Forum de la communauté ultrarapide du plateau de Saclay

June, 6th, 2023
École Polytechnique

Foreword

The Plateau de Saclay is a major international player in time-resolved studies, from the optical developments that gave rise to them to the experimental and theoretical studies that they allow. The field of research extends from atto-physics, atto- and femto-chemistry, and femto-biology to multi-scale studies in all phases of matter. The range of developments and studies carried out is extremely wide and includes many laboratories and stakeholders in the territory. The dynamism of theme 3 of the LABEX PALM is proof of this, as well as the two Equipex (ATTOLab and Apollon) which were built in the 2010s.This richness, resulting from the diversity of studies and sites, offers exceptional opportunities for transdisciplinary collaborations, provided that the members of the community know each other and exchange. In spite of the electronic means of communication that have been put in place, the end of the labex and equipex programs is altering the quality of these exchanges.

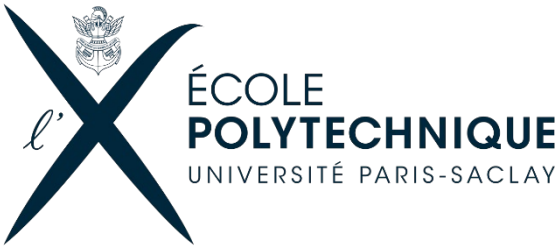
The objective of FOCUS is to federate the community of the Plateau de Saclay (IP-Paris and University of Paris-Saclay) working on scientific topics dealing with ultrafast dynamics (or almost). FOCUS proposes local and friendly events, encouraging discussions and scientific meetings.

Welcome to the second edition of FOCUS!

Pascale Changenet & Lionel Poisson

Co-chairs of the forum

Sponsors


ÉCOLE
POLYTECHNIQUE
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PALM
Laboratoire d'Excellence
Physique : Atomes Lumière Matière


CPPS
Fédération de Chimie Physique de Paris-Saclay

Scientific & organisation committee

- Pascale Changenet (LOB, Institut Polytechnique de Paris)
- Lionel Poisson (ISMO, Université Paris Saclay)
- Federica Agostini (ICP, Université Paris Saclay)
- Elsa Cassette (LuMIn, Université Paris Saclay)
- Fabien Gatti (ISMO, Université Paris Saclay)
- Romain Géneaux (LIDYL, Université Paris Saclay)
- Stefan Haessler (LOA, Institut Polytechnique de Paris)
- Catherine Leblanc (LCF, Université Paris Saclay)
- Manuel Llansola (I2BC, Université Paris Saclay)
- Dimitris Papadopoulos (LULI, Institut Polytechnique de Paris)
- Thierry Ruchon (LIDYL, Université Paris Saclay)

Practical information

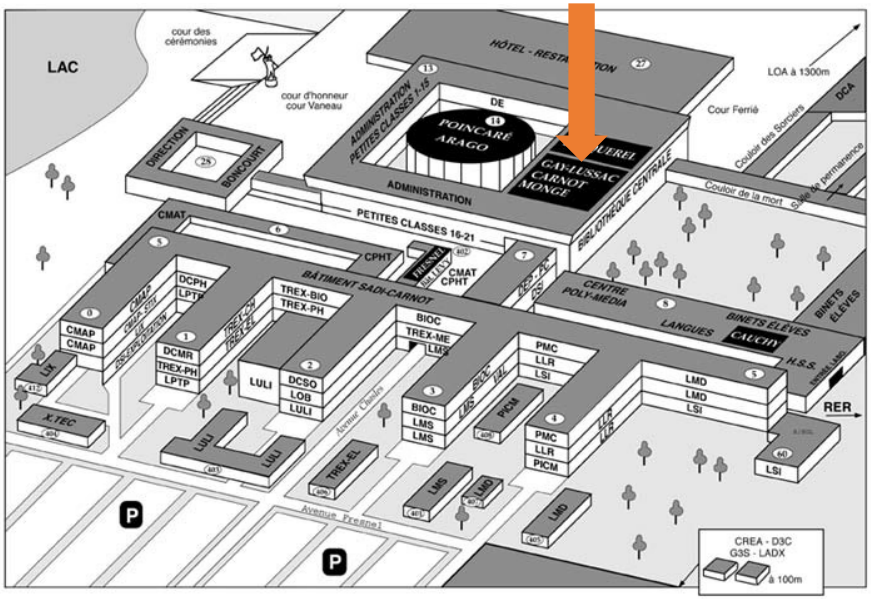
The meeting will start at 9:30 am, and will end from 5 to 7 pm with a cocktail and poster session.

It will be held in École Polytechnique

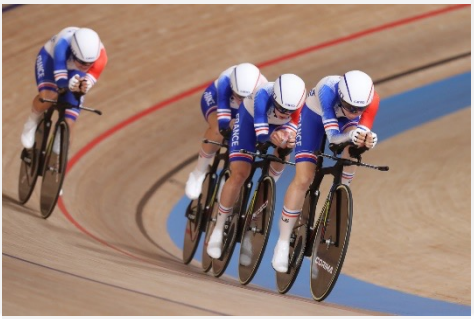
Amphi Gay-Lussac

GPS: 48.7129616084, 2.209816629

Parking lot: P1, GPS: 48.713971, 2.214638



Speakers



Christophe Clanet

Laboratoire d'Hydrodynamique de l'Ecole Polytechnique

Speaker

Physique au vélodrome

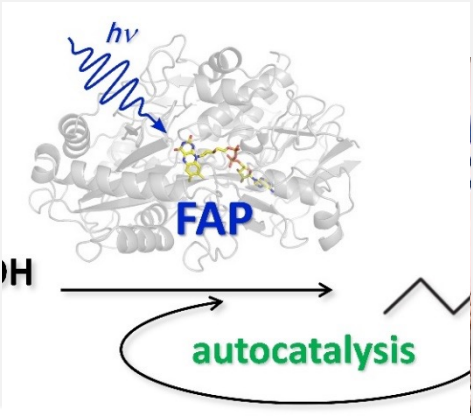
Le vélodrome est un petit monde peuplé de disciplines originales :

- *le 200m lancé où les coureurs atteignent des vitesses de 80 km/h.*
- *la vitesse par équipe où le concept de sprint décollé a été introduit.*
- *A ne pas confondre avec la poursuite par équipe où la question des relais est cruciale.*

Au total 12 titres olympiques y seront délivrés aux Jeux Olympiques de Paris 2024. Le séminaire sera consacré à l'étude physique de ce petit monde.

Pavel Müller

Institut de Biologie Intégrative de la Cellule



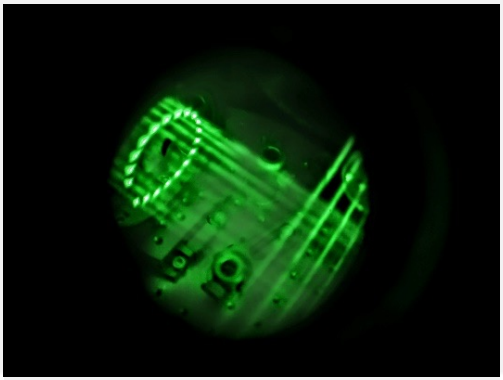
Ongoing climate change and geopolitical tensions are driving the search for renewable, carbon-neutral and local alternatives to fossil fuels. Photocatalytic conversion of fatty acids to hydrocarbons by Fatty Acid Photodecarboxylase (FAP) represents a promising route to green fuels. However, the alleged low activity of FAP on C2-C12 fatty acids seemed to preclude the use for synthesis of gasoline-range hydrocarbons. We reveal that Chlorella variabilis FAP (CvFAP) in vitro can convert octanoic acid four times faster than hexadecanoic acid, its best substrate reported to date. We also show that in vivo this translates into a CvFAP-based production rate over ten-fold higher for n heptane than for n pentadecane. Time-resolved spectroscopy and molecular modeling provide evidence that the high catalytic activity of FAP on octanoic acid is in part due to an autocatalytic effect of its n heptane product. These results should guide future FAP improvement strategies and represent an important step towards a bio-based and light-driven production of gasoline-like hydrocarbons.

Photoenzymatic decarboxylation of medium-chain fatty acids boosted by an unexpected auto-/co-catalytic effect of n-alkanes

P. P. Samire[1,2], B. Zhuang[1,3], B. Légeret[2], Á. Baca-Porcel[2], G. Peltier[2], D. Sorigué[2], A. Aleksandrov[3], F. Beisson[2], P. Müller[1]

[1] Université Paris-Saclay, CEA, CNRS, Institute for Integrative Biology of the Cell (I2BC
[2] Aix-Marseille University, CEA, CNRS, Institute of Biosciences and Biotechnologies, BIAM Cadarache.
[3] LOB, CNRS, INSERM, Ecole Polytechnique, Institut Polytechnique de Paris, Palaiseau

Speaker



Louis Daniault

Laboratoire d'Optique Appliquée

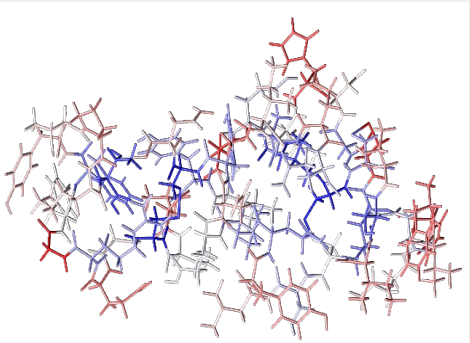
Speaker

Temporal compression and contrast cleaning of ultrashort pulses in multipass cells.

For the last decades, nonlinear temporal compression has been widely used to shorten the pulse duration of high energy ultrafast laser systems down to the few-cycle regime, a key feature for fundamental research such as attoscience or laser-plasma acceleration. These so-called post-compression experiments have been given a new impulse thanks to the advent of multipass cells (MPC), providing better efficiency and higher scalability along with excellent spatio-temporal pulse quality, at moderate cost and complexity. In addition, MPCs can involve other kinds of nonlinear interactions such as cross-polarized wave generation (XPW) and nonlinear ellipse rotation (NER), commonly used for pulse contrast cleaning. Post-compression in the few-cycle regime and contrast enhancement experiments based on XPW and NER using an MPC have been conducted at LOA, paving the way to high energy, high fidelity ultrashort pulses dedicated to fundamental research and applications.

Aurélien
de la Lande

Institut de Chimie
Physique



Promises of ab initio simulations to understand ultra-fast responses of inhomogeneous matter subjected to ionizing irradiation

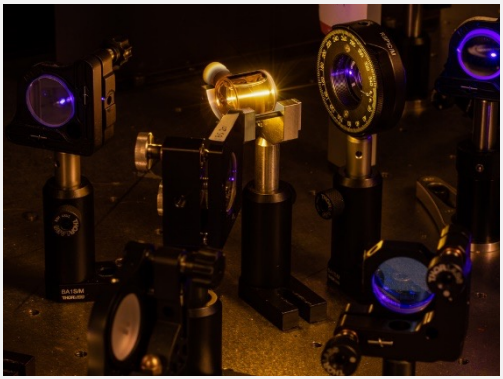
Speaker

We have developed original ab initio simulation approaches at the Institut de Chimie Physique to simulate energy deposition by fast ions or XUV photons in large molecular systems, such as those encountered in biology[1]. Our simulation codes are based on new algorithms of the time-dependent auxiliary density functional theory (RT-TD-ADFT) allowing to simulate inhomogeneous nano-sized systems.

I will review the current capabilities of our code and will illustrate recent applications in the context of guiding interpretation of pulse-radiolysis experiments and attosecond pump-probe spectroscopy experiments.

Reference:

[1] K A. Omar, F. A. Korsaye, R. Tandiana, D. Tolu, J. Deviers, X. Wu, A. Parise, A. Alvarez-Ibarra, F. Moncada, J. N. Pedroza-Montero, D. Mejia-Rodriguez, V. -O. Nguyen-Thi, F. Cailliez, C. Clavaguéra, K. Hasnaoui, A. de la Lande. Eur. J. Phys. S. T. under review.



François Hache

Laboratoire d'Optique et Biosciences

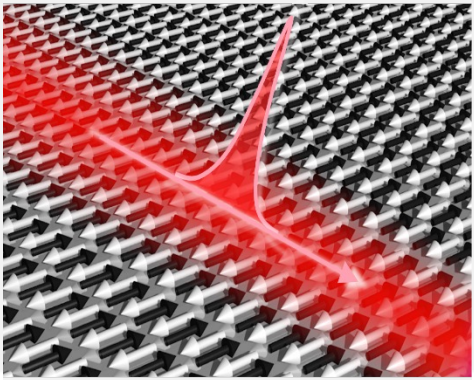
Speaker

Fast folding dynamics of DNA G-quadruplexes studied with time-resolved circular dichroism.

DNA G-quadruplexes (G4) are non-canonical nucleic structures whose physiological role is more and more documented. However, information on their folding/unfolding dynamics is still scarce. We have thus studied the conformational dynamics of several G4 by time-resolved circular dichroism. Two experimental configurations have been implemented. First, we measured these dynamics after a millisecond temperature jump followed by a cooling down phase, evidencing a rapid G4 unfolding and subsequent refolding. These experiments, which yield relevant information on the folding/unfolding kinetics and thermodynamics, reveal differences related to the G4 conformation. In a second set of experiments, we used an azobenzene derivative to phototrigger the G4 conformational changes allowing the observation of the various steps of their unfolding/folding independently. These two sets of experiments are complementary since the former gives information on the dynamical processes around the thermodynamic equilibrium whereas the latter investigates the full folding/unfolding processes.

Jean-Yves Chauleau

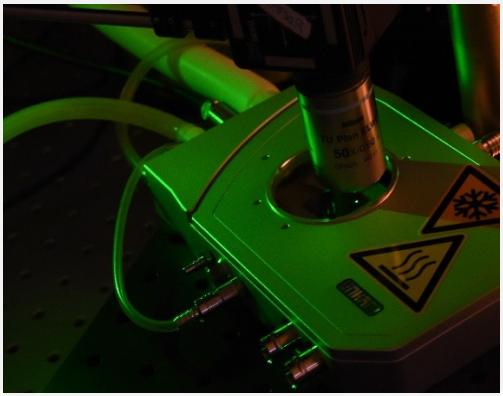
Service de Physique de l'Etat Condensé



Ultrafast spintronics and antiferromagnetic insulators

Speaker

Antiferromagnets (AF) are currently in the limelight thanks to recent breakthroughs demonstrating the efficient effect of spin currents in interacting with the AF order parameter. Besides, as the AF intrinsic dynamics directly lies in the Terahertz (THz) range, AF stand as one of the main players of ultrafast spintronics and for a potential processing of the spin information at picosecond timescales. On the materials side, antiferromagnets represent most magnetic materials and some of them show several simultaneous coupled ordered phases such as ferroelectric (FE), antiferromagnetic. They are commonly called 'multiferroics'. These materials are the focus of an intense research effort due to the significant technological interest of multifunctional materials as well as the rich fundamental physics lying in the coupling of various order parameters. However, the assessment of their coupled FE/AF textures remains a challenge. In this presentation, I will show our recent progress in investigating the AF textures and their THz dynamics using the optical second harmonic generation imaging and time-resolved magneto-optics.



Marie Legrand

Institut PhotoVoltaïque d'île de France

Speaker

Enhancing Time-Resolved Photoluminescence Spectroscopy with Spatially Resolved Techniques

Time-resolved photoluminescence (TRPL) spectroscopy provides the temporal evolution of the energy distribution of light. When applied to semiconductors characterization, it unveils fundamental mechanisms such as the transfer of charges between compounds, carriers' temperature evolution, or light reabsorption. These processes can be spatially dependent because of inhomogeneities or localized excitation. In such cases, measuring local variations can be crucial to disentangle the different mechanisms or to assess key properties, as demonstrated in multidimensional PL imaging. In this frame, we have developed a set-up that enables TRPL spectroscopy measurements in samples' selected areas at the microscale. Spectral decay in these locations can be measured with high temporal (<100 ps) and spectral resolutions (< 1nm). Our approach employs spatial light modulation combined with pixel clustering algorithms. This method has been successfully demonstrated on various materials including III-V, perovskites, and fluorophores.

Wutharath Chin

Institut des Sciences Moléculaires d'Orsay

Speaker

Ultrafast IR spectroscopy of Iron pentacarbonyl

W. Chin[1], A. Jouan[1], M. Jonusas[2], J. Helbing[3], J. Vincent[1], C. Crépin[1]

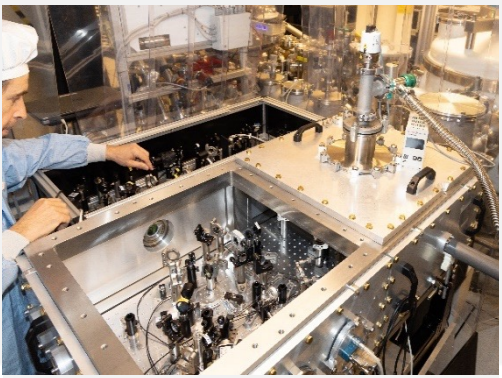
1ISMO, Univ. PAris Saclay, Orsay
2LOB, INSERM, IPP, Palaiseau
3Dpt of chemistry, Univ. of Zürich

We use two-dimensional infrared spectroscopy (2D-IR) to investigate the structural dynamics of Fe(CO) 5 Iron-pentacarbonyl at the sub-picosecond timescale. 2D-IR spectroscopy is a powerful tool for looking at both the structure and the vibrational dynamics of molecular systems. This four-wave mixing technique gives access to structural data (anharmonicity, vibrational couplings) and dynamics (energy transfer, spectral diffusion).

We present how the nature of the solvent influences the dynamics of the Fe(CO) 5 metal carbonyl complex. We will see if the environment can affect the excitation transfer between the two vibrational modes E' and A 2 '' that was assigned to the fluxional rearrangement of the molecule [1].

The setup at ISMO presents and unprecedented spectral resolution (<0.5 cm -1), which combined with a cryogenic device will, in the near future, enable new and interesting studies of environment effects from room temperature to cryogenic temperatures [2].

References:
[1] Cahoon et al., Science 319, pp. 1820-1823 (2008)
[2] Thon et al., J. Chem. Phys. 156, 024301 (2022)



Xavier Sarazin

Laboratoire de physique des deux infinis Irène Joliot-Curie

Speaker

Le projet DeLLight : Ralentir la vitesse de la lumière dans le vide avec des impulsions laser intenses

L'électrodynamique quantique (QED) prédit que le vide doit être un milieu optique non linéaire : la vitesse de la lumière devrait diminuer lorsque le vide est soumis à des champs électromagnétiques intenses. L'expérience DeLLight (Deflection of Light by Light) cherche à mesurer cet effet jamais encore observé en utilisant des impulsions laser femtosecondes ultra intenses délivrées par LASERIX à IJCLab. La méthode est de mesurer par interférométrie la réfraction d'une impulsion laser (sonde) de basse énergie, induite par le gradient d'indice du vide produit par une impulsion externe (pompe) de haute intensité. Je décrirai la méthode expérimentale et les enjeux techniques du projet et présenterai les récents résultats des mesures DeLLight dans un gaz à basse énergie obtenues avec l'expérience pilote.

Valérie Véniard

Laboratoire des Solides Irradiés

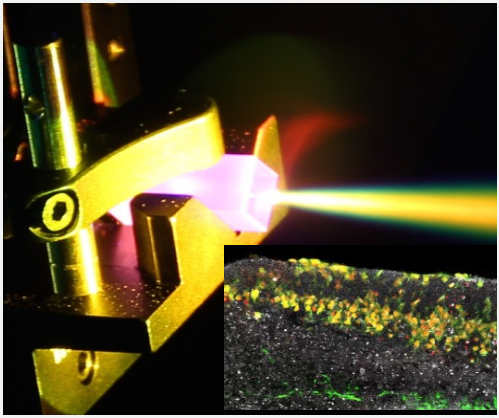
Knowledge of sub-femtosecond electron dynamics in many-electron systems is of utmost importance to achieve control over transport of charge carriers. This ultrafast electron dynamics in materials is often captured under excitation by high-intensity laser fields. A theoretical understanding of this dynamics, therefore, calls for solving the time-dependent Schrödinger equation (TDSE) for obtaining non-perturbative response of many interacting electrons under strong-field irradiation. For systems having more than two electrons TDSE calculation is numerically demanding if not impossible. In this context, a time-dependent density-functional theory (TDDFT) based approach is therefore highly solicited, due to its scaling with the size of the system. Although formally exact, in practice the exchange-correlation potential ($v_{KS}[n](x,t)$) in TDDFT is adiabatically approximated. While this approximation is reasonable for processes involving slow density variations, it does not describe the correlation dynamics of excited carriers when the density variation is rapid and significant. In this presentation, we will illustrate this behavior with several examples.

Speaker

Influence of Exact Features of Time-Dependent Kohn-Sham Potential on the Ionization Dynamics

Valérie Véniard [1,3], Rajarshi Sinha-Roy [2,3]

1 Laboratoire des Solides Irradiés, École Polytechnique, CNRS, CEA/DRF/IRAMIS, Institut Polytechnique de Paris, Palaiseau
2 Institut Lumière Matière, UMR5306 - UCBL – CNRS, Villeurbanne F-69622, France
3. European Theoretical Spectroscopy Facility (ETSF), www.etsf.eu



Frédéric Druon

Laboratoire Charles Fabry

Speaker

Source laser multicolore dans le SWIR pour la microscopie non-linéaire à 3 photons

Emmanuel Beaurepaire [2], Michele Natile [3], Marc Hanna [1], Khmaies Guesmi [1], Alexandre Thai [3], Yoann Zaouter [3], Stella Dees[2], Júlia Ferrer Ortas [2], Pierre Mahou [2], Willy Supatto [2], Patrick Georges [1]

[1] Laboratoire Charles Fabry, Université Paris Saclay, Institut d'Optique Graduate School, CNRS, 91127 Palaiseau, France
[2] Laboratoire d'Optique et Biosciences, Ecole Polytechnique, CNRS, INSERM, Institut Polytechnique de Paris, 91128 Palaiseau, France
[3] Amplitude, 11 Ave Canteranne, Cité Photon, 33600 Pessac, France

References:
Khmaies Guesmi, et al., « Dual-color deep-tissue three-photon microscopy with a multiband infrared laser » Light: Science & Applications, 7, (2018)

La microscopie multiphotonique est idéale pour l'imagerie de fluorescence de tissus biologiques. Cependant, la profondeur reste un paramètre crucial, en particulier pour les tissus présentant des hétérogénéités optiques et une forte diffusion, tels que les tissus cérébraux. Pour surmonter cette limitation et accéder à des zones plus profondes, une approche très prometteuse consiste à déplacer l'excitation vers le SWIR (Short-Wavelength InfraRed), et 1300 et 1700 nm sont les régions d'excitation spectrales optimales avec le meilleur compromis entre diffusion et absorption. Dans ce cadre, nous avons démontré la première source conçue de manière optimale pour cette application. Elle émet des pulses de ~50 fs à une cadence de 1 MHz pour des énergies de plusieurs centaines de nJ. Cette nouvelle source est basée sur un OPCPA (optical parametric chirped pulse amplification) robuste et simple, injecté par un système à fibre Yb de forte puissance. Cette nouvelle source multicolore représente un nouveau paradigme pour la microscopie non-linéaire à 3 photons.

David Gauthier

Laboratoire Interactions, DYnamiques et Lasers

Speaker

Génération d'harmoniques d'ordre élevé dans les cristaux sur la plateforme Nanolight

La génération d'harmoniques d'ordre élevé est un processus extrêmement non-linéaire qui peut être observé lorsqu'un solide cristallin interagit avec une impulsion laser ultra-courtes et intenses. Elle se traduit par l'émission d'un rayonnement cohérent composé de tout un ensemble d'harmoniques de la fréquence du laser de génération.

Ce rayonnement reflète les propriétés intrinsèques du matériau ainsi que les dynamiques électroniques lors de l'interaction avec le champs laser.

La première observation des harmoniques dans un cristal est relativement récente (2010) et a depuis initié un nombre très important d'études et de publications.

Après une introduction sur les mécanismes de génération, les différents aspects fondamentaux et potentielles applications seront illustrés avec les derniers travaux [1,2] de notre équipe sur la plateforme Nanolight du LIDYL (CEA-Saclay).

References:
[1] Shatha Kaassamani et al., Optics Express (2022).
[2] Sven Fröhlich et al., Optics Letters 47, 4865 (2022).

FOCUS

6 juin 2023
École Polytechnique
Amphi Gay Lussac

09:00	 **Registration and coffee** 	
09:30	Welcome – Pascale Changenet, Kees Van Der Beek	
09:50	Session I: Ultrafast optics and lasers (Lou Barreau ISMO)	Xavier Sarazin (IJCLab) Louis Daniault (LOA) David Gauthier (LIDYL)
10:50	**Coffee break**	
11:20	Session II: Non-linear spectroscopy (Adeline Bonvalet LOB)	Frédéric Druon (LCF) Wutharah Chin (ISMO)
12:00	**Lunch break**	
13:45	Conférence d'ouverture : Physique au vélodrome (Christophe Clanet)	
14:30	Session III: Dynamical processes in biomolecules (Karine Steenkeste ISMO)	Aurélien De La Lande (ICP) Pavel Müller (I2BC) François Hache (LOB)
15:30	**Coffee break**	
16:00	Session IV: Material (Spéphane Guizard LIDYL)	Marie Legrand (IPVF) Valérie Véniard (LSI) Jean Yves Chauleau (SPEC)
17:00	Closing remarks	
17:10	 **Cocktail & Posters**