Conférencière Plénière

Anne L'Huillier
Prix Nobel de physique 2023

Grande Conférence de l'Institut Courtois 2025

Frontière des processus lumière-matière dans la découverte des matériaux

15 et 16 octobre 2025

Université de Montréal

ATTENTION Jour 1 et 2 ont lieu à des endroits différents :

Jour 1 – 15 octobre : Université de Montréal, **Pavillon Roger Gaudry** Hall d'honneur L-400 (2900 Chemin de la tour)

Jour 2 – 16 octobre : Université de Montréal, Campus MIL B1007 (1375 Ave Thérèse Lavoie Roux)

Institut Courtois
Faculté des arts et des sciences
Université de Montréal

Jour 1 : 15 octobre - Université de Montréal, Pavillon Roger Gaudry L-400		
Heure	**Titre**	**Présentateur**
8:00 - 9:00	Café et inscription	
9:00 - 9:30	Mots d'ouverture par le directeur de l'Institut Courtois	Carlos Silva
9:30 - 9:40	Mots du président du CRSNG	Alejandro Adem
9:40 - 10:20	Light-matter interactions for material control and discovery	Keith Nelson
10:20 - 11:00	Mapping Atomic Motions with Ultrabright Electrons: Fundamental Space-Time Limits to Imaging Chemistry and Biology	Dwayne Miller
11:00 - 11:20	Pause café	
11:20 - 12:00	Variational Neural Annealing: Optimization in Physics, Biology, and Finance	Estelle Inack
12:00 - 12:40	Topological chains of fermions and bosons	Tamar (Tami) Pereg-Barnea
12:40 - 13:40	Dîner	
13:40 -14:20	Quantum Hall physics with light	Philippe St-Jean
14:20 - 15:00	Flying Doughnut Pulses – a Route to Isolated gigaGauss Magnetic Fields	Paul Corkum
15:00 - 16:00	The world of atoms at the attosecond time scale	Anne L'Huillier
16:00 - 18:00	Présentations d'affiches et cocktail	

Jour 2 : 16 octobre - Université de Montréal, Campus MIL B-1007		
		Salle
8:30 - 9:00	Inscription et café	B - 1007
9:00 - 12:00	Atelier laboratoire automatisé - en collaboration avec l'Acceleration Consortium	B - 1007
9:00 - 12:00	Atelier Quantique & IA - en collaboration avec le Perimeter Institute	A - 3561
12:00 - 13:00	Dîner	B - 1007

Nous remercions la Faculté des arts et des sciences pour leurs commandites

Nous remercions nos partenaires pour leur collaboration dans la préparation des ateliers du 16 octobre :

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Invitée d’honneur et conférencière plénière

Pre Anne L’Huillier

Département de physique, Lund University

Biographie

Pre Anne L'Huillier est une physicienne franco-suédoise spécialisée dans l’interaction entre les champs laser courts et intenses et les atomes. Elle a soutenu sa thèse sur l’ionisation multiphotonique multiple en 1986 à l’Université Pierre et Marie Curie, à Paris, ainsi qu’au Commissariat à l’Énergie Atomique (CEA). Elle a obtenu un poste de chercheuse permanente au CEA la même année. Elle a effectué un postdoctorat à l’Université de technologie de Chalmers à Göteborg en 1986, puis à l’Université de Californie du Sud à Los Angeles en 1988. En 1993, elle a été chercheuse invitée au Lawrence Livermore National Laboratory. En 1995, elle est devenue professeure associée à l’Université de Lund, où elle a été nommée professeure de physique en 1997. Elle est membre du *Royal Swedish Academy of Sciences* depuis 2004. Elle a reçu le prix Nobel de physique en 2023 pour ses travaux sur les impulsions attosecondes.

Les recherches du Pre L’Huillier, à la fois expérimentales et théoriques, portent sur la génération d’harmoniques d’ordre élevé dans les gaz et leurs applications. Dans le domaine temporel, ces harmoniques correspondent à une série d’impulsions lumineuses extrêmement brèves, dans le domaine spectral de l’ultraviolet extrême, d’une durée de quelques dizaines ou centaines d’attosecondes. Ses travaux concernent le développement et l’optimisation de sources attosecondes, ainsi que l’utilisation de ce rayonnement pour étudier la dynamique ultrarapide des électrons. Les sources lumineuses attosecondes peuvent être conçues pour différents objectifs, par exemple en visant une intensité élevée pour des expériences pompe-sonde non linéaires, ou une cadence de répétition élevée pour des applications en physique de la matière condensée. Un autre domaine de recherche actif pour Pre L'Huillier et son équipe est l'étude de la dynamique électronique des systèmes atomiques, à la suite d'un événement de photoionisation induit par l'absorption d'une impulsion lumineuse attoseconde.

The world of atoms at the attosecond time scale

Extreme Ultraviolet light sources based on high-order harmonic generation in gases consist of extremely short light bursts, in the 100-attosecond range, allowing for outstanding temporal resolution. Attosecond pulses enable the study of atoms in an entirely new way. It is now possible to measure tiny time delays in photoionization and the phase change of an electron across a resonance. Recently, the quantum state of a photoelectron has been determined by a tomography technique.

Pr Keith Nelson

Département de chimie, Massachusetts Institute of Technology

Light-matter interactions for material control and discovery

Parallel developments in optics and spectroscopy have brought us to a new era of optical control over material behavior and properties. We have light pulses, pulse sequences and waveforms with strong fields and high intensities, controlled temporal and polarization profiles, and specified spatial distributions in nearly every spectral range. These allow us to drive materials away from their equilibrium configurations with extraordinary control and to monitor their dynamical responses in incisive ways. We will emphasize the THz spectral range and show how strong THz fields have been used to drive electronic, structural, and magnetic responses including the formation of new transient and long-lived material configurations. We will also briefly illustrate the prospects for material control and discovery with ultrafast x-ray pulses and with tabletop generation of extreme states of matter.

Pr Dwayne Miller

Départements de chimie et de physique, University of Toronto

Mapping Atomic Motions with Ultrabright Electrons: Fundamental Space-Time Limits to Imaging Chemistry and Biology

One of the long-sought objectives in science has been to watch atomic motions on the primary timescales governing structural transitions. From a chemistry perspective, this capability would give a direct observation of reaction forces and probe the central unifying concept of transition states that links chemistry to biology. With the development of ultrabright electrons capable of literally lighting up atomic motions, this experiment has been realized (Siwick et al Science 2003) and efforts accelerated with the onset of XFELs (Miller, Science 2014). A number of different chemical reactions will be discussed from electrocyclization with conserved stereochemistry, intermolecular electron transfer for organic systems, metal to metal electron transfer, to the direct observation of a bimolecular collision and bond formation in condensed phase for the classic I3- system, in a process analogous to a molecular Newton's cradle. These studies have discovered that these high dimensional problems, order 3N (N number of atoms in the reaction volume) representing the number of degrees of freedom in the system, distilled down to atomic projections along a few principle reaction coordinates. The specific details depend on the spatial resolution to these motions, for which <.01 Å changes in atomic position (less than the background thermal motion) has now been achieved on the 100 fs timescale. Without any detailed analysis, the key large-amplitude modes can be identified by eye from the molecular movies. This reduction in dimensionality appears to be general, arising from the very strong anharmonicity of the many body potential in the barrier crossing region. The “magic of chemistry” is this enormous reduction in dimensionality in the barrier crossing region that ultimately makes chemical concepts transferrable. How far can this reductionist view be extended with respect to complexity? The spatial-temporal correlations discovered in this work provide new insight into how chemistry scaled up to biological systems. Similar spatial relationships must exist inside the cell. New concepts in determining molecular distributions inside the cell, to directly observe the free energy gradients leading to living systems, will be discussed.

Dre Estelle Inack

Perimeter Institute

Variational Neural Annealing: Optimization in Physics, Biology, and Finance

Variational Neural Annealing (VNA) [1] is an innovative optimization framework that emulates classical and quantum annealing processes by integrating variational principles with neural network parameterizations. It effectively utilizes autoregressive models to represent classical and quantum probability distributions during the annealing process, creating a new avenue for exploring complex energy landscapes, such as those encountered in disordered Ising glasses, protein folding, and portfolio optimization.

In this presentation, we will explore the foundational aspects of VNA, starting with its original formulation and extending to its applications across various domains. We will demonstrate, through case studies on prototypical spin glass Hamiltonians, that VNA outperforms traditional simulated classical and quantum annealing methods, particularly in asymptotic limits [1]. Furthermore, we will emphasize VNA's capacity to identify the folded states of lattice protein models [2] and optimize investment portfolios in complex financial environments [3].

[1] *"Variational neural annealing"*, Mohamed Hibat-Allah, Estelle M. Inack, Roeland Wiersema, Roger G. Melko, and Juan Carrasquilla. Nature Machine Intelligence, 3(11):952–961, October 2021
[2] *"Lattice Protein Folding with Variational Annealing"*, Shoummo Ahsan Khandoker, Estelle M. Inack, Mohamed Hibat-Allah, Machine Learning: Science and Technology, 6 035023 (2025)
[3] "Large-scale portfolio optimization with variational neural annealing", Nishan Ranabhat, Behnam Javanparast, David Goerz, and Estelle M. Inack, arXiv:2507.07159

Pre Tamar (Tami) Pereg-Barnea

Département de physique – McGill University

Topological chains of fermions and bosons

The Kitaev chain is a toy model for a one dimensional topological superconductor. It demonstrates how the superconductor can host Majorana modes at its edges. These special modes are their own antiparticles, exhibit non-abelian statistics and can serve as building blocks of qubits. This talk will introduce the model and present the results of some recent related studies. In particular, we will see how the topology can be controlled by a drive (such as light) and how disorder and noise affect it. In its original form the Kitaev model is intended for fermions (electron quasiparticles), however, we will also introduce a bosonic analogue which is intended for photonic or cold atom systems. Surprisingly, in the bosonic case, a hermition Hamiltonian leads to non-hermitian dynamics.

Pr Philippe St-Jean

Département de physique, Université de Montréal

Quantum Hall physics with light

One of the most prominent signatures of the quantum Hall effect is the emergence of quantized transport channels that are inherently robust against local perturbations and environmental fluctuations. As such, quantum Hall states are highly valuable for applications requiring stringent noise mitigation, ranging from precision metrology to quantum information processing. Extending this quantum Hall physics to photonic systems could allow engineering devices – both classical and quantum – in which light propagation is quantized and similarly robust. In this talk, I will present recent experimental efforts of my group to realize photonic Chern insulators – akin to quantum Hall phases – by encoding the Haldane model in the synthetic frequency dimension of an optical fiber loop platform inspired by electro-optic frequency combs. Notably, I will describe how we were able to show, for the first time, an anomalous quantized Hall drift of electromagnetic waves. I will conclude by discussing how the resulting non-reciprocal propagation of light can be harnessed to implement novel non-Hermitian sensing schemes.

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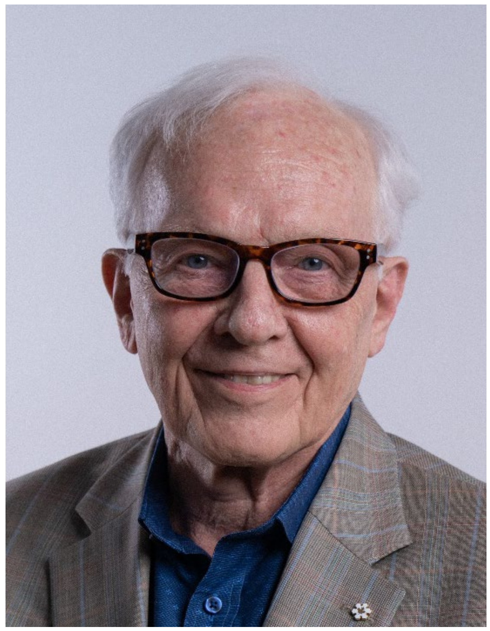
Pr Paul Corkum

Département de physique, University of Ottawa



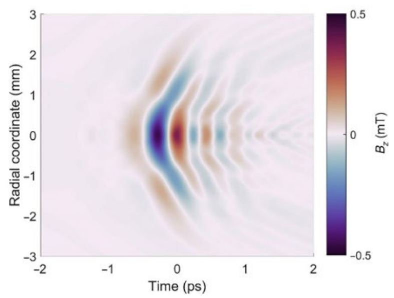
Flying Doughnut Pulses – a Route to Isolated gigaGauss Magnetic Fields

P.B. Corkum, K. Jana and D.H. Ko

Joint Attosecond Science Lab, University of Ottawa and National Research Council of Canada
Ottawa, K1N6N5, Canada

Introduction: Ultrafast magnetic fields are usually produced by an ultrafast current driven in metals, but the rise and fall times are limited by circuit inductance. Lasers offer options that minimize induction or even side-step the problem altogether. I will discuss some of the options and demonstrate one. Our short-term aim is to generate a Tesla-scale magnetic field lasting a few picoseconds. Long-term, we aim to generate 30 THz gigaGauss fields.
Semiconductors: When light is incident on a semiconductor it creates a photoelectron wave packet if it has sufficient photon energy. If the photon is in the bandgap, however, the lowest order process is a two-photon transition.

Therefore, it is possible to produce a wave packet in the conduction band by a single photon transition with a second harmonic beam and to produce an almost identical wave packet via a two-photon transition using the fundamental. As I will show, these two wave packets interfere, allowing us to control the direction of the resultant electron wave packet [1]. If one or both pulses are short, the controlled wave packet is also short as is the THz emission that follows.
We use azimuthal polarization for both wave packets and thus create a ring current and a magnetic field as described by the Biot-Savart law and shown in the figure.



In GaAs using 1.48 µm light and its second harmonic, we create a current that we can image by scanning a pixel detector [2]. Azimuthally polarized THz radiation (Fig. 1) results from this current. By improving the efficiency of our THz telescope, we now reach the peak intensity of 3 mTesla. Next, we will use higher pump power and search for the most efficient semiconductor.

Gases: Gases allow much higher fields to drive the current and they offer a vacuum in which to emit electrons. However, gases are much harder to use than solids. With our extensive experience from attosecond science, we model a breakdown plasma. Using azimuthal polarization to break down Helium, we predict fields exceeding 8 Tesla and we think this can be optimized to much higher THz fields [3].

Lasers: A physical current in a medium is one way to produce THz isolated magnetic fields but isolated fields are also found in the near field of structured, focused laser beams. With azimuthally polarized light one can think of it as destructive interference of the electric field and constructive interference of a longitudinal magnetic field. At 30 THz, CO_2 is the longest wavelength of the high energy storage lasers. At high pressure, it can produce energetic (15 Joule) pulses with duration of 2.5 ps and pulse compression, although not well developed in the mid infrared, has been demonstrated [4].
Since CO_2 lasers are insensitive to polarization, low power azimuthal pulses can be amplified. Assuming single period 1-Joule pulses in an azimuthally polarized beam, we can reach an isolated field of 10^9 Gauss near field.

References :

[1] Dupont et al. Phys. Rev. Lett. **74**, 3596 (1995)
[2] Sederberg et al. *Nature Photonics:* 14, 680 (2020)
[3] Sederberg et al. *Phys. Rev. X* 10, 011063 (2020)
[4] Corkum, *IEEE J. Quantum Elecrtron* **21**, 216 (1985)

Affiches des recherches et infrastructures financées par l'Institut Courtois:

- André B Charette (IC funded infrastructure) - Center for continuous flow synthesis: Infrastructure and Applications
- Charles Chénier (IC Chair program) - Taking Advantage Of Glass Disorder To Find New Materials
- Christian Pellerin (IC funded infrastructure) - Laboratoire de caractérisation des matériaux polymères
- Claudia Marcela Bazan (IC exploratory project) - Accelerating the characterization of functional materials with self-driven exploration tools
- David Otto Tiede (Fellow Postdoc IC) - Coherent non-linear spectroscopy on strongly light-matter coupled systems: Disentangling many-body interactions
- Emmanuel Bourret (IC exploratory project) - Toward Zero Resistance: Are Doped C100 Fullertubes Superconducting?
- Farshid Effaty (Fellow Postdoc IC) - Accelerated Crystal Engineering: AI-assisted prediction and mechanochemical synthesis of cocrystal materials
- Félix Thouin (IC funded infrastructure) – Ultrafast coherent non-linear spectroscopy tools at the Institut Courtois Frédéric Bellerive (IC exploratory project)- Novel high configurational-entropy solid solution with perovskite structure
- James Allen - (IC Chair program)- Scaling of Genuine Multiparty Entanglement at Measurement-Induced Transitions
- Kevin Delcourt (IC exploratory project)- Engineering Digital Twins for AI-Based Design Space Exploration: Case of Plasma-Enhanced Deposition
- Léo Prevost-Nottelet (IC exploratory project) - PlasmaLake: a Unified Data Architecture for Atmospheric Pressure Plasma Torch Deposition Experiments
- Marie-Chloé Michaud Paradis (IC Chair program) - Random-input error calculation for regression uncertainty estimation in analytical chemistry
- Patricia Moraille - (IC funded infrastructure) Scanning Probe Microscopy (SPM) At The Laboratory of Characterization Of Materials (LCM)
- Pedro Aguiar (IC funded infrastructure) - Regional Centre for Magnetic Resonance - Centre Régional de Résonance Magnétique
- Samir Elouatik (IC funded infrastructure) - Raman and IR microscopy and imaging at the LCM
- Simon Paiva – (IC Chair program) Multi-level vibration analysis for 2D electronic coherent spectroscopy

Affiches de participants

- Alexandre Chénier - Quantized Hall drift in a frequency-encoded photonic Chern insulator
- Álvaro Lozano-Roche - Effect of Size and Ligand on Functionalised Ru NPs for HER
- Ana Maria Borges Honorato - Molecules, Electrochemistry & Energy labs. Titre d'affiche: Mimer une batterie en fonctionnement pour atteindre la frontière des dynamiques rédox
- Antonella Badia - Self-Assembled Molecular Films: From Redox-Responsive Surfaces to Biomembranes
- Audren Dorval - Investigation of streamer-to-spark transition in plasma discharge in water using Gaussian processes
- Bradley Siwick - Ultrafast electron diffuse scattering (UEDS): direct measurement of nonequilibrium phonon distributions with momentum, mode and time resolution
- Claudiane Ouellet- Plamondon - Analyse d'image de béton par apprentissage profonds
- Clément Fortin - Lyapunov exponents in disordered non-Hermitian models
- David Bourbonnais Sureault
- Elizabeth Lamothe - Photoactive AMOX Ligands Featuring Anthracene Cores: Synthesis, Characterization, and Coordination to First Row Transition Metals
- Émile Roy - Development of a p-i-n avalanche photodiode based on WSe2
- Francisco Javier Morales Calero - Torche à Injection Axiale sur Guide d'Ondes (TIAGO): Characterization, Applications and Perspectives
- Gabriel Mercier - Polypyridyl Ruthenium Complexes for Artificial Photosynthesis
- Ilyes Oubaha - Homoleptic cobalt(III) bisguanidylpyridine complexes for photocatalytic and photoredox processes
- Iness Boubadjou - Synthèse d'une nouvelle famille d'Organic Framework: Les IOFs
- Jeanine Looman - Spatial Modulation and Raman Mapping of the Covalent Functionalization of Graphene Field Effect Transistors
- Javier A. Vargas - Préparation et caractérisation de cristaux liquides imprimés en 3D
- Jeremy Peltier - Anomalous Quantum Hall Effect for Light
- Louis-Charles Fortier - Caractérisation mécanique de couches minces nanocomposites à base de silice et de nanotubes de carbone oxydés à deux parois
- Maxime Goulet - Optimizing 3D Printing Parameters of Polymer Materials Using Machine Learning
- Megan McGeehan - Fabrication of Polymer-Based Electroactive Blends for Digital Light Processing
- Meghan McNeil - Tailoring aggregation of organic π-conjugated polymer for strong light-matter interactions and additive manufacturing applications
- Paul Vézina - Exploring IR signatures of non-covalent functionalization of graphene

- Pedro Lauand - Minimal Example of Quantum Nonclassicality without Freedom of Choice
- Sandra Jacqueline Cuevas Martinez - Ferromagnetic behavior of Koelsh's radical encapsulated in boron nitride nantoubes
- Ramzi Zidani - Understanding the Influence of Additives on the Crosslinking of Poly(dimethylsiloxane)
- Vedran Jelic - Lightwave-Driven Tunnelling Microscopy and High Harmonic Spectroscopy of Quantum Materials

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Atelier du 16 octobre

Université de Montréal, **Campus MIL** (1375 Ave Thérèse Lavoie Roux) B1007

9h00-12h00
Atelier 1 – Campus MIL B1007
Laboratoires autonomes – en collaboration avec Acceleration Consortium

Les professionels de recherche du Acceleration Consortium présenteront les capacités développées de leur *Self-driving lab* avec des démo.
Ali Satayesh and Yang Bai : SDL inorganic
Mills Harrison and Nipun Gupta: SDL polymer
Aaron Clasky and Frantz Le Dévédec: SDL formulation
Opentron sera aussi présent et aura un démonstrateur de leur équipement flex

9h00-12h00
Atelier 2 – Campus MIL A3561
Atelier sur l'exploration des propriétés quantiques et des outils guidée par l'IA — en collaboration avec le Perimeter Institute

Dans le cadre de cet atelier, l'Institut Courtois, IVADO et le Perimeter Institute exploreront les possibilités de développer un programme conjoint de projets exploratoires visant à intégrer l'intelligence artificielle dans la science des matériaux quantiques, ainsi qu'à intégrer les principes de la mécanique quantique dans le développement de l'IA. L'atelier permettra d'identifier les intérêts communs et de définir les axes prioritaires à fort impact pour cette collaboration.

Comment se rendre

Jour 1 – 15 octobre, Université de Montréal, Pavillon Roger Gaudry (2900 Édouard Montpetit) L-400

La Grande Conférence de l'Institut Courtois se tiendra au Pavillon Roger-Gaudry de l'Université de Montréal, dans le hall d'honneur. Ce hall se trouve au 4e étage de l'aile L. L'entrée située directement sous la tour mène directement au lieu de la conférence. Nous vous recommandons fortement de passer par l'extérieur du pavillon, car plusieurs zones à l'intérieur du bâtiment sont inaccessibles en raison de travaux.

En métro :
Le Pavillon Roger-Gaudry est situé à la station de métro Université-de-Montréal, sur la ligne bleue. En sortant du quai, prenez la sortie à gauche et montez les escaliers. Vous sortirez brièvement à l'extérieur, puis entrez dans l'édifice juste en face de la porte. Prenez les longs escaliers roulants, puis, en haut, tournez à droite. Marchez à l'extérieur sur le chemin de la Tour en direction de la tour : l'entrée se trouve directement sous celle-ci.

À vélo :
Trois espaces de stationnement pour vélos sont disponibles devant le pavillon Roger-Gaudry, sur le chemin de la Tour.

En voiture :
Le garage Louis-Colin est un stationnement de l'Université de Montréal. Deux entrées permettent d'y accéder :
• par le boulevard Édouard-Montpetit, à l'angle de l'avenue Louis-Colin ;
• par le chemin Queen-Mary, à l'angle de l'avenue Decelles.
Des frais de 21 $ par jour s'appliquent, non couverts par l'inscription à la conférence.

Jour 2 - Université de Montréal - Campus MIL (1375 Ave Thérèse Lavoie-Roux) B-1007

Pour se rendre au Campus MIL de l'Université de Montréal :

En métro :
Vous pouvez descendre soit à la station Acadie (à 5 minutes de marche), soit à la station Outremont (à 7 minutes de marche), toutes deux situées sur la ligne bleue.

À vélo :
Des supports à vélos sont disponibles à l'entrée de l'édifice.

En voiture :
Un stationnement souterrain est situé à l'arrière de l'édifice. L'entrée se fait par l'avenue Picard. Des frais d'environ 20 $ s'appliquent, non couverts par l'inscription à la conférence.