better than  $\pm 5\%$  as there is a higher risk of local recurrence or complications with incorrect exposure. Furthermore, since it is inevitable that healthy organs and tissue will also be exposed during treatment, overexposure increases the risk of secondary cancers. The RL/OSL dosimeter prototype has been developed for the routine assessment of patient exposure to ionizing radiation during radiotherapy treatments. In this study, we present the results obtained using radioluminescence (RL) from Al2O3:C irradiated with a 6 MV linear accelerator (Compact, Elekta, Crawly) and preliminary results obtained using optically stimulated luminescence (OSL). The dose rate dependence was assessed by varying the photon flux (MU/min) of the linac, effectively changing the pulse rate and keeping the dose per pulse fixed. It was found that the RL measured dose response demonstrated low dose-rate dependency, to within 1%. The dose response was found to be linear in a dose range from 0.1 up to a dose of 6 Gy, with reproducibility below 0.5%. The dosimeter is benchmarked by evaluating the ability to measure depth-dose distributions and lateral dose profiles accurately. RL derived dose profiles have been compared with dose profiles measured with a standard ion chamber (PTW). Depth-dose distributions in water were acquired for a 6 MV photon beam using a 10×10 cm2 field, set at 350 MU/min, corresponding with 3.5 Gy/min at 10 cm depth. All data have been normalized to the depth-dose maximum. The RL measured dose agreed with the ionization chamber measured dose to within 1% (1 SD) for depths from 0.5 to 20 cm. Lateral dose profile was set at 350 MU/min (3.5 Gy/min at depth 10 cm), using a 10x10 cm2 field size. Differences between measured RL and ion chamber are within 1.5% for de direct beam and 5% in the penumbra region. These results show that the RL/OSL detector system makes it suitable for measurements of depth and lateral dose distributions in clinical photon beams.

## **ATOMS, MOLECULES, OPTICS & PHOTONICS**

### AMOPo1 Imaging of a chiral molecule in the gas phase

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Chiral molecules exist in two different configurations which are non-superimposable mirror images of one another. The respective configurations are referred to as enantiomers. Most methods to distinguish between enantiomers rely on interactions with polarized light. However, to infer the underlying handedness of the molecular structure (the absolute configuration) from spectroscopic measurements is nontrivial. Here we present foil-induced Coulomb Explosion Imaging measurements of isotopically labeled dideuterooxirane ( $C_2H_2D_2O^+$ ). Our experiments allow for the determination of the handedness of enantioselected samples by direct imaging of individual molecular configurations [1,2]. Our method requires no quantum-chemical calculations, and it can be applied to small species like epoxides, where the chiral information is carried by light atoms exclusively.

In this talk I will first introduce the Coulomb Explosion Imaging technique using the illustrative example of metastable negative hydrogen molecular ions  $H_2^-$  [3]. In the second part I will describe our experiments with chiral molecules.

[1] P. Herwig et al., Science 342, 1084 (2013)

- [2] K. Zawatzky et al., Chem. Eur. J. 20, 5555 (2014)
- [3] B. Jordon-Thaden et al., Phys. Rev. Lett. 107, 193003 (2011)

### AMOPo2 The geometric structure of transition metal doped silicon clusters

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Silicon-based clusters have attracted continuous attention due to numerous technological applications of silicon. Contrary to carbon, silicon favors sp<sup>3</sup> hybridization rather than sp<sup>2</sup> hybridization, which leads to rather asymmetric and reactive structures for silicon clusters and makes the formation of cage-like structures unstable, which can be overcome by introducing transition metal dopant. It is wellknown that the physical and chemical properties of clusters can significantly be changed upon appropriate doping. Therefore, the knowledge of the structure of doped silicon clusters will be vital to understand their properties. Here, we have explored the geometric structures of cationic  $Si_nAg^+$  (n = 6-11) clusters using infrared multiple photon dissociation (IR-MPD) and of neutral  $Si_nCo$  (n = 10-12) clusters by a tunable IR-UV two-color ionization scheme, in combination with density functional theory computations. Based on the comparison of experimental and calculated IR spectra for the identified low energy isomers, structures are assigned. It is found that all SinAg+ (n = 6-11) clusters have exohedral structures. This is a surprising result since many transition metal dopant atoms have been shown to induce the formation of endohedral silicon clusters. The silicon framework of  $Si_nAg^+$  (n = 7–9) has a pentagonal bipyramidal building block, while the larger  $Si_nAg^+$  (n = 10–12, 14, 15) clusters have trigonal prism based structures. Comparing the structures of  $Si_{n}Ag^{+}$  with those of  $Si_nCu^+$  (for n = 6-11), the Ag dopant atom takes a lower coordinated site and is weaker bound to the  $Si_n^+$  framework than the Cu dopant atom. On the other hand,  $Si_nCo$  (n = 10–12) clusters have endohedral caged structures. Electronic structure analysis indicates that the clusters are stabilized by an ionic interaction between the Co dopant atom and the silicon cage due to the charge transfer from the silicon valence sp orbitals to the cobalt 3d orbitals. Strong hybridization between the Co dopant atom and silicon host quenches the local magnetic moment on the encapsulated Co atom. The different growth patterns of those clusters indicate that the atomic radius and the filling of the d orbitals of the dopant atom plays an important role in determining the critical size for cage formation of the transition metal doped-Si clusters, however, the bonding properties and electronic structure (i.e. orbital hybridization between the dopant atoms and Si atoms) cannot be ignored.

## AMOPo3 Plasmon hybridization in pyramidal metamaterials for ultrabroadband absorption

### Michaël Lobet, Michaël Sarrazin, Olivier Deparis, Luc Henrard Université de Namur

Over the past years, the need for thin films structures absorbing electromagnetic radiation over a broadband spectrum has become crucial in photovoltaic cells, thermal emitters or infrared detectors systems. Moreover, those structures could prevent cross-talks between optical interconnects in an all-in-one optical chip. Metamaterials can provide unprecedented ways to mold the flow of light at the nanoscale. Particularly, pyramidal metamaterials are developed for such ultrabroadband absorbers [1-3]. They consist of periodic arrays of alternating metal/dielectric layers forming truncated square-based pyramids. The metallic layers of increasing lengths play the role of coupled plasmonic resonators while the pyramidal shape also insures anti-reflection coating. The present numerical work exploits the concept of multilayer Au/Ge pyramidal structures in order to demonstrate the possibility to greatly extend the spectral range over which nearly total absorption (> 90%) is achieved [3]. We obtain here an ultra-broadband operation ranging from 200 nm to 5.8 µm, encompassing the UV-visible, the near-infrared and mid-infrared regions. The total absorption (integrated over the operational bandwidth) reaches 98.0% after optimization. Plasmon hybridization of dipolar and multipolar modes of coupled layered resonators is revealed to be responsible for the ultra-broadband characteristic. Fields maps and Poynting vector flux support this interpretation. Versatility in the choice of the dielectric spacer material is highlighted (Si versus Ge) as well as omni-directionality and polarization independence of the absorption. The tuning of plasmon hybridization is shown to be a key parameter to tailor the ultrabroadband absorption properties of metamaterials.

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- [2] L. Qiuqun, Y. Weixing, Z. Wencai, W. Taisheng, Z. Jingli, Z. Hongsheng and T. Shaohua, "Numerical study of the meta-nanopyramid array as efficient solar energy absorber", Opt. mat. Exp. 3, 8 (2013)
- [3] M. Lobet, M. Lard, M. Sarrazin, O. Deparis, L. Henrard, "Plasmon hybridization in pyramidal metamaterials: a route towards ultra-broadband absorption", Opt. Express, in press (2014)

#### AMOPo4 The role of weak values in quantum state reconstruction

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## <sup>2</sup> Department of Sciences, Philosophies and Societies, Université de Namur

During the last several decades, there has been considerable advancement in the study of quantum measurements, which differ from the standard projective measurements. In particular, pre- and post-selected measurements and non-ideal measurements with varying interaction strength have been studied with increasing interest. One of the most surprising discoveries was the measurement of the weak value [1], which appears for pre- and post-selected sub-ensembles with weak interaction strengths. Weak values are unusual mean values of an observable which can be complex or far outside the range of the eigenvalues. These strange properties gave rise to controversy and the physical meaning of weak value has not been fully understood yet. Notwithstanding their physical significance, weak values proved to be very useful in various fields of physics. Recently, a new technique based on the weak values has been used to reconstruct directly the quantum state of photons [2, 3]. In our research, we show that the application of different quantum gates and projection measurements of a qubit and an arbitrary quantum system allows us to bring the real and the imaginary parts of weak values in a direct relationship with measurable probability amplitudes. The last ones appear as interference terms in the calculated and measured two-event probabilities. These theoretical results are used for the measurement of the weak value of the Pauli-operator  $\sigma_z$  in a two-qubit system. Using these data, we determine directly the density matrix of the polarization state of an entangled photon pair produced by the nonlinear process SPDC (type I spontaneous parametric down-conversion). This direct measurement of the density matrix is an alternative technique to the generally used quantum state tomography [4]. Furthermore, we point out the essential role of the post-selection in our method, as our measurements of weak values are modeled theoretically without applying the weak measurement approximation in our calculations. All these results point to an interferometric interpretation of the weak value.

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[2] J. S. Lundeen, et al. Nature, 474, 188–191 (2011)

[3] J. Z. Salvail, et al. Nature Photonics 7, 316 – 321 (2013)

[4] "Photonic State Tomography", Advances in Atomic, Molecular, and Optical Physics, Elsevier, Volume 52, Pages 10 –442 (2005)

## AMOPo5 Nonlinear interferometry and enhancing of the contrast using femtosecond gate

#### Kamel Mallat

#### Université Catholique de Louvain

A difficulty often encountered in tomographic method like FDOCT is when strong undesired scattering and weak desired scattering interfaces exist across the sample depth range, An elegant solution to eliminate the strong scattering(enhance the contrast) is to exploit the possibilities of the nonlinear optics. The idea is to mix in a nonlinear crystal type II, the laser beams from the two arms of the interferometer. By exploiting the polarization properties of the light, and by using a second autocorrelator setup, it is possible by to generate a polarization proportional to the product of the intensities of the two pulses that arrive synchronously from the reference and the sample arm. So by aligning the reference path arm to the backscatter from the weak interfaces of interest, the strong undesired backscattered light can be removed. In order to eliminate the DC completely the two orthogonal pulses must coincide with the ordinary and the extraordinary axis of the crystal, but this will lead to removing the Michelson fringes. We demonstrated that Michelson fringes can be observed when turning the crystal around the field direction, and the contrast of these fringes can be controlled and it is function of the rotational angle. Since Michelson fringes will disappear if we want to remove the DC completely, we should realize fringes in the sample arm only, this is possible using Fizeau interferometer.

### **ASTROPHYSICS, GEOPHYSICS & PLASMA PHYSICS**

### AGPo1 A spectral discretization of a kinetic plasma model: comparison with the Particle-in-Cell method

Enrico Camporeale Centrum Wiskunde & Informatica, Amsterdam (NL)

We discuss a spectral method to solve the Vlasov equation for collisionless plasmas, by means of an expansion of the distribution function into a Fourier-Hermite basis. We have devised both a semi-implicit and a fully-implicit time discretization. The latter has the property of exactly conserving charge, momentum, and energy. The proof-of-principle results are obtained for the 1D-1V Vlasov-Poisson equation. We show results for several cases routinely used as benchmarks in computational plasma physics, and we compare the performance of this approach with a standard Particlein-Cell (PIC) method. It is shown that the Fourier-Hermite method can achieve a much more accurate solution in a tiny fraction of the computational time relative to PIC, with orders of magnitude higher efficacy (a measure of the cost-effectiveness of the algorithm).

## AGPo2 Core and filament formation in magnetised, self-gravitating layers

### Sven Van Loo, Eric Keto, Qizhou Zhang Harvard-Smithsonian Center for Astrophysics

Molecular clouds exhibit a hierarchical density structure with stars forming in their densest regions. Often, these star-forming complexes have an elongated, filamentary shape. Recent Herschel observations of such filaments show a column density profile that deviates from hydrostatic equilibrium. Several explanation have been proposed, but have not elucidated the formation process. We will discuss the formation of filaments in self-gravitating layers by gravitational instabilities. Self-gravitating layers are unstable to perturbations and fragment into clumps or thin filaments. When the layers are threaded by magnetic fields, fragmentation is still possible. Numerical simulations of the gravitational instability in magnetised layers produce density structures similar to observed ones. The filament network that forms is either a hubfilament or a parallel-filament network depending on the magnitude of the magnetic field. Although the filaments are collapsing, the central region of the filament can be perfectly described by an equilibrium density distribution. Excess mass accumulates at radii larger than the scale height resulting in a density and column density distribution that is flatter than for an equilibrium cylinder. We do not reproduce the quasi-constant filament width because no additional support is provided even though we include magnetic fields. Finally, using SMA polarization observations, we will interpret the filamentary network of the massive star forming complex G14.225-0.506 in terms of the gravitational instability model.

#### AGPo3 Solar wind modeling

## Michael Pieters Belgian Institute for Space Aeronomy

Not only does the Sun radiate light of different frequencies, it also blows out huge bubbles of supersonic plasma, engulfing all planets and a host of other bodies, shaping their environment. Solar wind related phenomena include geomagnetic storms on Earth, aurora and comet plasma tails. Although Parker was the first to describe the solar wind succesfully at the time, his elegant theory still masks a number of fundamental problems. The debate how the solar wind is accelerated and why the solar corona is so 'hot', is still in full swing. Nevertheless this does not seem to hamper solar wind modeling which has become increasingly more complex as is the picture of the solar wind itself. Hence modeling the solar wind is a huge undertaking. Before one can even start to cook, a lot of computational 'kitchen tools' are required. Ingredients are also hard to come by: initial conditions near the Sun (to drive models) are scarce. So one has to rely mostly on magnetograms and/or white-light coronagraphs. An overview will be given what the general strategy is to model the solar wind and the many pitfalls that one can encounter.

## AGPo4 The Kelvin-Helmholtz instability as a source for kinetic turbulence

<u>Koen Kemel<sup>1</sup></u>, Giovanni Lapenta<sup>1</sup>, Pierre Henri<sup>2</sup>, Stefano Markidis<sup>3</sup>, Francesco Califano<sup>4</sup> <sup>1</sup> CmpA, KU Leuven <sup>2</sup> CNRS, Université d'Orleans, France <sup>3</sup>KTH, Stockholm, Sweden <sup>4</sup>Physics Department, University of Pisa, Italy

We studied numerically the Kelvin-Helmholtz instability as a source for generic turbulence in a magnetised, two-dimensional collisionless plasma. In two subdomains of the simulation, the magnetic field was approximately aligned and anti-aligned with the vorticity of the shear flows. We found that for the magnetic field, the turbulent spectrum was largely isotropic in both turbulent boundary layers and agreed with earlier observations and theoretical estimates. However, the behaviour of the electric energy scaling does not match these and is strongly different between the layers. The relatively laminar zones show a population of hot electrons, diffused from the 44

turbulent zones while the latter remain Maxwellian, implying a thermalisation process. This agrees with a measured imbalance of Ohm's law proportional to the current.

## AGPo5 **Progress in the ion cyclotron resonance heating of (3He)-H** tokamak plasmas in support of ITER

Yevgen Kazakov, Dirk Van Eester, Ernesto Lerche Laboratory for Plasma Physics, Royal Military Academy

Ion cyclotron resonance heating (ICRH) has been used successfully for bulk ion and electron heating in fusion devices. It is foreseen as one of the additional heating systems to be installed at the ITER tokamak. At the initial stage of ITER operation, predominantly hydrogen or helium-4 plasmas will be used, to minimize the neutron generation and the activation of the tokamak components [1]. The existing scalings suggest that the power threshold to access the regime of high confinement in hydrogen plasmas is a factor of two higher than for deuterium plasmas. Hence, there is a concern if one can rely on H-mode operation in hydrogen plasmas in ITER with the heating powers that will be available. Thus, it is particularly important to optimize the efficiency of the heating systems, including ICRH, for the scenarios relevant for this initial stage of ITER. The present paper discusses recent theoretical and experimental achievements on the optimization of the fundamental cyclotron heating of helium-3 minority ions, which is the main ICRH scheme for the full-field hydrogen phase of ITER. The (<sup>3</sup>He)-H heating scenario has been experimentally studied at JET for various <sup>3</sup>He concentrations [1, 2]. Those JET experiments were performed with the carbon wall and revealed a significant impact of intrinsic impurities on the ICRH performance. High plasma contamination with carbon ions resulted in the appearance of a supplementary mode conversion layer, substantial radial shift of the heating region and low 3He concentrations marking the transition from minority to mode conversion heating. In view of the installation of the new ITER-like wall at JET, the effect of beryllium and tungsten impurities, replacing carbon, in (<sup>3</sup>He)-H plasmas heated with ICRH has been studied in [3]. As the price of <sup>3</sup>He gas has been continuously increased, a potential method to reduce the <sup>3</sup>He level needed for efficient ICRH heating has been proposed. New series of JET experiments on optimizing (<sup>3</sup>He)-H heating scenario are scheduled for the fall of 2014 [4]. Here, we present results of the accompanying 1D and 2D full-wave modeling to identify and optimize plasma and ICRH parameters, in preparation of the forthcoming experiments.

[1] M.-L. Mayoral et al., Nucl. Fusion 46, S550 (2006)

[2] D. Van Eester et al., Plasma Phys. Control. Fusion 54, 074009 (2012)

[3] Ye.O. Kazakov et al., Nucl. Fusion 53, 053014 (2013)

[4] http://users.jet.efda.org/tfwiki/index.php/H14-09:\_ICRF\_heating\_studies

## AGPo6 Magnetic reconnection in turbulent space plasmas: null-points or pinches?

<u>Vyacheslav Olshevsky</u><sup>1</sup>, Giovanni Lapenta<sup>1</sup>, Stefano Markidis<sup>2</sup>, Andrey Divin<sup>3</sup> <sup>1</sup> CmpA, KU Leuven <sup>2</sup>KTH, Stockholm, Sweden <sup>3</sup>Swedish Institute of Space Physics

We report particle-in-cell simulations of magnetic reconnection in the configuration containing both null-points and pinches. All indicators suggest that secondary magnetic reconnection driven by kinking of the pinches plays a dominant role in the energetics of the system. While there is no substantial energy dissipation in the vicinity of X-type null-points. Such reconnection results in tremendous release of magnetic energy, generation of suprathermal particles and waves. Similar scenario may take place in turbulent space plasmas, where current channels and twisted magnetic fields are detected.

## AGPo7 Effects of solar illumination on ionospheric outflows in fieldaligned acceleration regions above the polar caps

Lukas Maes, Romain Maggiolo, Johan De Keyser Belgian Institute for Space Aeronomy

When the interplanetary magnetic field is directed northwards for long periods, optical luminescent arcs frequently appear in the polar ionosphere. They are similar to auroral arcs, but located at higher latitudes. These polar cap arcs are created by quasi-static electric fields parallel to the Earth's magnetic field (or field-aligned electric fields in short), accelerating electrons downwards into the atmosphere and ionospheric ions upwards. Such accelerated ion beams have been observed by the ESA Cluster spacecraft which crosses the polar cap region at altitudes between ~4

and ~9 Earth radii. Since solar illumination changes the ionization in the ionosphere, and consequently modifies its composition and electric conductivity, the flux of ions coming from the ionosphere is expected to be affected as well. Therefore we made a statistical analysis of the properties of the upflowing ion beams as a function of solar illumination in the local ionosphere using a set of  $\sim$ 70 events observed by the Cluster spacecraft. The ion beams above the polar cap are also interesting to investigate the properties of cold, low density plasma flowing out of the polar ionosphere, called the polar wind. Indeed, polar wind ions are very difficult to measure, due to positive spacecraft charging, which repels ions with too low energy to overcome the spacecraft potential. While there are indirect ways to measures the plasma density, the composition of this ion population is still inaccessible. In the field-aligned electric fields, the ions beams are accelerated to high enough energy to overcome this barrier and be measured by the ion detector aboard the spacecraft. Thus the field-aligned electric fields can be seen as an extension of the experiment, providing enough energy to the ions to allow them to enter the ion detector. The upflowing ion beams mostly consist of a mixture of H+ and O+ ions. Using Cluster observations, we show that the amount of O<sup>+</sup> ions is higher above the sunlit polar cap than above the dark polar cap. We also show that the field-aligned acceleration is affected: no low field-aligned potential drops (~below 300 V) are found above the dark polar cap contrary to above the sunlit polar cap. This study illustrates how the properties of the local ionosphere, such as its composition and conductivity, can affect atmospheric erosion. It both modulates the composition of the ions extracted from the ionosphere and the acceleration processes energizing them.

## **ABSTRACTS BEST POSTER CONTEST**

# FUNDAMENTAL INTERACTIONS, PARTICLE & NUCLEAR PHYSICS

## BP1 Electroweak (VBF) production of a Z boson in association with forward/backward jets at CMS

### <u>Tom Cornelis</u> Universiteit Antwerpen

The first measurement of the electroweak production cross section of a Z boson with two jets (Zjj) in pp collisions at  $\sqrt{s}$  =7 and 8 TeV is presented, based on a data sample recorded by the CMS experiment at the LHC with an integrated luminosity of 5 and 19 fb<sup>-1</sup>, respectively. The hadronic activity in events with Z-boson production in association with jets is also studied, in particular in the rapidity interval between the jets.

#### BP2 Glueballs and the Yang-Mills plasma

### Gwendolyn Lacroix Université de Mons

Understanding the QCD phase transition is a fascinating topic since RHIC and LHC have pointed out some evidences of the existence of the Quark-Gluon Plasma (QGP). From a theoretical point of view, the understanding of the QGP has motivated in particular many lattice QCD studies, focusing mostly on the structure of the QCD phase diagram, but also a great number of works resorting to phenomenological approaches. These approaches can provide us a more intuitive picture of the physical mechanisms underlying the QCD phase transition and characterising the QGP.

In this poster, we address the question of the existence of bound states and of the equation of state in pure glue QCD in the deconfined phase. Our approach is a quasiparticle approach in which we have explicitly taken into account the 2-body interactions thanks to the T-matrix formalism. Within the same formalism, we are able to show that glueballs may exist after deconfinement and that the obtained equation of state agrees well with recent lattice data.

#### BP3 New signalling techniques for an upgraded IceCube detector

Elisa Pinat, Kael Hanson Université Libre de Bruxelles

Future IceCube upgrades may include the Precision IceCube Next Generation Upgrade (PINGU), the High Energy Extension (HEX), and the Surface Extension (SE). PINGU is a proposed low-energy in-fill extension to the IceCube Neutrino Observatory, located at the geographic South Pole, which will increase IceCube's sensitivity at neutrino energies down to a few GeV with a multi-megaton effective volume. PINGU will probe the neutrino mass hierarchy (NMH) as well as provide measurements of neutrino oscillation parameters. On the other hand, both HEX and SE aim to augment the observatory's science reach at the high end of the energy spectrum: recent analysis of IceCube data has vielded the first detection of a highenergy extraterrestrial neutrino flux. This analysis benefits from the use of wellcontained events and veto layers. HEX and SE will aim thus at enlarging the effective volume of the detector and the atmospheric background vetoing capability. Both PINGU and HEX/SE will need new hardware to be deployed in ice: based on the current IceCube Digital Optical Module (DOM) as a starting point, the new DOMs offer big improvements. Together with the optical modules, the communication system must undergo a big change: the need to increase the number of detector channels per communication pair requires an overhaul of the existing communication system. In addition, improving the robustness of the communication system, increasing the time accuracy and reducing timing systematic offsets are among the technical goals. Currently new communication techniques are under investigation. We present the status of the simplest modulation technique studied, that is Binary Phase Shift Keying.

### **CONDENSED MATTER & NANOSTRUCTURE PHYSICS**

# BP4 Ultra-stable glass properties revealed by simultaneous dielectric and ac calorimetric measurements

## Angeline Akelo Kasina, Michael Wubbenhorst KU Leuven

Two approaches are typically used to prepare glasses; namely ultrafast cooling to quench the liquid below the freezing temperature and preparing amorphous films

directly from the vapor phase by condensing the molecules onto a cold substrate. This study investigates molecular dynamics and thermal signature of ultra-dense glasses by means of in-situ simultaneous broadband dielectric spectroscopy and accalorimetric measurements. The ultra-dense glasses are produced by slow vapour deposition of organic molecules from the gas phase on to a cooled target. After deposition the dielectric as well as the calorimetric response is monitored during heating from glassy state to adsorption. This is done with an aim of studying the correlation between glass density and local order. The role of substrate topology in introducing or preventing orientational order and glass stability is also investigated. By means of calorimetry, kinetic stability of the glasses are analyzed by calculation of heat capacity.

## BP5 Thermal Properties of Synthetic Spider Silk by Photothermal Fluorescence

<u>Troy Munro<sup>1,2</sup></u>, Christ Glorieux<sup>1</sup>, Heng Ban<sup>2</sup>, Cameron Copeland<sup>2</sup>, Randolph Lewis<sup>2</sup> <sup>1</sup> KU Leuven <sup>2</sup> Utah State University

Spider silks exhibit excellent strength, stiffness, and toughness simultaneously, a feat unachievable in most synthetic structural materials. Recently, it was reported that natural dragline silk from the Nephila clavipes spider has a thermal conductivity similar to that of copper, while a more recent study has reported a value two orders of magnitude lower. Synthetic spider silk fibers have been developed with the potential to mimic natural dragline silk's behavior and provide the potential to tune a fiber's properties based on the production process of the silk. To measure the thermal conductivity and diffusivity of the synthetic silks, the fibers are coated in Rhodamine B dye for use as a fluorescent thermometer. Laser heating will be applied and the axial thermal conductivity and diffusivity of the fibers will be extracted from the fluorescent temperature data by means of a neural network.

#### BP6 Annealing Effect of Sol-Gel Deposited ZnO Film

<u>Ahmet Yasin Atalay<sup>1</sup></u>, Ayşe Evrim Saatci<sup>2</sup>, Pelin Kavak<sup>2</sup>, Patrick Wagner<sup>1</sup>, Orhan Özdemir<sup>2</sup>, Kubilay Kutlu<sup>2</sup> <sup>1</sup> Institute for Materials Rsearch IMO-IMOMEC, Hasselt University <sup>2</sup> Department of Physics, Yildiz Thecnical University, Esenler, Instanbul, Turkey

Zinc oxide (ZnO) as a transparent II-VI compound semiconductor has attracted intensive research effort for its unique properties and versatile material with the potential for use in semiconductor electronics, optoelectronics and other photovoltaic devices due to wide band-gap and high transmittance in the visible part of the spectrum.

ZnO thin films were produced by sol-gel method on soda lime glass (SLG) and Zinc oxide dihydrate used as a main precursor. ZnO thin films were investigated through thermogravimetric and differential thermal analysis (TG-DTA), Attenuated Total Reflectance, Fourier Transform Infrared Spectroscopy (ATR-FTIR) and UV-Vis transmission spectroscopies to find out its structural and optical properties. The chemical and physical changes of ZnO thin films characteristics as a function of temperature investigated by TG-DTA analysis. The obtained data by TG-DTA was taken as a refence to examine the effect of annealing temperature. Moreover, annealing effects on the present films were monitored by the mentioned techniques after performing TG-DTA analysis on precursor to select the annealing temperature. The deposited ZnO films of 1, 3, 6 layers were annealed at 200°C, 300°C, 400°C for one hour. UV-Vis spectrophotometry method revealed the optical transmittance and ultraviolet emission property. The optical band-gap values of the ZnO thin films were obtained by analyzing the absorbtion edge and the values of the determined bandgaps are 2.66eV and 3.19eV. The refractive index of the film was determined by using UV-Vis data. Dielectric constant of the film was calculated from refractive index as  $\varepsilon_{7n0}=n_2\varepsilon_0$  and the value is  $6.25\varepsilon_0$ . FTIR spectroscopy was used to acquire spectra of compounds and indentify the molecules regarding vibration mods of bonds. Therefore, this work reports a comparison between the growth of ZnO thin films due to annealing temperature and structural properties by examining with ATR-FTIR and UV-Vis transmission spectroscopic methods.

#### BP7 Disordered graphene Josephson junctions

### <u>William Armando Munoz</u>, Lucian Covaci, Francois Peeters Universiteit Antwerpen

Since disorder is inherent in graphene synthesis or because of the method in which it is embedded in the substrate, we study the effect of the disorder on the Andreev states of a graphene Josephson junction. From the Dirac perspective it is expected than disorder that preserve time-reversal symmetry does not affect the Andreev scattering. However, tight binding based calculation shown that Andreev reflection can been affected by inhomogeneous strain [1] suggesting that lattice distortion modifying the trajectory of the electron or the reflected hole affect the Andreev reflection process. In our work we consider the most common types of disorder found in graphene: vacancies, ripples and charges pockets. Stochastic calculations of the density of states detail the influence of these disorder mechanisms over the Andreev states for different configurations. Vacancies are shown to affect strongly, even for lower concentration where low energy Andreev peaks are suppressed as concentration increases. Gaussian bumps-like ripples seem to influence according to the magnitude of the pseudo-magnetic field induced by the lattice deformation. On the other hand, in the presence of non-magnetic impurities we show that the effect on the Andreev peaks is given according to the smoothness of the disordered potentials. The Josephson current is influenced accordingly to the electron-hole scattering in the disorder junction.

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## **BP8** Sputter deposition of multi-component alloy thin films by using powder targets

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Since the beginning of the 21st century, a novel approach to design alloys with promising properties has been introduced. High Entropy Alloys (HEA) are composed of five or more principal elements in equimolar ratios. The high mixing entropy can significantly reduce the Gibbs free energy, and thus single-phase multi-component solid solutions are thermodynamically stable, especially at high temperature. In contrast to conventional alloys, the large number of elements will not lead to complex

systems but remain fairly simple, essentially amorphous or fcc and/or bcc crystalline structures. HEA have excellent properties such as high hardness and strength, corrosion resistance and thermal stability, which makes them suitable for a range of applications. The majority of the research on HEA has been focused on bulk alloys, however HEA as thin films have not yet been extensively studied.

This work investigates some key parameters of sputter deposited multi-component thin films using powder targets. The use of cold pressed powder targets allows to control the composition of the target, and hence the film, in a flexible way. This approach has the advantage of using only one magnetron. Out of 5 principal elements (Al, Cr, Cu, Ta and Ti), binary, ternary, quaternary and quinary alloys have been deposited. The sputtering behavior of the powder targets will be discussed. The resulting composition of the films have been studied with SEM-EDX and compared to the original target composition. The crystallographic properties of the films have been studied by XRD. Some interesting trends related to the phase composition will be discussed, and confronted with published trends for bulk high entropy alloys and metallic glasses.

#### BP9 Braess paradox at the mesoscopic scale

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We theoretically demonstrate that the transport inefficiency recently found experimentally for branched-out mesoscopic networks can also be observed in a quantum ring of finite width with an attached central horizontal branch. This is done by investigating the time evolution of an electron wave packet in such a system. Our numerical results show that the conductivity of the ring does not necessary improves if one adds an extra channel. This ensures that there exists a quantum analogue of the Braess Paradox, originating from quantum scattering and interference.

### BP10 Self-doping of ultrathin insulating films by transition metal atoms

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Deposition of metal atoms on solid surfaces is usually employed to study nucleation and growth of metal nanoparticles that are relevant for heterogeneous catalysis, sensors, optical and magnetic data storage, etc. Growth of ultrathin films of insulating materials on a metallic substrate prior atom deposition can provide additional control of the coupling of the metal adsorbates with the metallic substrate [1-3]. Soft landing of metal atoms on insulating thin layers is typically noninvasive and results in cluster growth with little or no surface damage.

Here, we demonstrate an uncommon case of spontaneous doping by transition metals on ultrathin insulating films. Individual magnetic atoms (Co and Cr) are deposited on atomically thin NaCl films on Au(111). Two different adsorption sites are revealed by high-resolution scanning tunneling microscopy (STM), i.e., at Na and at Cl locations. Using density functional based STM simulations, we show that the magnetic atoms substitute with either a Na or a Cl atom of the NaCl surface, resulting in cationic and anionic dopants with a high thermal stability. Moreover, since the dopants bear large localized magnetic moments, the dimers represent an ideal system to study magnetic interactions between diluted magnetic impurities in an insulating matrix. By mapping the local density of states, the dependence of the magnetic coupling between neighboring magnetic atoms on their separation is investigated. The here reported self-doping of an insulating material by magnetic atoms may open a novel route to tune catalytic, optical, magnetic, and transport properties of materials.

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# BP11 PCDTBT:[70]PCBM blend nanoparticles for opto-electronic applications

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Conjugated polymer nanoparticles (NPs) recently gained large interest as a new class of functional nanomaterials. For bulk heterojunction organic photovoltaics, the formulation of NPs as confined packages of active layer blend materials provides the possibility to study the morphology-dependent electro-optical properties in depth on the nanoscale. Here, the NPs can be regarded as intermediate systems between bulk films and single molecules, as they offer the functionality of bulk materials but without significant heterogeneity. [1,2]

In this contribution, eco-friendly water-based blend NP dispersions of the low band gap donor polymer poly[[9-(1-octylnonyl)-9H-carbazole-2,7-diyl]-2,5-thiophenediyl-2,1,3-benzothiadiazole-4,7-diyl-2,5-thiophene-diyl] (PCDTBT)[3] and the fullerene acceptor phenyl-C71-butyric acid methyl ester ([70]PCBM) were prepared using the miniemulsion technique[4,5] and characterized for their relevance in the field of opto-electronic devices. The optical properties of the NP dispersions with different PCDTBT:[70]PCBM ratios were studied using UV-Vis absorption and stationary as well as time-resolved fluorescence spectroscopy to achieve insight into the polymer conformation and the interaction with [70]PCBM.

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## BP12 Formation and STM characterization of nanoporous DBA molecular networks

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Self-assembled two-dimensional (2D) molecular networks have an excellent potential as templates for memory, sensors and spintronic applications [1]. In this study we successfully demonstrate the formation and evolution of molecular networks of triangular dehydrobenzoannulene with butoxy groups (DBA-OC<sub>4</sub>) [2]. Using ultrahigh vacuum (UHV) scanning tunneling microscopy (STM) at helium temperature only single DBA molecules on Au (111) are observed in the early stages of the deposition process and no networks are formed. A controlled reconfiguration of an isolated molecule can be obtained by applying a voltage pulse and is witnessed by a jump in the tunneling current. Maps of the local density of states at different voltages reveal a series of unoccupied molecular orbitals. The formation and expansion of 2D molecular networks can be promoted by post-annealing at a temperature close to the evaporation temperature of the molecules. The confinement of the surface state electrons of the Au substrate within the pores of the network is clearly evidenced by a shift of the STM spectral features [3].

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## BP13 Lattice site and thermal stability of implanted transition metals in germanium

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Compared to silicon, the dominant semiconductor in electronics, germanium exhibits a number of advantages (e.g. higher charge carrier mobility) which makes it an interesting material in the context of future, higher performance electronics. Since the behavior of (electrically, optically or magnetically) doped semiconductors strongly depends on the exact position of the dopant atoms in the semiconductor host lattice, precise determination of the dopant's lattice location is crucial for the understanding of its functional properties. We present an experimental study on the lattice location and thermal stability of 3d transition metals (Mn, Fe, Ni and Cu) implanted in intrinsic Ge, using the emission channeling technique [1]. Radioactive <sup>56</sup>Mn, <sup>59</sup>Fe, <sup>65</sup>Ni and <sup>67</sup>Cu ions were implanted at the radioactive ion beam facility ISOLDE at CERN. Upon beta-decay of the implanted probes, the emitted electrons experience channeling and blocking effects, resulting in anisotropic emission patterns which characterize the occupied lattice sites. Apart from the occupation of the expected substitutional position (i.e. transition metals on a position originally occupied by a germanium atom) [2,3], interstitial sites were detected as well. For all investigated transition metals, a significant fraction, up to 28%, was found to occupy a near-bondcentered site (between two nearest neighboring substitutional positions) which we interpret as resulting from the split-vacancy configuration [2]. For Ni, an additional fraction (up to 28%) was identified in a near-tetrahedral site, which is likely to be associated with complex defect structures (e.g. containing more than two vacancies). We will show that the occupancy of the different sites varies upon thermal annealing in vacuum. In terms of thermal stability of the investigated transition metals, the substitutional site persists up to at least 350°C and the near-bond-centered location up to 300°C. The near-tetrahedral site, which is only present for Ni in Ge, is still present at 400°C. These findings are relevant for the understanding of the mechanisms of electrical activation (and deactivation) of transition metal impurities in germanium.

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#### BP14 Valley filtering by electrostatic potentials in bilayer graphene

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The unique band structure of graphene has brought the possibility of developing devices based on different degrees of freedom, other than charge (electronics) and spin (spintronics), namely, using its different pseudo-spin states (pseudo-spintronics) and electronic valleys (valleytronics). Valley filtering in graphene has been pursued by many researchers, as a path to use the valley degree of freedom of electrons as the basis for a future valley-tronics. Several possibilities have been proposed in the literature for valley filtering in graphene. Most of the proposals demand a high control of the atomic structure of the graphene layer, either by cutting it in specific directions as to produce uniform edges [1], or by applying local stress in the system which results in a pseudo-magnetic field [2,3], or even by taking advantage of the valley filtering process that occurs when an electron propagates through a line of heptagon-pentagon defects on the honeycomb lattice [4]. In this work we propose a novel approach to realise valley filtering which is based on electrostatic confinement. We consider the propagation of a wave packet describing the electron motion through a quantum point contact (QPC) as defined by electrostatic gates in bilayer graphene. The gates are set as to provide a bias between the layers, in order to produce a gap in the electronic spectrum. Our results demonstrate that if the gates on both sides of the contact produce the same bias, steps in the electron transmission probability as a function of the barrier height are observed, just as in the usual QPC. On the other hand, if the bias is inverted in one of the sides of the QPC, only electrons belonging to one of the Dirac cones are allowed to pass, thus producing a very efficient valley filtering.

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## BP15 **Ring-shaped ferromagnetic nanowires for current-induced** domain wall motion studies

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Ring-shaped ferromagnetic nanowires are well suited for the investigation of fundamental magnetic properties such as domain wall (DW) trapping and DW dragging with a spin-polarized electrical current and may also be useful for technological applications. In the present study we fabricated permalloy (Ni80Fe20) nanoring-based devices and investigated their suitability for current-induced DW motion studies. A series of 30 nm thick permalloy nanorings of various diameters (20-30 µm) and widths (200-600 nm) were fabricated by combining electron beam lithography and conventional lift-off techniques. We characterized the fabricated devices using magnetotransport measurements and magnetic force microscopy (MFM) in the presence of an external magnetic field. We have directly imaged by MFM the internal magnetic domain structure of the rings and its evolution when applying an external magnetic field. An important contribution to the magnetoresistance of the intermediate metastable magnetization states, which lead to switching effects, is observed. This way we confirm the suitability of permalloy nanoring-based devices for current-induced DW motion studies. Magnetoresistance measurements combined with in situ MFM experiments will allow to directly link changes in the magnetoresistance to current-induced changes in the magnetic domain structure.

## BP16 Area-selected deposition of graphene oxide using dielectrophoresis in a top down approach

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Introduction Since the discovery of graphene and its unique physical properties in 2004, graphene has triggered an enormous interest by the scientific society. Due to its special electrical properties, graphene seems also to be a promising platform material for various kinds of sensors. In our case, we will study the impact of the adsorption of gas molecules (such NO2), which was earlier predicted in theoretical studies based on density functional theory. There is indeed experimental evidence that even single absorbed molecules change the local carrier concentration and can thus be detected The effect of dielectrophoresis (DEP) is known since the 1950s, but recently its usage has increased because of its potential to manipulate nanoparticles, cells, and carbon species including graphene and its oxide. In DEP, a non-uniform electrical field induces a dipole moment in particles. The particle encounters a force through the interaction between the electric field and moves towards areas of higher- or lower field strength. This depends on the induced dipole moment, the field gradient, and the oscillation frequency of the applied field. Experimental method First, a 500 nm aluminium layer is sputtered on the backside of a silicon sample. The aluminium layer is annealed at 450 °C for 45 min to improve the electrical contact to the silicon. The topside is covered by a 300 nm silicon dioxide layer. A photoresist is spin-coated on the SiO<sub>2</sub> layer and structured by UV-lithography. Afterwards, a PDMS flow cell with a planar aluminium electrode on top is attached onto the sample. Graphene oxide solution is introduced into the flow cell and an AC electrical field with a frequency of 1 MHz is applied between the top- and backside electrode. The thickness of the GOlayer can be controlled by the duration of the DEP process. After the DEP process the flow cell is flushed with DI water and the flow cell is detached. Finally, the sample is rinsed with acetone and 2-propanol. Conclusions & Outlook These GO-layers will be the basis of our electronic- and magneto-transport studies. For this purpose, we will compare different reduction methods to con-vert graphene oxide into reduced graphene oxide (rGO). Afterwards, the rGO-layers will be sensitive surfaces for the detection of selected gasses.

## BP17 Modifying the reaction of thin Ni films with Si by Si implantation

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The solid phase reaction of thin (100-10 nm) nickel films deposited on Si has been studied extensively over the last few decades [1]. This reaction starts with the formation of metal-rich phases around 250°C, after which the film is converted to NiSi around 350°C. Around 800°C, the final phase, NiSi<sub>2</sub>, nucleates. Several ways of modifying this reaction have previously been investigated [2-4]. This work focuses on how this reaction is altered when Si ions are implanted into the as-deposited Ni layer, by means of in situ X-ray diffraction (XRD) and Rutherford backscattering and channeling spectrometry (RBS/C). Depending on the implantation energy (25-60 keV), the solid phase reaction is modified in several ways. After implantation at low energy, the metal-rich phases appear at lower temperature, and grow sequentially. After implantation at 40 keV, no metal-rich phases are observed during annealing: either the grains of these are too small for detection, or NiSi is the first phase to form. Additionally, the texture of the NiSi film is different than for unimplanted samples. At the highest energy of implantation, an early onset of NiSi2 is observed (almost 300C below the thermodynamically expected temperature) during annealing. The implantation of Si significantly alters the reaction, likely to due to the crystalline damage and the intermixing of elements caused by implantation. Damage in the Ni layer and Si substrate might increase the diffusion of Ni (and thereby, the kinetics of the reaction), whereas intermixing of Ni and Si at the interface would alter the thermodynamic drive of the reaction [5].

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## BP18 Stable half quantum vortices in mesoscopic p-wave superconductors

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The prediction that cores of half quantum vortices (HQV's) could host Majorana zero energy modes (MZM's) has encouraged the search for HQV's and possible ways of their manipulation. The importance of MZM's relies on their non-abelian statistics which provides a practical realization of a quantum state free of decoherence, extremely useful for quantum computation purposes. Here, we report HQV's solutions of the Ginzburg-Landau model that was proposed to describe the p-wave superconductivity of strontium ruthenate,  $Sr_2RuO_4$ . The HQV's are found to display non-Meissner electrodynamics as a consequence of analytically shown minimal coupling to the vector potential. The combination of mesoscopic confinement and pwave chirality provides the required stability for HQV's and creates suitable environment to set up a solid state qubit.

### BP19 One dimensional superconductivity in Sn nanowires

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Conventional superconductivity arises from the coupling between electrons and phonons. When the size of a superconductor is reduced to the nanoscale, confinement effects for both electrons and phonons are expected to modify the electron-phonon coupling, leading to modifications in the critical temperature and the critical magnetic field. In particular, an enhancement of the critical temperature for Sn nanowires, which are a good model for one dimensional systems, has been predicted [1] when the nanowire diameter is smaller than the superconducting coherence length. Sn nanowires with diameters ranging from 100 nm down to 13 nm and a length of 15  $\mu$ m have been electrodeposited in porous alumina membranes. The structure of the

nanowires was investigated by means of X-ray diffraction showing that the nanowires are strongly textured and composed of very elongated crystallites. The critical temperature and the field-temperature phase boundary for a magnetic field parallel and perpendicular to the nanowires axis were obtained by magnetotransport measurements. An enhancement of the critical temperature and the critical magnetic field, and a higher field-temperature phase boundary compared to the bulk values were observed. The variation of the critical temperature with the diameter will be discussed and compared to the theoretical models, from which a good agreement is found. These preliminary measurements open perspectives for solving the still unanswered question of which mechanism, electron confinement or phonon softening, is responsible for the enhancement of the critical temperature in one dimensional superconductors.

#### BP20 Metal germanide formation on Ge<sub>1-x</sub>Sn<sub>x</sub>

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Although silicon is the semiconductor used for more than 95% of all devices, germanium offers advantages, e.g. a higher charge carrier mobility, that may favor this material in a number of specific future devices [1,2]. Moreover, alloying a small fraction of Sn to the Ge lattice allows to tune the (magnitude and nature of the) bandgap, as well as to induce uniaxial strain [3]. In order to implement GeSn in technology, a suitable contact material to the active areas (transistor source, drain and gate) must be identified. Due to their low resistivity, their resistance to oxidation and their morphological stability, nickel, cobalt, copper, palladium and platinum germanides have been considered [4]. We have investigated the reaction between these metals and GeSn in detail, i.e. germanides formation through solid phase reaction (SPR). More specifically, we studied the phase formation, the elemental

redistribution (including alloying versus segregation of the Sn), the dominant diffusing species and the growth kinetics during germanide formation. To this end, two complementary techniques were applied in situ (hence, while the reaction took place): Rutherford backscattering spectrometry (RBS) and x-ray diffraction (XRD). In this work germanide phases were successfully identified. Results have shown that in terms of phase sequence there is no difference between M-GeSn and M-Ge and that metals diffuse into GeSn. For Cu a particularity was identified: the diffusion continues even after germanides formation using the Ge from sample substrate. The Sn redistribution behavior is highly dependent on the metal applied for metallization. For Ni, Co and Pt it was observed that Sn segregate towards the surface of the germanides layers and there is an absence of Sn segregation in the case of Cu and Pd. Those results allow us to say that the Pd is the most appropriate metal to be applied as contact for GeSn alloy.

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#### BP21 Enhanced ferromagnetism in BiFeO<sub>3</sub> by Co ion implantation

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 $BiFeO_3$  is the only intrinsic room temperature multiferroic material showing simultaneous and coupled antiferromagnetic and ferroelectric properties. In thin films with thickness below a few hundred nanometers,  $BiFeO_3$  exhibits weak ferromagnetism due to the suppression of the spin spiral structure. We demonstrate

that the ferromagnetic response of polycrystalline single-phase BiFeO<sub>3</sub> films (with a thickness of approximately 300 nm) can be significantly enhanced by Co ion implantation and subsequent annealing. Ion implantation energy and fluence of 60 keV and  $10^{16}$  ions/cm<sup>2</sup> have been used, respectively. While the room temperature (RT) hysteresis loops exhibit a coercivity of around 100 Oe, the low-temperature loops show coercivities in excess of 17 kOe. This is explained by the formation of a secondary cobalt ferrite phase which, according to synchrotron XRD results, grows coherently within the BiFeO<sub>3</sub> crystal structure. Cobalt ferrite has shown to have strong temperature dependent magnetic properties. Whereas at RT the Co ferrite inclusions are mainly superparamagnetic, they become single-domain at low temperature. Furthermore, the samples show pronounced shape anisotropy at low temperature in which, surprisingly, the out-of-plane direction seems to be a magnetically easier configuration compared to the in-plane orientations.

### BP22 Growth and characterization of metastable alpha-Sn films

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Alpha and beta Tin are two stable phases of Tin. Beta Tin is a low-temperature superconductor and stable above 286.4 K, while alpha Tin is a quasi zero band gap semiconductor and stable below that temperature. The structural transition from the alpha-Sn to the beta-Sn phase is still poorly understood, but it is known that the transition is closely related to the atomic vibrations. This phase transition is a prototype of a vibrational entropy-driven phase transformation and serves as a model system to better understand the role of lattice vibrations in these types of transitions, especially in confined geometries [1]. In order to study the atomic vibrations and the structural phase transition in thin Sn films, it is of key importance to stabilize alpha-Sn phase layers in a broad temperature range up to room temperature and above. In thin films of Sn, however, the alpha-phase typically exists only as a very thin seed layer and it remains a challenge to stabilize layers with a thickness exceeding several tens of nm, e.g., by epitaxial growth of metastable alpha-Tin on very specific substrates [2,3]. The transition to the beta-phase can then be induced by increasing the temperature with a transition temperature inversely proportional to the layer

thickness [4]. In this work, we have stabilized alpha-Sn films up to 40 nm at room temperature through the epitaxial growth of Sn on InSb (001) [2,3]. InSb is a very good candidate because of the small mismatch of only 0.14 % of its lattice constant with that of alpha-Sn. We discuss the influence of the substrate surface conditions and the Sn growth rate on the quality and the alpha phase purity of the resulting Sn layers. The substrates were chemically cleaned prior to loading them into ultrahigh vacuum, followed by in-situ argon sputtering. Different annealing steps were applied to repair any damage caused by the argon sputtering. The cleanliness and quality of the substrate surface were investigated by Auger spectroscopy and RHEED. The structural quality of the alpha-Sn films and the alpha-Sn to beta-Sn phase transition were studied by X-ray diffraction (XRD) and atomic force microscopy (AFM). Local probing of the Young's modulus allows to distinguish between alpha-Sn and beta-Sn regions.

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#### BP23 Angular dependence of Rayleigh-wave velocity in steel plates

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Most steel production involves changes in microstructure by recrystallization and grain growth but these events cannot normally be recorded in real time. A laserultrasonic approach based on the propagation of Rayleigh wave (SAW) is investigated for the measurement of texture in low carbon steel plates. The angular dependence of the SAW velocity presents different patterns attributed to texture, comparison with the pole figure measured by electron backscatter diffraction (EBSD), these velocity anisotropies permit the evaluation of steel plate's anisotropies. The limitation and application are discussed.

# BP24 How does the film thickness influence the optical behavior of plasmonic nanocomposites?

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Nano-objects and more particularly metal nanoparticles (NPs) play a central role in the development of nanotechnology-based optical devices. Their optical properties are strongly influenced by their shape and size but also by the dielectric properties of their environment, in particular when the NPs are embedded in a dielectric matrix. A wide range of experimental methods is available for the synthesis of such materials. Besides the methods involving the synthesis of the NPs in a liquid medium, with or without further coating to prevent their aggregation and their dispersion in a solid phase, NPs can be synthesized in situ following the irra-diation or the thermal annealing of the solid phase. Although the first approach has an evident advantage of leading to the syn-thesis of NPs with wide ranges of shapes, size ..., the synthesis methods of the second category are usually simpler (one-pot syn-thesis) but their mechanism is today not fully understood although being the subject of an increasing number of publications. In this study, we investigated using spectroscopic and imaging ellipsometry in the visible spectral domain the optical properties of polyvinyl alcohol/silver nanocomposites. AFM in non-contact mode was used to measure the topography of our surfaces. The ellipsometric spectra were modeled by describing the nanocomposite layer by a Cauchy law with a Lorentzian absorption peak to account for the plasmon resonance. The distribution of optical resonance parameters of more than 90 samples was ana-lyzed using multivariate statistical methods (principal components analysis and support vector machines), allowing us to con-clude that significant differences exist between thin (less than 30 nm) and thick (more than 300 nm) nanocomposite films. As expected, the amplitude of the resonance peak is strongly correlated with the silver content but the correlation between the width and the position of the peak are different for thick and thin films. We showed that the optical behavior of plasmonic nanocom-posites materials was not only controlled by the amount of metal nanoparticles but also by the thickness of the film.

## BP25 Applications of k-means and hierarchical clustering in the analysis of the optical properties of materials: the case of spectroscopic imaging ellipsometry

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Imaging ellipsometry (IE) is a non-destructive optical analysis technique based on the relative change of polarization of the p- and s- components of the light at the interface between two media characterized by different optical properties. When used in spectroscopic mode (SIE), the technique generates a huge data cube. As the ellipsometric angles  $\Psi$  and  $\Delta$  have to be interpreted on the basis of an optical model, the inversion of the ellipsometric equations are mandatory to determine the dielectric function of the constitutive layers of an optical stack, as well as their thickness. An ellipsometric image ( $\Psi$  or  $\Delta$  map at one wavelength) has typically 600x400 pixels. An inversion of each SIE pixel is therefore excluded because of the run-time complexity of the algorithm. Going from IE to SIE contributes to the accuracy of the measurements and also to their flexibility but increases the complexity of the ellipsometric data inversion. In this paper, a multivariate approach involving a twosteps classification scheme based on k-means and ascendant hierarchical clustering is proposed. The classification is applied on a data cube of 2N x L x W pixels, with N the number of wavelengths, L the length and W the width of the mapped region. The combination of these two multivariate statistical methods helps in the speed-up of the data inversion (at least two orders of magnitude) but also in the choice of the local optical model. Examples are given for patterned silicon dioxide samples.

#### BP26 Elastic characterization of porous MnO<sub>2</sub>

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 $MnO_2$  is an interesting material with regard to the development of microscale batteries. While the electrochemical properties have been mapped carefully, the elastic properties are yet to be determined. In this work an estimation of the Young's modulus and the porosity of a 500 nm porous  $MnO_2$  film is presented. They are obtained from surface acoustic wave velocity dispersion analysis. The surface

acoustic waves are generated using impulsive stimulated thermal scattering and analyzed in the theoretical framework of acoustic waves in layered anisotropic media.

#### BP27 Dynamic visualization of nanoscale vortex orbits

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The dynamics of nanoscale objects is a very interesting field of research with a strong technological impact (e.g. the investigation of catalysis or crystal growth). Still, the combination of a technique resolving (sub) nanometer particles within a time frame relevant to observe dynamics is a very challenging task. Due to the inherent atomicscale resolution, scanning tunneling microscopy (STM) is an ideal candidate to achieve this goal. Nevertheless, in most physical systems the dynamic events of the objects under investigation cannot be resolved by conventional STM image acquisition and will only reveal an average trace of the moving object. This is why a strong drive exists to develop new functionalities of STM, and in general of scanning probe techniques, which allow studying dynamic events at the nanoscale [1]. We address this issue, for vortex matter in NbSe<sub>2</sub>, by driving the vortices using an ac magnetic field and probing the induced periodic tunnel current modulations [2]. Our results reveal different dynamical modes of the driven vortex lattice. In addition, by extending a known functionality of STM, (called the 'Lazy Fisherman' technique [3]) we can use single pixel information to obtain the overall dynamics of the vortex lattice with sub millisecond time resolution and sub nanometer spatial resolution.

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#### BP28 PH-sensitive quantum dots and rods

## David Debruyne, Olivier Deschaume, Margriet Van Bael, Carmen Bartic KU Leuven

Quantum dots and quantum rods are semiconductor nanoparticles with interesting fluorescence properties. These nanoscale particles possess a large surface area, thus their fluorescence is highly sensitive to surface phenomena. Unpassivated surface sites and changes in the surface charges can quench the fluorescence intensity and shift the emission wavelength. In polar solvents, the surface charge and passivation are influenced by environmental factors such as the pH. Therefore, quantum dot fluorescence is in general pH-sensitive [1,2], rendering such particles useful for pH/(bio)sensing applications. We will discuss the pH-sensitivity of CdSe/ZnS quantum dots (ODs) and CdSe/CdS quantum rods (ORs). The dots and rods are initially dispersed in organic solvents. Different strategies exist to obtain watersoluble particles. We use both ligand exchange by thiols and ligand addition of phospholipids. These two water-solubilisation strategies lead to markedly different pH-responses. As generally observed, the fluorescence intensity of QDs is quenched at acidic pH. The quenching is reversible for phospholipid-encapsulated QDs, but irreversible for thiol-capped QDs. The pH-response of the QRs differs from that of the QDs, showing atypical quenching at alkaline pH. The changes in the fluorescence intensity are often accompanied by small, but consistent shifts of the emission wavelength, the origin of which is not immediately clear [2,3]. Possible sources of spectral shifting are electronic energy transfer and polarization by electric fields. We investigate the source of the spectral shift by measurements of the hydrodynamic size and of the zeta potential, providing information on the particles aggregation state and surface potential, respectively. In conclusion, we investigated in detail the pHsensitivity of quantum dots and rods and show how experimental parameters affect the pH-response. A better understanding of the mechanism behind the pH-effect will enable the development of future biosensing applications based on quantum dots/rods.

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#### BP29 Designing phosphors for brighter LEDs

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Light-emitting diodes or LEDs are steadily consolidating their share in the lighting and display market. This does however not mean that current technology is fully established yet. Contrary, improvements are still desirable, both for lighting and display applications.

White LEDs are typically built from a blue emitting In1-xGaxN pumping LED and one or multiple phosphors which convert the blue light into green, yellow and red light in order to complete the visible spectrum and to obtain the desired white light.

Depending on the application of the LED, the specifications for the white light are completely different. For lighting, a compromise between a high color quality and a good luminous efficacy has to be made, while for display applications, saturated primary colors are indispensable.

Currently, only a handful of phosphor materials exist that can meet the strict requirements needed for applications. Furthermore, so called rare earth elements (such as Ce, Eu, Y, Lu) form an important building block of these phosphors, making their synthesis expensive and environmentally unfriendly and the availability of phosphors susceptible to market shortages.

Because of the increasing demand and the difficulties with current materials, it is desirable to develop novel phosphor materials with improved properties. To obtain this goal in an efficient way, a combination of experimental research and modelling of the electronic and optical properties of the phosphor materials is used.

Careful analysis of the experimental input of photoluminescence emission and excitation spectra, luminescence decay measurements and thermal quenching of the fluorescence allows to distill empirical energy level schemes of the optically active region of the luminescent material. These energy level schemes offer a deeper understanding about the interactions on the atomic scale which drive the luminescence process. If the reasoning is inverted, luminescent properties can be predicted in advance and suitable dopant-host combinations selected without the need of numerous syntheses.

In addition, structure analytical techniques, such as the powerful combination of cathodoluminescence spectroscopy and scanning electron microscopy are utilized to gain knowledge about the crystallography and synthesis process of the phosphor powders that came out of the empirical selection procedure.

# **BIOPHYSICS, MEDICAL, STATISTICAL & MATHEMATICAL PHYSICS**

#### BP30 **Phase coexistence of phospholipid mixtures determined by** quartz crystal microbalance with dissipation and adiabatic scanning calorimetry

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One of the most debated issues in lipid biophysics is lipid miscibility and its relevance to the function and organization of biological membranes [1,2]. In spite of the relevance of lipid-protein interactions, the phase behavior of the lipid components of the cell membrane is still believed to be of major importance to uncover some underlying principles behind membrane function. From a fundamental viewpoint, the interest on lipid phase behavior stems from the nature and the thermodynamics of phase transitions, the mechanisms behind lipid miscibility and lateral phase separation and the existence of critical phenomena. This includes the knowledge of static and kinetic thermodynamic properties of pure lipids and lipid mixtures [3]. In this work we present a combined study of phase transitions of lipid mixtures by means of quartz crystal microbalance with dissipation (QCM-D) and peltier element based adiabatic scanning calorimetry (pASC). Using OCM-D we propose a genuine way of determining phase diagrams by analysing viscosity temperature profiles  $\eta(T)$ , while with pASC, a novel type of calorimeter, we test its capability in measuring biologically relevant samples obtaining unambiguous information on thermal properties, namely, the heat capacity cp(T) and the enthalpy h(T). As a proof of concept, we chose two types of mixtures of phospholipids with the same polar head differing chain length, namely, 1,2-dimyristoyl-sn-glycero-3and alkyl phosphocholine DMPC with 1,2-dipalmitoyl-sn-glycero-3-phosphocholine DPPC and with 1,2-distearoyl-sn-glycero-3-phosphocholine DSPC. Results obtained using both techniques are mutually consistent and the different features of both phase diagrams were well reproduced as compared with previous literature works [4].

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### BP31 DNA electrical behavior at room temperature: I-V measurements on single molecules

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Rosalind Franklin's X-ray diffraction images, paved the way for Watson and Crick in 1953 to describe DNA as two antiparallel helical strands with hydrophobic bases in the core and the hydrophilic phosphate backbone positioned outside the helix [1]. From this structure, it can be observed that i) Aromatic stacking (p-orbitals overlapping between nucleotides) and, ii) Hydrogen bonds between bases (Chargaff's rules) [2] are contributing to the stability of DNA. In our research, we are interested on the properties associated to the pi-pi orbital stacking of DNA in the single molecule level. Previous reports on DNA electrical behavior have been contradictory, ranging among insulator [3], semiconductor [4] conductor [5]. These differences may be attributed to the differences on the DNA samples preparation, sequence, conformation, and length. Moreover, one or multiple strands, different type of setups, electrical contacts and conditions make it more difficult to find a consensus. We report here I-V curves measured with conductive atomic force microscopy (I-AFM) on top of single dsDNA molecules functionalized with fullerene groups. From our results, we can observe that electron transfer is strongly dependent on the type of base pair under the tip, showing lower resistance values for GC compared to AT bases. Finally, in order to understand the type of charge transport behind our results, we analyzed and compared our data with the models of: 1) Cuniberti based on a hopping

tunneling mechanism [6], and 2) Berlin taking into account a competition between thermal activation vs tunneling depending on the base pairs arrangement [7].

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#### BP32 Arduino based impedance measurement platform

#### Stijn Duchateau UHasselt

Impedance spectroscopy has been well used in the last decade in biological measurements. However current state of the art measurement devices still have a large form factor, high cost and need for specialised operators. A possible outcome is the use of new small form factor devices with an easy to use user interface. This abstract presents a homemade stand-alone Arduino based measurement system fine-tuned for biological measurements.

#### BP33 Affinity and specificity studies of novel selected 17β-estradiol (E2) aptamers via Surface Plasmon Resonance (SPR)

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Binding quantification of Biological Recognition Ligands (BRLs) to specific targets is a key concept of theoretical studies in biosensors research. The main aspects of ligand-target binding interactions include binding affinity and kinetics, which can be analyzed by different methods such as labelled, label-free, structure-based assays etc. Surface Plasmon Resonance (SPR) is one of the most important label-free binding assays. SPR is based on the resonance of surface plasmon polaritons which are electromagnetic waves generated when light interacts with surface charges in gold surface. One of the most important applications of SPR is to analyze the binding of the targets to the ligands which are linked to a gold surface to study binding kinetics. The analyzed interactions between a ligand and its target include formation of a ligand-target complex and dissociation of this complex followed by the target removal. SPR is applied to follow the association and dissociation mechanisms in real-time by creating a sensorgram which detects the changes in the reflected light wavelength.

Aptamers are artificial BRLs, which are beneficial for biosensors applications, since their high stability and selectivity for small molecules, and their lower production cost makes them advantageous compared to other BRLs. They are selected during Systematic Evolution of Ligands by EXponential enrichment (SELEX) process.

In this research two novel 17 $\beta$ -estradiol (E2) aptamers were selected during an optimized SELEX. Afterwards, the chemically synthesized biotinylated aptamers were immobilized on a streptavidin (SA)-modified SPR sensor chip for affinity and specificity analysis. Under experimentally realistic conditions (e.g. PBS with 10% ethanol buffer, at room temperature) both selected sequences 1 and 2 showed good dissociation constant (KD) values (7.67 $\mu$ M vs. 0.95 $\mu$ M, respectively), as well as a broad range of detection (1.44-22.95 $\mu$ M and 0.36-11.47 $\mu$ M, respectively) for E2. Moreover, the reliability of the measurement was confirmed by an automated statistical analysis. Specificity studies indicated a high selectivity of both sequence 1 and 2 for cholesterol derivatives with a phenolic group A epitope (17 $\alpha$ -ethinylestradiol, E2, and Estrone). In conclusion, despite a very small molecular weight of E2, SPR measurements for binding assays of the aptamers to E2 were successful.

Financial support by the Research Foundation Flanders (FWO) is gratefully acknowledged.

#### BP34 **Probing the mechanical properties of living neurons by Atomic** Force Microscopy

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Knowledge concerning the influence of biochemical signaling on cell functioning is rapidly increasing, although, cellular processes resulting from mechanical cues are currently poorly understood [1]. Mechanical stresses can modulate cell function by either activating or tuning signal transduction pathways1. Mechanotransduction processes occur both in cells specialized for mechanical sensing, and in cells whose primary function is of a different kind [2]. Key roles in the molecular pathways involved in cellular mechano-sensing are played by the adhesion complexes and the actin cytoskeleton, who generate and transmit contractile forces through transcellular structures [3]. Understanding cellular responses to mechanical cues and mechanical properties of living cell membrane and cytoskeleton has important implications for development, differentiation, aging, disease, and regeneration studies [1,3]. Atomic force microscopy (AFM) can be used to probe the mechanical properties of living cells with exquisite spatial resolution. The AFM provides force versus indentation measurements, which give information about cellular stiffness. Moreover cells actively respond to mechanical stimuli applied by the AFM tip. Changes in cellular resilience occur during measurements as a result of internal remodeling. It has been shown that actin recruitment was responsible for stiffening of airway smooth muscle cells when applying a constant load [4]. In this study, we evaluate the elastic behavior of primary rat hippocampal neurons under different environmental conditions and for different developmental ages. For this purpose, we use spherical beads (15  $\mu$ m in diameter) attached to the AFM tip to indent the entire cell body. Repetitive indentation of the cell soma at given forces and frequencies, provide information about the neuronal responses to force (i.e. stiffening).

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## BP35 Thermodynamics of DNA hybridization: theory and applications for molecular diagnostics

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DNA hybridization is a process of binding between two single-stranded DNA sequence into a double helix conformation. This process is very important in biological systems and also in many biotechnological applications. Our research focuses on studying this process in the thermodynamics context and use it as the basis of methods for molecular diagnostics. We have two main objectives: (1) to deepen our understanding of the fundamental properties of hybridization from equilibrium thermodynamics and (2) to turn the acquired knowledge into applications in clinical diagnostics, in particular in the case of accurate detection of mutations in a sample. Here, we present an overview of the results that we have so far.

#### **ATOMS, MOLECULES, OPTICS & PHOTONICS**

# BP36 Experimental and theoretical study of 3-photon ionization of He (1s2s<sup>3</sup>S) and He (1s<sup>2</sup>p<sup>3</sup>P)

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While the photoionization of atoms in the ground state has been intensively studied, less is known concerning photoionization of excited states, particularly multiphoton ionization. We report here the results of an experimental and a theoretical study of the three-photon ionization of the 1s2s  ${}^{3}S_{e}$  and  $1s2p^{3}P_{o}$  states of helium by a laser operating in the green and red regions of the visible spectrum. In the experiment, He<sup>-</sup> (1s2s2p  ${}^{4}P_{o}$ ) ions are first formed by collisions of fast helium ions with cesium. Photodetachement by a Nd:YAG laser then leaves an atom of helium in either the 1s2s  ${}^{3}S_{e}$  or the 1s2p  ${}^{3}P_{o}$  state. These are subsequently ionized by the absorption of three more photons. The ion yield from either of the two excited states is recorded respectively in the the 530-560 nm and 685-730 nm wavelength ranges, for different

laser pulse peak intensities ( $\sim 3 \times 10^{10}$  W/cm<sup>2</sup>) and incident polarizations. The experimental results show two series of asymmetric peaks, associated to two-photon resonances with ns and nd Rydberg states for He(1s2s <sup>3</sup>S<sub>e</sub>) and with np and nf Rydberg states for He(1s2p  ${}^{3}P_{0}$ ). For the latter, a series of peaks has tails towards higher photon energies while the other has tails changing direction below 706.7 nm. A model Hamiltonian is built using matrix elements from DVR and QDT calculations and checked against a full, ab initio R-matrix Floquet calculation. The timedependent Schrödinger equation is numerically integrated to reproduce the experimental spectra. The series of peaks are consistently reproduced over the large wavelength ranges considered, both in shape and position. Ionization of 1s2p state is shown to occur via two resonantly enhanced multiphoton ionization (REMPI) schemes: a (1+1+1) scheme for M<sub>I</sub>=0, never encountered before in atomic multiphoton ionization, and a (2+1) scheme for  $M_L = \pm 1$ . The two series of two-photon Rydberg resonances are associated with the two initial states  $1s2p {}^{3}P_{o}$  (M<sub>L</sub>=0,±1), and we conclude that their differing behaviour as a function of the peak laser intensity is due to the strong 1s2p-1s3s dressing, present only when M<sub>L</sub>=0. A such coupling is not observed for He(1s2s  ${}^{3}S_{e}$ ), which exhibits a much simpler (2+1) REMPI behaviour.

### BP37 Many-body quantum transport of Bose-Einstein Condensates: a truncated Wigner approach

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We study the transport properties of an ultracold gas of Bose-Einstein condensed atoms that is coupled from a magnetic trap into a one-dimensional waveguide. Our theoretical approach to solve this problem is based on the truncated Wigner (tW) method for which we assume the system to consist of two semi-infinite noninteracting leads and a finite interacting scattering region. The coherent and incoherent part of the atomic density and the transmission are computed in the steady-state regime. In the case of transmission through disordered potentials, we find that incoherent atoms destroy Anderson localization and that ensemble-averaged observables agree with mean-field predictions obtained from the Gross-Pitaevskii equation. In the case of scattering across microscopic quantum dot potentials, we find clear signatures for inelastic resonant transmission within the energy distribution of the transmitted atomic matter wave.

#### BP38 Metamaterial hybridization

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Recent years show a great interest in negative refractive metamaterials (NRMs) due to their intriguing physics as well as promising applications, which have not seen in natural materials. A negative refractive index can be achieved by simultaneous negative permittivity and negative permeability. While the negative permittivity is originally obtained by the low-frequency broadband plasma behavior of continuouswire media, the artificial magnetic resonator is employed exclusively to realize negative permeability. However, the conventional NRMs with defined geometrical parameters often operate at a single and narrow frequency band. Hence, the quest for an optimal NRM structure, which expands its functionality over a wide frequency range, is still a challenging topic for scientists. Several designs have been proposed so far, presenting multi but isolated NR band by integrating individual resonant structures. Unfortunately, this approach requires more sophisticated geometries that forces additional restrictions on the design and fabrication. In this report, we show that the NR broadband effect can be achieved by introducing the hybridization in a conventional NRM dimer without breaking its geometrical symmetry. The electromagnetic evolution of the NRM dimer with respect to the hybridization strength is experimentally and numerically studied at microwave frequencies. It is shown that the NR band of the dimer significantly broadens with increasing hybridization. A general energy scheme is proposed to predict the hybridization landscape of NRM n-mers, which allows us to arbitrarily tune the bandwidth of NRMs. This finding would serve as an important step towards the applications of broadband NRMs.

# BP39 The geometric structure of transition metal doped silicon clusters

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Silicon-based clusters have attracted continuous attention due to numerous technological applications of silicon. Contrary to carbon, silicon favors sp<sup>3</sup> hybridization rather than sp<sup>2</sup> hybridization, which leads to rather asymmetric and reactive structures for silicon clusters and makes the formation of cage-like structures unstable, which can be overcome by introducing transition metal dopant. It is wellknown that the physical and chemical properties of clusters can significantly be changed upon appropriate doping. Therefore, the knowledge of the structure of doped silicon clusters will be vital to understand their properties. Here, we have explored the geometric structures of cationic  $Si_nAg^+$  (n = 6-11) clusters using infrared multiple photon dissociation (IR-MPD) and of neutral  $Si_nCo$  (n = 10-12) clusters by a tunable IR-UV two-color ionization scheme, in combination with density functional theory computations. Based on the comparison of experimental and calculated IR spectra for the identified low energy isomers, structures are assigned. It is found that all SinAg+ (n = 6-11) clusters have exohedral structures. This is a surprising result since many transition metal dopant atoms have been shown to induce the formation of endohedral silicon clusters. The silicon framework of  $Si_nAg^+$  (n = 7-9) has a pentagonal bipyramidal building block, while the larger  $Si_nAg^+$  (n = 10–12, 14, 15) clusters have trigonal prism based structures. Comparing the structures of  $Si_nAg^+$  with those of  $Si_nCu^+$  (for n = 6-11), the Ag dopant atom takes a lower coordinated site and is weaker bound to the  $Si_n^+$  framework than the Cu dopant atom. On the other hand,  $Si_nCo$  (n = 10–12) clusters have endohedral caged structures. Electronic structure analysis indicates that the clusters are stabilized by an ionic interaction between the Co dopant atom and the silicon cage due to the charge transfer from the silicon valence sp orbitals to the cobalt 3d orbitals. Strong hybridization between the Co dopant atom and silicon host quenches the local magnetic moment on the encapsulated Co atom. The different growth patterns of those clusters indicate that the atomic radius and the filling of the d orbitals of the dopant atom plays an important role in determining the critical size for cage formation of the transition metal doped-Si clusters, however, the bonding properties and electronic structure (i.e. orbital hybridization between the dopant atoms and Si atoms) cannot be ignored.

#### **ASTROPHYSICS, GEOPHYSICS & PLASMA PHYSICS**

#### BP40 Potential Magnetic Field Extrapolation

#### Sofia Paraskevi Moschou, Chun Xia, Rony Keppens Mathematics Department, KU Leuven

We demonstrate available modules of the MPI-AMRVAC open source code (Porth et al. submitted ApJS 2014, Keppens et al. JCP 2012) of frequently used models for global spherical (PFSS) models, as well as for local Cartesian box models (Green function based), and make some observations on their accuracy. We use the split of a potential field solution  $B_0$  as a steady background field, and reformulate the evolution equations in terms of the deviation  $B_1$ , a technique particularly useful for studying plasma dynamics in a realistic solar coronal field topology. We can routinely use synoptic magnetograms as inputs from GONG observations at resolution 180x360 and from MDI at resolution 1080x3600. We make use of these magnetograms after performing the magnetogram remeshing technique, similar to Chebyshev collocation method to interpolate a  $\cos(\theta)$ -grid, with denser grid points at the poles than in the middle, onto a uniform  $\theta$ -grid. Here we present a study for the solar Carrington rotation number CR2029 in 2005, using observations from the space telescope instrument MDI. We focus on two active regions within CR2029, one located at the North hemisphere AR10759 and one at the South hemisphere AR10756. These two dominant active regions on each hemisphere will be used to (1) compare the global potential field source surface spherical extrapolation approach and a local potential field Cartesian one, and (2) to understand the influence of raising the number of spherical harmonics. For the latter, we will take active region AR10756 as the photospheric region on which we examine the radial magnetic field variation over a line crossing the active region's opposite polarities, as influenced by the number of spherical harmonics used.

### BP41 Electromagnetic particle-in-cell simulations of the solar wind interaction with lunar magnetic anomalies

Jan Deca<sup>1</sup>, Andrey Divin<sup>2</sup>, Giovanni Lapenta<sup>3</sup>, Stefano Markidis<sup>4</sup>, Bertrand Lembège<sup>5</sup>, Mihály Horányi<sup>6</sup>, <u>Emanuele Cazzola<sup>3</sup></u> <sup>1</sup> Centre for mathematical Plasma Astrophysics, KU Leuven <sup>2</sup> Swedish Institute of Space Physics <sup>3</sup> Department of Mathematics, KU Leuven
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Electromagnetic particle-in-cell simulations of the solar wind interaction with lunar magnetic anomalies J. Deca, A. Divin, G. Lapenta, B. Lembège, S. Markidis and M. Horányi We present the first three-dimensional fully kinetic and electromagnetic simulations of the solar wind interaction with lunar crustal magnetic anomalies (LMAs). Using the implicit particle-in-cell code iPic3D, we confirm that LMAs may indeed be strong enough to stand off the solar wind from directly impacting the lunar surface forming a mini-magnetosphere, as suggested by spacecraft observations and theory. In contrast to earlier MHD and hybrid simulations, the fully kinetic nature of iPic3D allows to investigate the space charge effects and in particular the electron dynamics dominating the near-surface lunar plasma environment. We describe the general picture of the interaction of a dipole model centred just below the lunar surface under various solar wind and plasma conditions and focus on the kinetic effects. It is shown that the configuration is dominated by electron motion, because the LMA scale size is small with respect to the gyroradius of the solar wind ions. Driven by strong pressure anisotropies, the mini-magnetosphere is also unstable over time, leading to only temporal shielding of the surface underneath. Our work opens new frontiers of research toward a deeper understanding of LMAs and is ideally suited to be compared with field or particle observations from spacecraft such as Kaguya (SELENE), Lunar Prospector or ARTEMIS. The ability to evaluate the implications for future lunar exploration as well as lunar science in general hinges on a better understanding of LMAs.

#### BP42 Methods of the search for the radio emission from M-dwarf star AD Leonis with the radio telescope UTR-2

<u>Anastasiya Boiko<sup>1</sup></u>, Vladimir Koliadin<sup>2</sup>, Alexander Konovalenko<sup>2</sup>, Valentyn Melnyk<sup>2</sup>, Stefaan Poedts<sup>1</sup> *<sup>1</sup>KU Leuven* <sup>2</sup>Institute of Radio Astronomy, NASU, Kharkiv, Ukraine

The aim of the observations of the M-dwarf flare star AD Leonis (AD Leo) is the registration of the radio emission from this star at decameter wavelengths, namely in the frequency range of 16.5–32 MHz. The newest observations of AD Leo with the 82

radio telescope UTR-2 located in Grakovo, Ukraine are presented. The flux of the radio emission from AD Leo is at the limit of the UTR-2 sensitivity. When observing at such a low frequencies there is a problem to sort out the events with potentially stellar origin from both strong ionospheric scintillations and noise of terrestrial origin. In order to find the solution of this problem a number of methods and criteria were implemented during the observational experiments in 2010, 2011, and 2012. The results of the analysis of the events in the form of bursts which potentially originated from the AD Leo, are presented. As such, 26 events were considered rather confidently as radio emission with the stellar origin. The main properties of the events detected at decameter wavelengths are as follows: they are seen in the form of isolated bursts with both positive (0.2–5 MHz/s) and negative (0.2–4.2 MHz/s) frequency drift rates, with durations in general between 2 and 14 s, and fluxes mainly of 10–40 Jy.

#### BP43 Energetic particle telescope, first results

#### <u>Graciela López Rosson</u>, Viviane Pierrard Belgian Institute for Space Aeronomy

The Energetic Particle Telescope (EPT) is a charged particle spectrometer onboard Belgian satellite PROBA-V, launched on 7 May 2013. Thanks to the LEO polar orbit of PROBA-V, EPT is a perfect instrument to measure energetic particles in Van Allen radiation belts. First analysis of observations show particles fluxes (electrons, protons, and Helium ions) in the South Atlantic Anomaly (SAA) and at high latitudes. We have observed that Helium ions and protons fluxes increase during SEP (Solar Energetic Particle events), while for electrons the fluxes are more affected during geomagnetic storms. Our results are in agreement with NASA AE8 model.

#### BP44 **Test particle simulations of electrons and protons in Earth's** radiation belts during storms

#### <u>Kris Borremans</u>, Joseph Lemaire, Viviane Pierrard Belgian Institute for Space Aeronomy

The radiation belts are charged particles, trapped in the magnetic field of the Earth. Observations show that during geomagnetic storms the electron fluxes vary several orders of magnitude. During the main phase of a geomagnetic storm, measured by a rapid decrease of the Dst index, a spectacular electron dropout is observed. During the recovery phase of a storm the electron flux will increase with several orders of magnitude compared to the pre-storm situation. We performed relativistic test particle simulations of radiation belt electrons and protons during magnetic storms. These 3D test particle simulations show that electrons with relativistic energies escape and get lost from the inner magnetosphere. During the main phase of a geomagnetic storm the particles decelerate, their mirror points are uplifted, and they drift radially outwards. During the recovery phase the reverse happens, the electrons accelerate, but not sufficient to create a relativistic radiation belt. The simulations also show that the radial transport is pitch angle dependent.

#### BP45 Dust in Kelvin Helmhotz instabilities

<u>Tom Hendrix</u>, Rony Keppens Centre for mathematical Plasma Astrophysics, Departement wiskunde, KU Leuven

Dust has been known to reside in a broad range of vastly different locations in space, from tori around supermassive black holes to outflows of AGB stars and tails of comets. However, the dust particles have a large (and often unknown) variety of sizes and compositions, therefore including the effect of dust in the analysis of the dynamics of these systems causes a significant increase in the complexity of numerical and analytical analysis. Furthermore, in most cases the density of the dust is several orders of magnitude lower than the local gas density, and as a consequence the contribution of dust on the dynamics has often been ignored. In this poster we will shed light on how we aim to investigate the importance of dust on astrophysical fluid dynamics, namely by performing numerical simulations. Specifically, we will elaborate on how dust tends to alter the formation of several instabilities which are recurrently encountered in the astrophysical fluid dynamics.

#### **ABSTRACTS REGULAR POSTERS**

# FUNDAMENTAL INTERACTIONS, PARTICLE & NUCLEAR PHYSICS

#### FPNp1 Constraints on the Higgs boson width from off-shell production and decay to $ZZ \rightarrow 4l$ or 2l2v

#### Jian Wang

Université Libre de Bruxelles

We constrain the total Higgs boson width,  $\Gamma$ H, using off-shell production and decay to four leptons, 4l, or two leptons plus two neutrinos, 2l2v with  $l = e,\mu$ . The measurement is based on the data collected in 2012 by the CMS experiment at the LHC, corresponding to an integrated luminosity L=19.7 fb-1 at  $\sqrt{s} = 8$  TeV. The 4l analysis makes use of the ZZ invariant mass distribution and of a matrix element likelihood discriminant to separate the ZZ components originating from gluon- and quark-initiated processes, while the 2l2v analysis relies on the transverse mass distribution or missing transverse energy distribution in jet categories. An unbinned-maximum likelihood fit of the above distributions combined with the 4l measurement near the resonance peak leads to an upper limit on the Higgs boson width of  $\Gamma$ H < 4.2\* $\Gamma$ H(SM) at the 95% confidence level, assuming  $\Gamma$ H(SM) = 4.15 MeV. This result considerably improves over previous experimental constraints from the measurement near the resonance peak.

## FPNp2 Space-charge effects in WITCH, a penning trap experiment for weak interaction studies

<u>Tomica Porobic<sup>1</sup></u>, Claire Couratin<sup>1</sup>, Paul Finlay<sup>1</sup>, Xavier Flechard<sup>2</sup>, Xavier Fabian<sup>2</sup>, Etienne Lienard<sup>2</sup>, Gilles Ban<sup>2</sup>, Valentin Kozlov<sup>3</sup>, Ferenc Gluck<sup>3</sup>, Andreas Knecht<sup>4</sup>, Martin Breitenfeldt<sup>1</sup>, Nathal Severijns<sup>1</sup>, Michael Tandecki<sup>5</sup>, Simon Van Gorp<sup>1</sup>, Gergely Soti<sup>1</sup>, Dalibor Zakoucky<sup>6</sup>, Marcus Beck<sup>7</sup>, Peter Friedag<sup>7</sup>, Christian Weinhemer<sup>7</sup>

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One of the goals of precision measurements in nuclear beta decay is the search for deviations from the Standard Model potentially unraveling new physics. Within the Standard Model, beta decay is described by the V-A theory but exotic contributions are experimentally not excluded with high precision. The primary aim of the WITCH experiment [1] at the ISOLDE/CERN facility is the precise determination of the beta-neutrino angular correlation coefficient, a, which is in the case of Ar-35 sensitive to a possible scalar contribution. For that purpose, a scattering-free source consisting of two Penning traps is combined with a MAC-E retardation spectrometer to probe the energy of recoiling daughter nuclei. In large capacity Penning traps such as WITCH's, the space-charge effect causes shifts of the motional eigenfrequencies and limits their ion cloud cooling and centering effectiveness, presenting itself as one of the most significant systematic effects. Furthermore, it hinders the usage of Penning traps as isobaric separators, limiting the number of trapped ions. In this presentation, recent experimental results and simulations on the behavior of large ion clouds under high space-charge conditions in WITCH Penning traps will be presented.

### FPNp3 Measurement of the beta-asymmetry parameter in search for physics beyond the Standard Model

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Measurement of the beta-asymmetry parameter in search for physics beyond the Standard Model A precise measurement of the beta-asymmetry parameter A nuclear beta decay provides a sensitive probe of the weak interaction Hamiltonian. Here we will present the results obtained for the decay of <sup>67</sup>Cu. The technique of on-line low temperature nuclear orientation was employed to polarize the nuclei. The electrons

were registered using planar high-purity Ge detectors mounted on the 4 K radiation shield, looking directly at the source. A Geant4-based Monte Carlo program was used to account for the scattering of electrons and for the effect of magnetic fields. The experimentally obtained value of the A parameter in the decay of <sup>67</sup>Cu is 0.587(14), in agreement with the Standard Model value of 0.5991(2). The results can be interpreted in terms os possible tensor type charged currents, yielding the limits of -0.045 < (CT + CT')/CA < 0.159 (90% C.L.).

#### **CONDENSED MATTER & NANOSTRUCTURE PHYSICS**

#### CMNp1 Superconductivity in a LaAlO<sub>3</sub>-SrTiO<sub>3</sub> heterostructure

<u>Serghei Klimin<sup>1</sup></u>, Jacques Tempère<sup>1</sup>, Jozef Devreese<sup>1</sup>, Dirk van der Marel<sup>2</sup> <sup>1</sup>TQC, Universiteit Antwerpen <sup>2</sup>DPMC, Université de Genève

In the present work, superconductivity in a lanthanum-aluminum oxide/strontium titanate (LAO-STO) heterostructure is explained in terms of the electron - LO phonon interaction. Superconductivity in bulk strontium titanate was convincingly interpreted within the electron - LO phonon picture [1]. Consequently, this mechanism of superconductivity is promising for the explanation of the experimental data on superconductivity also in the LAO-STO heterostructures. Superconductivity has been detected in strontium titanate at relatively low carrier densities. For polar crystals with sufficiently high optical-phonon frequencies and/or low carrier densities, the conditions for the Migdal theorem are not fulfilled. Therefore we use the dielectric function method [2] to treat the superconductivity caused by the electron-phonon interaction with polar optical phonons. The method has been re-formulated [3] for a multilayer structure with several polar layers. In these structures, the electrostatic electron-electron interaction, the optical-phonon spectra, and the amplitudes of the electron-phonon interaction are strongly modified compared to those in bulk. For the calculations, we use well-established material parameters without fitting, except for the acoustic deformation potential of strontium titanate, for which the values reported in the literature show a considerable spread. The calculation yields critical temperatures within the same range as the experimental data [4]. Even taking into account the apparent uncertainty of the present experimental results for the critical temperatures and the uncertainty of the published values of the acoustic deformation potential, the suggested theoretical explanation of the superconducting phase

transition in the LAO-STO heterostructures is a plausible interpretation. The present study calls for further experiments leading to a reliable value of the acoustic deformation potential and to more precise critical temperatures for different densities.

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### CMNp2 Tuning the ferromagnetic-antiferromagnetic interfaces of granular Co-CoO exchange bias systems by annealing

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The low-temperature magnetic behavior of granular Co-CoO exchange bias systems, prepared by oxygen ion implantation in Co thin films and subsequent annealing, is addressed. The thermal activation effects lead to an O migration which results in virtually pure Co areas embedded in a structurally relaxed and nearly stoichiometric CoO phase. This yields decreased training and exchange bias shifts, while the blocking temperature significantly increases, coming close to the Néel temperature of bulk CoO for samples implanted to a fluence above  $1 \times 10^{17}$  ions/cm<sup>2</sup> (15% O). The dependence of the exchange bias shift on the pristine O-implanted content is antiferromagnetic to that of the thickness in analogous most ferromagnetic/antiferromagnetic systems (i.e., an increase in the exchange bias shift up to a maximum followed by a decrease until a steady state is reached), suggesting that, after annealing, the enriched Co areas might be rather similar in size for samples implanted above  $1 \times 10^{17}$  ions/cm<sup>2</sup>, whereas the corresponding CoO counterparts become enlarged with pristine O content (i.e., effect of the antiferromagnet size). This study demonstrates that the magnetic properties of granular Co-CoO systems can be tailored by controllably modifying the local microstructure through annealing treatments.

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#### CMNp3 Spectral force approach to solve the time-dependent Wigner-Boltzmann transport equation

#### <u>Maarten Van De Put</u>, Wim Magnus, Bart Soree Universiteit Antwerpen / Imec

The Wigner-Liouville equation provides the time evolution of the Wigner function f(x,p,t) which provides a phase-space picture of statistical quantum mechanics. Combined with a Boltzmann-like inelastic scattering term, this is ideal to describe electronic transport in nano-scaled semiconductor devices. The Wigner kernel introduces a non-local interaction with the potential V(x) introduced by the device structure in accordance with quantum theory. Unfortunately, even without interparticle interaction the mathematical form of the kernel includes highly oscillatory components by integrating over e<sup>ikx</sup>, impeding stable numerical implementation based on a finite discretization scheme.

Going back to classical mechanics and using the force F(x)=-dV(x)/dx instead of the potential, we derive a new expression for the Wigner kernel. Using the wave nature of quantum mechanics, we expand the force in terms of its Fourier components F(k) and see a factor 1/k emerge. This factor provides a natural damping of the highly oscillatory components of the Wigner kernel, making numerical implementation easier. Furthermore, this process yields a much simpler WL equation which is local in position and contains only a single integral over momentum. In the classical limit, for momenta p>>hk the Boltzmann equation emerges naturally.

An intriguing interpretation of this new form of WL equation consists of Newtonian transport of free particles absent potential and a 'quantum generation' term that mediates the force. The generation term is responsible for the production of symmetric positive and negative contribution at momenta p+hk/2 and p-hk/2 with a rate determined by  $F(k)e^{ikx}/(hk)$  f(x,p,t). The rate is directly proportional to the spectral component of the force at k. Higher frequency components of the force represent the quantum corrections with respect to the classical Boltzmann picture.

We implemented this new form based on a discretized position and momentum. The momenta naturally follow from the FFT of the force, replacing the integral over k with a finite sum. An initial condition  $f_0(x,p)$  is chosen and the system is solved by stepping through time until a steady state is reached. As a proof-of-concept we simulated an electron flow through a resonant tunnel diode and a structure with a periodic potential, two structures that rely on coherent transport for their working principle. A relaxation time approximation provides a source of scattering, breaking this coherence.

### CMNp4 High throughput first-principles calculations of bixbyite oxides for TCO applications

#### Nasrin Sarmadian, Rolando Saniz, Bart Partoens, Dirk Lamoen University of Antwerp

We use high-throughput computing based on density functional theory to generate new bixbyite ternary oxides and screen them with the aim of identifying those that might be electronically appropriate for transparent conducting oxides (TCO) applications. The screening criteria used are a minimum band gap to ensure sufficient transparency, a band edges alignment consistent with easy n- or p-type dopability, and a minimum thermodynamic phase stability to be experimentally synthesizable. We screen 23 binary and 1518 ternary bixbyite oxides in order to identify promising candidates, which can be then subject of an in-depth study. The results for the known TCOs are in good agreement with the reported data in the literature. We suggest a list of several new potential TCOs, including both n- and p-type compounds.

#### CMNp5 Resistivity scaling in ultra-thin metallic nano-wires

#### Kristof Moors KU Leuven

The resistivity in metallic wires of decreasing diameters scales up for decreasing diameters. This behaviour is well known and caused by an increase of electron scattering due to surface roughness and grain boundaries. The experimental observations are well described by semi-classical descriptions: the Fuchs-Sondheimer model (1938-1952) for surface roughness and Mayadas-Shatzkes model (1970) for

grain boundaries. To go beyond this semi-classical description, which looses validity at ultra-thin diameter scales, we adopt the quantum-mechanical relaxation time approximation (RTA) in the Boltzmann transport equation. This approach gives a rigorous quantum-mechanical framework for electron scattering and resistivity calculations. The model is already widely known and used, but in an approximated form that supposes a state-independent relaxation time. This is applicable to interconnects that are used today, but as scaling goes on, diameters can be reached where the relaxation time becomes highly state-dependent. In this presentation an improvement of the model will be explained and results are shown for electron surface roughness scattering in nano-wires of different diameters. The surface roughness properties can be changed, like the standard deviation or correlation length, showing interesting scaling behaviour for ultra-thin diameter wires. Maybe the resistivity will not keep on increasing after all?

#### CMNp6 Effective field theory for a two-band ultracold Fermi gas

#### Serghei Klimin, Jacques Tempère, Jozef Devreese TQC, Universiteit Antwerpen

The present work is devoted to the time-dependent formalism for ultracold interacting Fermi gases in terms of the macroscopic wave function. We derive a finite temperature effective field theory [1], capable of describing both single-band and two-band Fermi superfluids at all temperatures below the critical temperature. The developed method is focused on strong-coupling superfluid systems, especially the ultracold atomic Fermi gases in the BCS-BEC crossover regime. The effective field functional is derived using a derivative expansion of an exact action up to the second order both in space and time without assuming the field fluctuations small. A complete summation of the whole series in powers of the order parameter has been performed in each term of the derivative expansion. As a result, we arrive at the effective field theory (EFT) which is a straightforward extension of several limiting theories. The present method can retrieve the known limiting cases: the GL equation in the close vicinity of the critical temperature and the Gross-Pitaevskii (GP) equation in the BEC regime. Also we reproduce the homogeneous results obtained within the microscopic path-integral formalism through the whole BEC-BCS crossover. In the limit of small temperatures, we retrieve the ground state energy obtained from the microscopic path-integral theory for Fermi superfluids, and for temperatures near the critical temperature, we obtain the standard Ginzburg-Landau expressions. Here, we

discuss several applications of the developed finite-temperature EFT. First, the present formalism has been applied to reveal the presence of two healing length scales in two-bandgap superfluid Fermi gases. Second, we investigate the finite-temperature vortex in the BCS-BEC crossover comparing the results with the Bogoliubov – deGennes (BdG) theory. In comparison with BdG, the finite temperature EFT allows us to consider the spatially inhomogeneous Fermi gases at arbitrary temperatures and arbitrary coupling strength with greatly reduced computation time. Moreover, in some cases, the extended GL yields exact analytic solutions. Finally, we analyze the ground state parameters and spectra of collective excitations for two-band superfluid Fermi gases through the entire BCS-BEC crossover.

This work was supported by FWO-V projects G.0370.09N, G.0180.09N, G.0115.12N, G.0119.12N, the WOG WO.033.09N (Belgium).

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# CMNp7 Engineering the band structure of nanoparticles by an incommensurate cover layer

<u>Koen Schouteden<sup>1</sup></u>, Zhe Li<sup>1</sup>, Violeta Iancu<sup>1</sup>, Dmitry Muzychenko<sup>2</sup>, Ewald Janssens<sup>1</sup>, Peter Lievens<sup>1</sup>, Chris Van Haesendonck<sup>1</sup> <sup>1</sup>Laboratory of Solid State Physics and Magnetism, KU Leuven <sup>2</sup>Faculty of Physics, Lomonosov Moscow State University, Russia

When two incommensurate lattices are stacked on top of each other, a superlattice emerges with a periodicity larger than that of the two lattices involved. This periodic structure is often referred to as a Moiré pattern [1].

Here, we exploited for the first time the Moiré-effect-related periodic potential to modify the electronic structure of nanoparticles. For this purpose we covered socalled vacancy islands, created in a Au(111) surface, by an atomically thin NaCl film. So far, NaCl films on Au(111) have been used primarily to insulate molecular adsorbates from the metallic substrate [2], thereby leaving the influence of the Moiréeffect-related potential unaddressed. Relying on scanning tunneling microscopy and spectroscopy, we find that the Moiré-effect-related potential results in the appearance of standing-wave patterns and the opening of multiple band gaps in the local electron density of states of the vacancy islands. Furthermore, we find that the NaCl cover layer gives rise to a shift of the quantized energy levels of the islands to higher energies, leading to (partial) depopulation of the modified Au(111) surface state. The use of a cover layer for band structure engineering can likely be applied to any metallic surface or nanoparticle that exhibits an electron gas at its surface and that is incommensurate with the cover layer.

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### **BIOPHYSICS, MEDICAL, STATISTICAL & MATHEMATICAL PHYSICS**

### BMSMp1 Molecularly imprinted nano and micro particles for the detection of testosterone

#### Evelien Kellens, Hannelore Bové, Matthias Conradi, Lien D'Olieslaeger, Thomas Junkers, Anitha Ethirajan, Patrick Wagner *Hasselt University*

The development of biosensors for the detection of biological molecules in physiological con-centrations in a fast, cost effective and reliable way is highly demanded in medical diagnostics as well as in food and environmental safety. A limitation is that there are target molecules for which natural receptors either do not exist or exhibit insufficient specificity and physical or chemical stability. A compelling alternative is to develop molecularly imprinted polymers (MIP) which contain cavities that are complementary to the target molecule regarding size, shape and functional group arrangement. Therefore these cavities are able to rebind the target molecule with high specificity. The bi-functional N,O-bismethacryloyl ethanolamine (NOBE) monomer (functional and crosslinking) was synthesized successfully. A stable water based dispersion of polymer MIP nanoparticles (NP, ~ 450 nm) based on NOBE and targeted towards testosterone was successfully made via the miniemulsion polymerization technique with a high efficiency monomer to polymer NP conversion. Also NOBE based MIP microparticles were obtained using a

bulk polymerization protocol. The use of MIP NPs is expected to offer specific advantages over bulk MIPs with respect to size, shape and homogeneity. The imprinting efficiencies of both the bulk and miniemulsion MIPs were characterized using optical batch rebinding experiments and non-imprinted polymers (NIP) were used as a negative control. For this, a fixed amount of dry MIP and NIP powder is resuspended in a water based solution containing a known concentration of testosterone. After reaching equilibrium between imprints bound to target molecule and free target molecule in solution, the MIPs and NIPs are separated from the solvent. The free target molecule concentration is determined by UV-VIS absorption measurements and the amount of target molecule bound to both MIPs and NIPs is calculated. The miniemulsion MIPs show significantly less aspecific binding and better imprint factors in comparison with the bulk MIPs. At a free concentration of 0.1 µM the miniemulsion MIPs and NIPs show an imprint factor that is approximately 7 times higher compared to the imprint factor from the corresponding bulk MIPs and NIPs. As a next step, these NPs will be transferred onto biomimetic sensor platforms for electronic read-out.

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#### BMSMp2 Vacuum-deposited metallic nanoparticles on a proteinrepellent background for site-selective protein adsorption

<u>Tobias Peissker<sup>1,2</sup></u>, Olivier Deschaume<sup>1</sup>, Danielle R. Rand<sup>2</sup>, Margriet Van Bael<sup>1</sup>, Carmen Bartic<sup>1,2</sup> <sup>1</sup>Laboratory of Solid State Physics and Magnetism, KU Leuven <sup>2</sup>Imec

Using immobilized biomolecules including proteins (e.g. antibodies or enzymes) in biosensing devices requires a reliable control over the amount, the position and eventually the configuration of the biomolecules attached to the sensing surface [1]. The provision of pre-defined binding sites for protein attachment allows for a control of the quantity of both the immobilized protein and the detected biomolecule. A reduction of the steric hindrance between immobilized proteins is achieved by increasing the inter-molecular distance which further facilitates the accessibility of the biomolecules and hence increases the interaction between the immobilized molecule and target. However, non-specific protein attachment on the substrate might redundantise prepared binding sites as the entire substrate will be covered with proteins [2]. The avoidance of non-specific protein attachment is hence an important 94

constraint. In this contribution we will present an elegant way of providing predefined protein binding sites by using preformed vacuum-deposited metallic nanoclusters on a protein-repellent polymer layer. The nanoclusters with sizes around 2-4nm, i.e. in the size range of proteins, are deposited from ultra-pure noble metals and do not require a stabilizing ligand layer. We verify that proteins, attached by using a thiol-linker molecule to the Pt nanoclusters, remain biologically active and can be used to detect a target molecule. Furthermore, we highlight the importance of the protein-repellent layer on both the protein attachment and the protein detection.

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#### **ATOMS, MOLECULES, OPTICS & PHOTONICS**

### AMOPp1 Rovibrational distribution of O2+ produced by solar wind interaction and REMPI

#### <u>Arnaud Dochain</u>, Xavier Urbain Université Catholique de Louvain

The interaction of the solar wind with the gas plume evaporating from comets is at the core of the ROSETTA mission. As a test case, we have studied the ionisation of  $O_2$  by charge transfer (CT) to protons and alpha particles at velocities typical of minima and maxima of solar activity. This study focused on the rovibrational and electronic excitation of the resulting  $O_2^+$  ions, which was analysed by dissociative charge transfer.

In the experimental setup, the protons or alpha particles are extracted from a duoplasmatron ion source and accelerated to an energy equal to the sum of the desired collision energy and the voltage applied to the collision region. They are decelerated in a unique combination of Einzel lens and resistive glass tube to enter the collision cell hosting neutral molecules from an effusive jet. The daughter molecular ions are further accelerated to 4 keV as they leave the floating interaction region, and cross an effusive potassium jet where they undergo resonant dissociative

CT. Due to energy and momentum conservation in the predissociation process, the positions and flight time difference of the two resulting O atoms give access to the vibrational distribution of the CT products.

While the vibrational distribution was found unchanged when varying the velocity of the incoming ions from 320 to 660 km/s<sup>-1</sup> (corresponding to 530 eV to 2320 for H<sup>+</sup>, 2120 to 9300 eV for He<sup>++</sup>), we observed an increasing population of the  ${}^{4}\Pi_{u}$  metastable state of  $O_{2}^{+}$ , more prominent in the case of fast alpha particles. This population is subject to slow radiative decay, which will reshuffle the vibrational distribution in the ground  ${}^{2}\Pi_{g}$  state. This distribution is known to affect the dissociative recombination of  $O_{2}^{+}$ .

In order to study the reactivity of particular excited states of  $O_2^+$ , we have studied the resonance enhanced multiphoton ionization of  $O_2$  via the  ${}^{1,3}\Pi_u$  states with a 296.5 - 303.5 nm frequency-doubled dye laser. We managed to produce  $O_2^+$  in v=0-1 states with rotational quantum numbers ranging from <5 to more than 25. This allows us to fully specify the rotational and vibrational state of an ensemble of molecular ions, for which collisional or radiative properties can be studied.

### AMOPp2 Tolerance of platinum clusters to CO poisoning induced by molybdenum doping

#### <u>Vladimir Kaydashev</u>, Ewald Janssens, Peter Lievens Laboratory of Solid State Physics and Magnetism, KU Leuven

Pt alloys have been studied extensively and still remain the most widely used catalysts in proton exchange membrane fuel cells. CO poisoning of the platinum anode in these fuel cells is a serious problem and limits their performance. The development of efficient catalysts requires inhibition of CO adsorption or the capability to oxidize adsorbed CO at low potentials.

In this work we investigate the influence of a single Mo dopant atom on the CO adsorption on small cationic platinum clusters in the gas phase,  $Pt_n^+$  ( $13 \le n \le 24$ ). The sticking probability of the first CO molecule to bare  $Pt_n^+$  clusters is estimated to be close to unity and is not notably changed upon Mo doping. The adsorption probability of the second CO molecule, however, shows a significant reduction for  $Pt_{n-1}Mo^+$  compared to  $Pt_n^+$ , reaching a maximal reduction of as much as 80% for  $Pt_{19}Mo^+$ . As a result, the average number of CO molecules adsorbed on  $Pt_n^+$  with  $19 \le n \le 24$  decreases by about 10-15% upon substitution of a single Pt atom by a single Mo atom. Electron transfer from Mo to Pt resulting in a decrease of the amount of Pt

5d vacancies and a downshift of the 5d band center is likely responsible for the reduced CO chemisorption energy upon doping.

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#### AMOPp3 Fluorescence spectra shape based dynamic thermometry

Liwang Liu, Christ Glorieux

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Temperature measurement is ubiquitous in scientific research and industrial applications. A variety of techniques have been developed to enable both contact and remote thermometry. Due to the required electrical wiring, contact methods - like thermocouples, thermistors and resistance temperature detectors (RTDs) - are not suited for situations where electromagnetic noise is strong, where the environment is corrosive or where parts are rapidly moving. Different optical thermometry techniques are therefore being explored to meet particular challenging situations. Among the optical methods available, fluorescence-based thermometry has attracted attention because of its fast response, high spatial resolution, and safety of remote handling. Fluorescence-based thermometry utilizes the temperature dependence of the fluorescence intensity (integrated intensity and/or peak intensity of the fluorescence spectrum) or of the fluorescence lifetime of thermographic fluorophores (organic dyes, inorganic dyes and quantum dots) to determine the temperature. As measuring fluorescence lifetimes generally requires complex data analysis and costly instruments, fluorescence intensity-based approaches tend to be the most costeffective method to implement. However, the fluorescence intensity is affected by several factors, associated with the mechanical, electrical and optical stability of the measurement arrangement, such as drifts of optical element positions and of the excitation laser power. This reduces the accuracy of the measurements, which in turn hampers applications.

In this work, we report a fluorescence spectral shape-based thermometry technique, in which the sample temperature is recovered by neural network (NN) recognition that enables the combined exploitation of different features of fluorescence spectra, thus overcoming the limitations of fluorescence intensity based thermometry, and improving the measurement accuracy. As a proof of concept, the frequency dependent photothermally induced temperature change of rhodamine B (RhB) and copper chloride (CuCl<sub>2</sub>) dyed glycerol at three positions along the axis of the excitation laser beam are determined by means of the developed method and the result is fitted by a 1D thermal wave model.

#### **ASTROPHYSICS, GEOPHYSICS & PLASMA PHYSICS**

#### AGPp1 The evolution of the global coronal shock in the June 7, 2011 event: An MHD simulation study

Jens Pomoell, Stefaan Poedts Centre for Mathematical Plasma-Astrophysics, KU Leuven

A variety of transient phenomena in the solar corona such as global EUV waves, type II radio bursts, coronal dimmings as well as coronal loop oscillations have the potential of being important diagnostic tools for space weather prediction purposes due to their intimate connection to coronal mass ejections (CMEs) and flares, and thereby, to the genesis of energetic particle populations in the heliosphere. However, the nature and interconnection of these phenomena remain veiled in spite of tremendous advancements in the observational capabilities during the past decades. In part, this stems from the inherent difficulty of interpreting the coronal remote observations as well as the complexity of the solar coronal dynamics.

A viable path for gaining insight in to the physics of the eruption-associated phenomena is to construct numerical models capable of simulating the coronal dynamics with such a degree of realism that direct comparisons to observations can be made. To that end, we have conducted a global three-dimensional magnetohydrodynamic simulation of the June 7, 2011 eruption. The dynamics of the launched global shock wave in the simulation matches closely the dynamics of the observed EUV wave, suggesting a close relationship between the two. The work focuses in particular on determining the evolution of the characteristics of the global coronal shock wave, and discussing the implications for the generation of solar energetic particle events.

### AGPp2 Tunneling and mode conversion of fast magnetosonic waves in the planetary magnetospheres

<u>Yevgen Kazakov<sup>1</sup></u>, Tünde Fülöp<sup>2</sup> <sup>1</sup>Laboratory for Plasma Physics, Royal Military Academy <sup>2</sup>Chalmers University of Technology, Göteborg, Sweden

Observational studies indicate, in addition to protons, the presence of several ion species, e.g. He<sup>+</sup> at Earth's, Na<sup>+</sup> at the Mercury's,  $S_2^+$  and O<sup>+</sup> at Jupiter's environments [1]. Narrow-band linearly polarized ultra-low frequency (ULF) waves (f~1 Hz), having a resonant structure and a peak frequency between the cyclotron frequency of protons and heavy ions, have been detected in the magnetospheres of Earth and Mercury. Such wave events have been suggested to be driven by linear mode conversion (MC) of the fast magnetosonic waves at the ion-ion hybrid (IIH) resonances. Since the resonant frequency is linked to the plasma composition, solving the inverse problem allows one to estimate the concentration of the heavy ions from the measured frequency spectra.

Planetary magnetic fields are intrinsically radially inhomogeneous that leads to the appearance of the L-cutoff layer accompanying the IIH resonance to the low magnetic field side. In this work we prove that waves with a low parallel wave number  $k_{//}$  cannot tunnel through the cutoff-resonance layer, and thus can not be detected by the satellite. On the contrary, we evaluate conditions under which an efficient tunneling and MC can occur in magnetospheric plasmas [2]. For such conditions, the resonant MC frequency is close, but somewhat below, the crossover frequency. Finally, we discuss how these results can be applied to the interpretation of experimental observations.

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#### AGPp3 Minority ion cyclotron resonance heating in H-mode in presence of the ITER-like wall in JET

### Dirk Van Eester, Ernesto Lerche Laboratory for Plasma Physics, Royal Military Academy

In the 2013 JET campaign the focus was on characterizing H-mode operation in presence of the "ITER-like" wall. In the context of ion cyclotron resonance heating (ICRH) or radio frequency (RF) heating, particular attention was paid to identifying experimental parameter settings for which the high Z impurity influx off the wall remains acceptably low while good heating and confinement is achieved.

Hydrogen minority fundamental cyclotron heating in a Deuterium plasma guarantees very high single pass absorption (80-100%), in particular at concentrations of the order of 5%. ICRH power levels of 4-5MW were used while the beam power was typically 15MW. At the high densities commonly observed in H-mode due to both the good confinement and the high particle influx via neutral beam injection, the ICRH efficiency remained high (>50%) up to Hydrogen concentrations in excess of 20% whereas it dropped to lower values (30%) in L-mode plasmas. In agreement with theoretical expectations, high energy tails were observed both by the time-of-flight neutron spectrometer and neutral particle analysis diagnostics, the tails being more pronounced in H-mode than in L-mode and dying away when going to high X[H]. The direct response of H as well as D tails to minute changes of the plasma parameters; e.g. periodic strike point sweeping triggered a correlated driven response of the tail, believed to be due to shape changes of the magnetic equilibrium and thus both to the density the antenna instantaneously faced.

Whereas a clear minimum of the bulk radiated power was observed at intermediate concentrations in earlier L-mode experiments - the radiation dropping by a factor of 1.7 when increasing X[H] from 12 to 20% for PICRH ~ 3.4MW - this effect was absent in H-mode at similar ICRH power and only weakly observed at higher PICRH: a reduction of only 1.2-1.3 was observed at PICRH ~ 4.7MW but the effect is only visible at very low X[H] ~ 2%.

#### AGPp4 Numerical Simulations of Solar-Wind Comet interactions based on implicit Particle-In cell/Monte Carlo Method

#### Wei Jiang, Giovanni Lapenta KU Leuven

The ROSETTA mission will approach the comet this year, and thus offers a unique opportunity to study the plasma activity during the solar-wind comet interactions. In order to study the transition from the collisionless outer coma to the collision-dominated inner coma, it is necessary to adopted the kinetic include the electron and ion collisions, as well as the photon chemical and photon ionization processes.

We have developed an implicit Particle-In cell/Monte Carlo (PIC/MC) Method to study this process self-consistently, which solves the Vlasov equation in the weakly collisional regime, and include both the kinetic and the collisional treatment of cometary electrons, ions with molecules. In this model, we consider the charged particles of electrons,  $H^+$ ,  $H_2O^+$ ,  $O^-$ , and the neutrals of  $H_2O$  are treated as background with analytical formulation. One dimensional electrostatic and implicit PIC method is used to follow the motions of the charged particles. Photoionization and dissociation are also included. 12 electronic and 2 ionic collision processes are included, with the cross sections from LXCat (www.lxcat.net/). Recombination processes between the electrons and ions are also considered with temperature dependent recombination rate.

The simulations are performed with different distance between the sun and the comet. A clear transition from the solar wind proton-dominated flow to a plasma population primarily consisting of relatively cold cometary heavy ions, are observed, and the position of the cometopause are also predicted. The plasma density and temperature profiles, as well as the spatial dependent electron energy distributions functions, are calculated self consistently. It was shown the plasma properties in the come strongly rely on the solar-wind and photon properties, i.e. the distance between the sun and comet, as well as the comet outgassing characters.

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#### AGPp5 Asymmetric Reconnection: a Breakthrough to More Realistic Reconnection Events in Space

#### Emanuele Cazzola, Giovanni Lapenta KULeuven

Magnetic reconnection is a process already known as early as the forties, when Giovannelli first suggested the possibility for the magnetic field to change topology and release energy. This is of primary importance in driving many physical events in space, such as solar flares and geomagnetic substorms, and required further studies. Specifically, the GEM challenge turned out to be fundamental in explaining reconnective events in the magnetotail. This region is usually well described with the Harris conditions concerning the balance between magnetic and plasma pressures into a symmetric current sheet.

However, reality is often strongly asymmetric in either magnetic field or density or both. Only recently this asymmetric configuration has been studied using several different approaches, including MHD and kinetic simulations.

Particularly, asymmetric reconnection results in having new interesting hallmarks. For instance, due to the difference of the magnetic energy across the current sheet, a co-location between the X-line and the stagnation point no longer exists. This offset leads to a plasma flow through the null point. Moreover, the X-line may experience a further lateral diamagnetic drift governed by the electron diamagnetic velocity when a proper out-of-plane magnetic component is present (i.e. guide field).

Finally, this work aims at going deeper into the abundance of physics behind the process of asymmetric reconnection in collisionless plasmas using a powerful tool as the fully kinetic implicit code iPIC3D. This tool allows us to perform simulations with larger spatial and temporal scales thanks to the reduced computational costs of the implicit algorithm.

As first application of asymmetric conditions, we are going to analyze the dayside magnetosphere, where the shocked solar wind (magnetosheath) encounters the magnetosphere plasma and strong gradients in both magnetic field and density are measured. Great interest in this region has been lately remarked, mostly in light of the upcoming 4-satellites cluster NASA mission, named MMS (Magnetosphere Multiscale Mission), devoted to observe reconnection behaviors into these large spatial scale of the magnetosphere.

This work has received funding from the European Union's Seventh Programme for Research, Technological Development and Demonstration under Grant Agreement No. 284461 - Project eHeroes (www.eheroes.eu)

#### AGPp6 Mesh-free formulation of two dimensional Darwin model

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In many astrophysical and fusion applications the CFL stability condition implies strong computational efforts. We propose here a magneto-inductive (Darwin) plasma model, which neglects retardation effects so that the electromagnetic propagation speed is effectively infinite. In this way long timescale phenomena can be investigated without the need to explicitly resolve wave propagation. By neglecting the solenoidal part of the displacement current in Ampere's law and setting up the vector potential as a divergence-free field, the Maxwell-Darwin equations are converted from hyperbolic to elliptic partial differential equations, which can then be solved with the help of tree methods. Our purpose is to formulate a mesh-free model based on particles with finite-size shape function to avoid singularities in pair potential.

The main challenge of this work is to construct a robust method which avoids the numerical instabilities due to combination of Darwin approximation with standard integration schemes. Examples of planned applications will also be described.

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## AGPp7 The DFMS sensor of ROSINA onboard Rosetta: Mission to comet Churyumov-Gerasimenko

Johan De Keyser, Frederik Dhooghe, Herbert Gunell, Romain Maggiolo Belgian Institute for Space Aeronomy

Rosetta will rendez-vous with comet 67P/Churyumov-Gerasimenko in Summer 2014. The Rosetta ROSINA instrument consists of a pressure sensor COPS and the mass spectrometers RTOF and DFMS. The double focusing magnetic mass spectrometer DFMS is optimized for mass resolution and has been built partly by the Belgian Institute for Space Aeronomy. This contribution describes the DFMS data analysis and the scientific work that we plan as Rosetta approaches the comet.

The data processing chain is largely automated. The first step consists of data acquisition from the 512 pixel detector array in the form of ADC counts as a function of pixel number over a limited mass range. The second step is the mass calibration. An accurate correlation of pixel number and m/Z (mass-over-charge) ratio is needed. This depends on commanded mass (fixed by setting the electric and magnetic fields in the instrument optics) and is described by an offset of the pixel associated with the commanded mass from the centre of the detector and a dispersion factor. Mass calibration is aided by the built-in gas calibration unit (GCU), which can inject a known gas mixture. An initial mass calibration extracts information from all GCU spectra about the central mass peak, which can be identified unambiguously, to build a mass calibration relation that is further improved by human-assisted identification of additional mass peaks. A subsequent step is ion flux calibration. ADC counts are converted to ion counts using overall gain and individual pixel gain. DFMS performs a pixel scan to assess the changing pixel gain as the detector ages. The last step converts the ion fluxes into densities of neutrals at the instrument entrance. Neutrals may fragment as they are ionized upon entering the mass analyser. Multiple spectra are combined to provide an overview of the recorded fragments, and then a database of fragmentation patterns is used to figure out which neutrals entered the instrument. Finally, experimentally determined sensitivities are used to obtain gas number densities.

These data are then used in chemical models of the comet atmosphere. Given measured neutral gas densities of certain species at a number of positions, we try to determine the production rate of the sublimating volatiles at the comet nucleus surface. Knowledge of the volatile composition can tell us more about the origin of comets and of the Solar System itself.

#### AGPp8 Realistic mass ratio simulations of magnetic reconnection with the Multi Level Multi Domain method

<sup>1</sup><u>Maria Elena Innocenti</u>, <sup>2</sup>Arnaud Beck, <sup>3</sup>Thomas Ponweiser, <sup>4</sup>Stefano Markidis, <sup>1</sup>Giovanni Lapenta

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Space physics simulations with the ambition of realistically representing both ion and electron dynamics have to be able to cope with the huge scale separation between the electron and ion parameters while respecting the stability constraints of the numerical method of choice. Explicit Particle In Cell (PIC) simulations with realistic mass ratio are limited in the size of the problems they can tackle by the restrictive stability constraints of the explicit method (Birdsall and Langdon, 2004). Many alternatives are available to reduce such computation costs. Reduced mass ratios can be used, with the caveats highlighted in Bret and Dieckmann (2010). Fully implicit (Chen et al., 2011a; Markidis and Lapenta, 2011) or semi implicit (Vu and Brackbill, 1992; Lapenta et al., 2006; Cohen et al., 1989) methods can bypass the strict stability constraints of explicit PIC codes. Adaptive Mesh Refinement (AMR) tech- niques (Vay et al., 2004; Fujimoto and Sydora, 2008) can be employed to change locally the simulation resolution. We focus here on the Multi Level Multi Domain (MLMD) method introduced in Innocenti et al. (2013) and Beck et al. (2013). The method combines the advantages of implicit algorithms and adaptivity. Two levels are fully simulated with fields and particles. The so called "refined level" simulates a fraction of the "coarse level" with a resolution RF times bigger than the coarse level resolution, where RF is the Refinement Factor between the levels. This method is particularly suitable for magnetic reconnection simulations (Biskamp, 2005), where the charac- teristic Ion and Electron Diffusion Regions (IDR and EDR) develop at the ion and electron scales respectively (Daughton et al., 2006).

In Innocenti et al. (2013) we showed that basic wave and instability processes are correctly reproduced by MLMD simulations. In Beck et al. (2013) we applied the technique to plasma expansion and magnetic reconnection prob- lems. We showed that notable computational time savings can be achieved. More importantly, we were able to correctly reproduce EDR features, such as the inversion layer of the electric

field observed in Chen et al. (2011b), with a MLMD simulation at a significantly lower cost.

Here, we present recent results on EDR dynamics achieved with the MLMD method and a realistic mass ratio.

### AGPp9 Antenna near-field wave studies in magnetized plasmas as part of the optimization of auxiliary heating in fusion devicesAntenna near-field wave studies in magnetized plasmas as part of the optimization of auxiliary heating in fusion devices

#### Dirk Van Eester, Kristel Crombe LPP-ERM/KMS

After having relied on low Z first-wall or coating materials (typically carbon or thin low-Z coatings) for a few decades to progress significantly on being able to heat tokamak plasmas to fusion relevant temperatures, the next step towards actual fusion-based reactors is to guarantee similar performance in presence of metallic walls, the latter allowing to avoid wall erosion when doing long-duration shots. Recent experiments on various devices with metallic plasma facing components (e.g. ASDEX-U, Tore Supra and JET) have demonstrated that impurities tend to invade the plasma and make plasma heating less efficient as a result of Bremsstrahlung. As electromagnetic fields in the edge - and in particular in the sheaths that form close to metallic objects - are believed to accelerate particles to high energies and give rise to sputtering of wall material, having a proper understanding of the electromagnetic field structure outside the last closed flux surface in general and near wave launchers in particular is important to enable reducing the wall-impurity influx by eliminating its presumed source.

In the context of the Fusion Road Map through which the European Fusion effort is organized since the beginning of 2014, attention is paid to address this important issue. The co-existence of short and long wavelength modes, field-induced flows and partial ionization makes this branch of research both interesting and challenging. A state-of-the-art of the modeling is given and the plans towards experimental verification in test beds are presented.

#### AGPp10 Wave-particle interactions in collisionless plasmas -- Landau damping vs. cyclotron resonance

#### Yana Maneva, Stefaan Poedts CmPA KU Leuven

We present the results from hybrid numerical simulations of wave-particle interactions between finite-amplitude Alfven waves, protons and alphas particles in collisionless low-beta plasmas. The electrons are treated as a chare-neutralizing fluid and the fully kinetic ions initially have isotropic drifting bi-Maxwellian velocity distribution functions. The only energy source in the system comes through the initial Alfven waves, which are chosen from the low-frequency MHD domain, below the lowest ion-cyclotron resonance in the system. The initial magnetic fluctuations are stable with respect to linear kinetic plasma instabilities. Fast ion-acoustic waves, with speeds close to the local Alfven speed, and high frequency ion-cyclotron waves are generated via non-linear wave couplings due to parametric instabilities of the initial pump waves. Those nonlinear couplings result in direct and inverse cascade with energy transfer to both smaller and larger spacial scales. Depending on the value of the relative drift speed between protons and alpha particles the daughter waves produced during the parametric decays can can to accelerate or decelerate the minor ions. Without drifts the Landau damping of the daughter ion-acoustic waves leads to strong parallel heating and acceleration and the cyclotron resonance increases the perpendicular temperature for the minor ions. Thus both processes are important. At low relative drifts Landau damping is stronger and at high drift cyclotron resonance becomes dominant. Those results provide new insights to the wave-particle interaction at kinetic scales and can be used to explain the observed differential acceleration and preferential heating of minor ions in the fast solar wind.

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- > Web enabled set-up and operation
- Flexible hardware/software controls for sample changers, external acquisition and MCS start/stop, coincidence gating and auto pole/zero

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