JMCS8 - 2025

Eight Journée Systèmes & Matière Complexes

November 14, 2025

Amphithéâtre Claude Bloch, bâtiment 772, CEA,
Service de Physique de l'État Condensé (SPEC)
Orme des Merisiers
Gif-sur-Yvette, France

INSTITUT INTÉGRATIF DES MATÉRIAUX | université PARIS-SACLAY

spec | cea | université PARIS-SACLAY GRADUATE SCHOOL Physique | PhOM Physique des Ondes et de la Matière

Contents

Introduction

The eight Journée Systèmes & Matière Complexes (JSMC8) will be held at the SPEC-Amphi Bloch on Novembre 14, 2025. The meeting's objective is to provide the opportunity for UPSaclay's research scientists to showcase their works and network around the complex system's theme in 2IM – Theme 2 and PHOM:

- disordered systems
- complex fluids
- turbulence
- complex dynamics
- statistical approaches
- multi-scale materials
- biological systems

This will be the eighth time the event will be hosted on the Plateau de Saclay. Specifically, previous editions were held at CEA Orme des Merisiers on November 7, 2016, ENS Cachan on November 30, 2017, Ecole Centrale Supélec on November 23, 2018, Institut Pascal on October 14, 2019, Covid edition online November 16, 2020, ENS Paris-Saclay October 04, 2021 and LPS Faculté des sciences d'Orsay October 16, 2023.

Organizing committee

The meeting is organized by the Institut Intégratif des Matériaux (2IM) - Theme 2 board members:

Carine Douarche	UPSaclay, ORSAY, FAST
Cindy Rountree	CEA, IRAMIS, SPEC, SPHYNX
David Simeone	CEA, DES, SRMA, LA2M
Antoine Thill	CEA, IRAMIS, NIMBE, LIONS

Program - JSMC8-2025

09:00	Welcome
09:15	Stefania CACOVICH IPVF *Multimodal Photoluminescence Imaging in Photovoltaic Material Analysis*
09:55	Session A: Short Presentations (4 minute presentation)
10:30	Coffee Break
11:00	Guillaume ZANTE DRF, IRAMIS, NIMBE, LICSEN *AI-assisted sorting of electronic waste enabling improved chemical recycling of critical and precious metals*
11:40	Session B: Short Presentations (4 minute presentation)
12:15	Lunch Break
13:55	Laurence RAMOS University Montpelier, L2C *Catching Enzymes in Action*
14:35	Session C: Short Presentations (4 minute presentation)
15:05	Coffee Break
15:30	Philippe THOMAS CNRS - IPP *A two-parameter nucleation model for the condensation of Lennard-Jones particles*
16:10	Session D: Short Presentations (4 minute presentation)

Session A: Short Presentations (4 minute presentation)

- Bastien GIRAULT
  CEA, SPEC, SPHYNX
  Elaboration and characterization of glasses containing chromium-bearing minerals
- Jasurbek GULOMOV
  DES, ISAS, DRMP, S2CM, SRMP
  Local disorder in bulk and surfaces of inorganic halide perovskites for photovoltaic applications
- Mary WILLIAMS
  UMONS
  Viscous adhesion with soft interfaces
- Esther María ZAMORA SÁNCHEZ
  Laboratoire Jean Perrin
  Maze-solving with density-driven swarms
- Marceau HENOT
  CEA, SPEC, SPHYNX
  Molecular dynamics insights into the Debye process of a mono-alcohol
- Herve HENRY
  CNRS, Laboratoire PMC
  Modeling of cracks propagating in heterogeneous materials
- Jules TRUBERT
  CEA, SPEC, SPHYNX
  How can the structural heterogeneity of differently quenched glasses be explored?

Session B: Short Presentations (4 minute presentation)

- David CARRIERE
  CEA, NIMBE, LIONS
  Formation of a dense liquid precursor in mineral crystallization: spinodal decomposition evidenced by sub-millisecond microfluidics coupled to time-resolved in situ SAXS
- Yilin YE Ecole Polytechnique *First-passage times to a fractal boundary: Local persistence exponent and its log-periodic oscillations*
- Elina GILBERT
  CEA, SPEC, SPHYNX
  Ultrastiff lightweight isotropic metamaterials
- Daniel BONAMY
  CEA, SPEC, SPHYNX
  Crack growth in microtruss-based mechanical metamaterials of random architecture
- Mikhail SEMEYKIN
  ENS, LPENS
  Universal amplitude of the critical force at depinning
- Priscille FAUVARQUE
  CEA, SPEC, SPHYNX
  Influence of crystallization of oxide glasses on their stress corrosion cracking behavior
- Vincent FLEURY
  Université de Paris-Cité/CNRS
  L'origine de l'homme et le paradoxe de l'ajustement fin (fine tuning)

Session C: Short Presentations (4 minute presentation)

- Arach GOLDAR
  I2BC
  DNA repaire: cooperative or exclusive?
- Sumeja BUREKOVIC
  CEA, SPEC, SPHYNX
  Active phase separation: a systematic coarse-graining approach
- Edgar ZEMBRA
  Polytechnique
  Numerical study of fracture propagation using the phase field method - Influence of material heterogeneities and anisotropies
- Christophe POULARD
  Université Paris-Saclay, LPS
  Rheological response of soft Solid/Liquid Composites
- Tristan CERDIN
  Université Paris-Saclay, FAST
  Number fluctuations distinguish different self-propelling and reorientation dynamics
- Mathis PLAPP
  CNRS/Ecole Polytechnique
  Multi-physics modeling of microstructure evolution during phase-change memory operations

Session D: Short Presentations (4 minute presentation)

- Herve HENRY
  CNRS, Laboratoire PMC
  Modeling of cracks propagating in heterogeneous materials
- Nitin GUPTA
  CEA, SPEC, SPHYNX
  Fast Crack Propagation in Disordered Materials
- Armand RYKNER
  CEA, SPEC, SPHYNX
  Glass relaxation from out-of-equilibrium states
- Léo-Paul BARBIER
  ESPCI Paris
  Swimming droplets facing gravity
- Sebastien AUMAITRE
  CEA, SPEC, SPHYNX
  Dissipated Power measurement in turbulent flows
- Abderraouf BOUNJAD
  Physique de la matière condensée
  Modeling of membrane formation induced by diffusive transport
- Marouane EL OMARI
  CEA, DES, ISAS, DRMP, S2CM, LM2T
  Atomistic Modeling of Alteration Phenomena at the Surface of Silicate Glasses

Abstracts

Multimodal Photoluminescence Imaging in Photovoltaic Material Analysis

Stefania CACOVICH

CNRS – UMR 9006, Institut Photovoltaique d'Ile de France (IPVF), Palaiseau, France

Photovoltaic devices enable the direct conversion of light into electricity, playing a crucial role in achieving climate targets and advancing a low-carbon economy. In the solar cell community, there is growing interest in optical imaging techniques—particularly luminescence-based methods—as powerful, contactless, and non-destructive tools for probing device performance across their entire lifecycle, from material growth to operando operation. These methods are applicable to a range of technologies, including emerging halide perovskites, organic solar cells, II–V compounds, and silicon. I will discuss how quantitative photoluminescence imaging advances our understanding of the opto-electronic properties of halide perovskites, bridging the gap between fundamental material characteristics and device-level performance. Key strategies explored include efficiency enhancement, scalable fabrication, and stability improvement, with special emphasis on interfacial passivation using organic cations to suppress non-radiative recombination and enhance charge transport[1]. Finally, I will highlight the potential of CIGS-based absorbers for solar-to-fuel conversion, where luminescence imaging provides a direct link between electrochemical reactions and changes in semiconductor opto-electronic properties[2]. This work demonstrates how luminescence imaging not only accelerates the optimization of next-generation solar cells but also opens pathways toward scalable, efficient, and durable energy technologies for electricity generation and solar-driven chemical conversion.

1. Cacovich, S., Vidon, G., Degani, M., Legrand, M., Gouda, L., Puel, J.-B., Vaynzof, Y., Guillemoles, J.-F., Ory, D., and Grancini, G. (2022) Imaging and quantifying non-radiative losses at 23% efficient inverted perovskite solar cells interfaces. Nat Commun, 13 (1), 2868.

2. Guerrero, J., Rebai, A., Tom, T., Coutancier, D., Raimondi, T., Schneider, N., Cacovich, S., and Naghavi, N. (2025) From solar cells to solar fuels: assessment of Cu(In,Ga)Se2 absorbers as photocathode for CO2 reduction. J. Phys. Energy, 7 (4), 045015.

AI-assisted sorting of electronic waste enabling improved chemical recycling of critical and precious metals

Guillaume ZANTE

DRF, IRAMIS, NIMBE, LICSEN

Electronic waste is the fastest growing source of waste, with more than 17 kg/capita generated in Europe, of which less than 50% is properly documented, collected, and recycled [1]. Recycling strategies involve to shred the waste and recover metals through high-temperature (pyrometallurgy) and/or chemical processing using aqueous solutions (hydrometallurgy). Most recyclers focus on highly concentrated (copper, aluminium, etc) or highly valuable metals (precious and platinum group metals). Recycling rates of the critical metals (neodymium, tantalum, niobium) found in waste printed circuit boards (PCBs) are generally lower than 10% [2]. Despite their importance to the economy and their high supply risk, concentration of those metals in electronic waste is too low to ensure economic viability of their recovery from such a complex stream. The alternative approach developed at CEA Saclay involves dismantling PCBs to recover electrical components, the latter being enriched in critical metals (Nd in multi-layer capacitors, Ta and Nb in capacitors, etc). 90% of the components can be sorted by machine vision with an accuracy as high as 97.5% by training a convolutional neural network on a database containing images of components [3]. The remaining 10% of components have a similar appearance but a different chemical composition. This fraction can be sorted by elemental composition using multi-energy X-ray transmission. The obtained hyperspectral image is treated to identify target elements and their specific k-edge energy. An overall accuracy of 97% was obtained, allowing to concentrate the metals with enrichment factors as high as 10,000. This approach also facilitates the downstream processing to recover metals with high recovery rates, high purities and low environmental footprint through simple hydrometallurgical steps. High purity (>99%) and high-yield (>90%) neodymium recovery was achieved with a simple dissolution- precipitation strategy [4]. Similar results were obtained for tantalum recovery from capacitors or elemental gold recovery from wire-bonded micro-controllers, which was demonstrated at the kg-scale. In this presentation, we will describe the sorting tool and give examples of tailored hydrometallurgical process aimed at critical and precious metals recovery from e-waste.

References

1. C.P. Baldé, R. Kuehr, T. Yamamoto, R. McDonald, E. D'Angelo, S. Althaf, G. Bel, O. Deubzer, E. Fernandez-Cubillo, V. Forti, V. Gray, S. Herat, S. Honda, G. Iattoni, V.L. di Cortemiglia, Y. Lobuntsova, I. Nnorom, N. Pralat, M. Wagner, The Global E-Waste Monitor 2024, (2024).
2. DocsRoom - European Commission, (n.d.). https://ec.europa.eu/docsroom/documents/27348 (accessed July 21, 2025).
3. N.M. Charpentier, A.A. Maurice, D. Xia, W.-J. Li, C.-S. Chua, A. Brambilla, J.-C.P. Gabriel, Urban mining of unexploited spent critical metals from E-waste made possible using advanced sorting, Resources, Conservation and Recycling 196 (2023) 107033. https://doi.org/10.1016/j.resconrec.2023.107033.
4. D. Xia, N.M. Charpentier, A.A. Maurice, A. Brambilla, Q. Yan, J.-C.P. Gabriel, Sustainable route for Nd recycling from waste electronic components featured with unique element-specific sorting enabling simplified hydrometallurgy, Chemical Engineering Journal 441 (2022) 135886. https://doi.org/10.1016/j.cej.2022.135886.

Catching Enzymes in Action

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The propagation mechanisms of enzymes in the substrates they degrade is an interdisciplinary topic of current debate, involving complex diffusion in crowded environments, polymer physics and enzymology. Besides, the understanding of the enzymatic degradation of hemicellulose is of utmost importance for a sustainable production of fuels and bioplastics from plant biomass. We investigate the enzymatic degradation of solutions and gels of arabinoxylan (AX), one of the most abundant polysaccharides of plant hemicellulose, by means of an original optical setup which combines Fluorescence Imaging and Photon Correlation Imaging (PCI), a multispeckle Dynamic Light Scattering technique allowing one to probe the spatio-temporal heterogeneous dynamics of colloidal and polymer systems. Thanks to this setup, the time-evolution of the spatial distribution of the fluorescently-labelled enzyme and the microscopic dynamics of the polymer matrix undergoing degradation are measured simultaneously. In this talk, I will present our technique and our first sets of experimental results and analysis.

A two-parameter nucleation model for the condensation of Lennard-Jones particles

Philippe THOMAS

Laboratoire de Physique de la Matière Condensée (PMC, École Polytechnique / CNRS), France

While very popular for its ability to provide an elegant conceptual framework, classical nucleation theory often fails at quantitatively reproducing most of the experimental and numerical observations of first order transitions. In this talk, we extend CNT by explicitly incorporating the multi-dimensional aspect of nucleation. Focusing on the liquid condensation of a Lennard-Jones gas, we used state of the art rare event sampling simulations to precisely characterize the nucleation event emphasizing the specific features of the critical cluster. Our numerical results indicate a simultaneous growth and densification in liquid condensation. We then exploit these insights to develop a 2-variable nucleation theory. Our model based on the capillary approximation is able to quantitatively retrieve the numerical results in nucleation rate and critical cluster properties. Furthermore, our model provides a qualitatively more accurate representation of nucleation near the spinodal regime. The effectiveness of this integrated numerical and theoretical framework highlights the limitations of CNT and more recent theories while offering a robust foundation for its refinement.

Useful Information

Talks will be held at the **Amphi Bloch** at Orme de Merisiers on the Campus of the CEA-Saclay research center in Gif-sur-Yvette. It is situated on the ground floor to the left of the main entrance of building 772.

To get there from Paris or Charles de Gaulle airport take the RER B subway to the stop 'Le Guichet' and then bus 9. Please ask the driver to stop a the Orme de Merisier.

Coffee breaks will be offered in the main entrance hall.

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