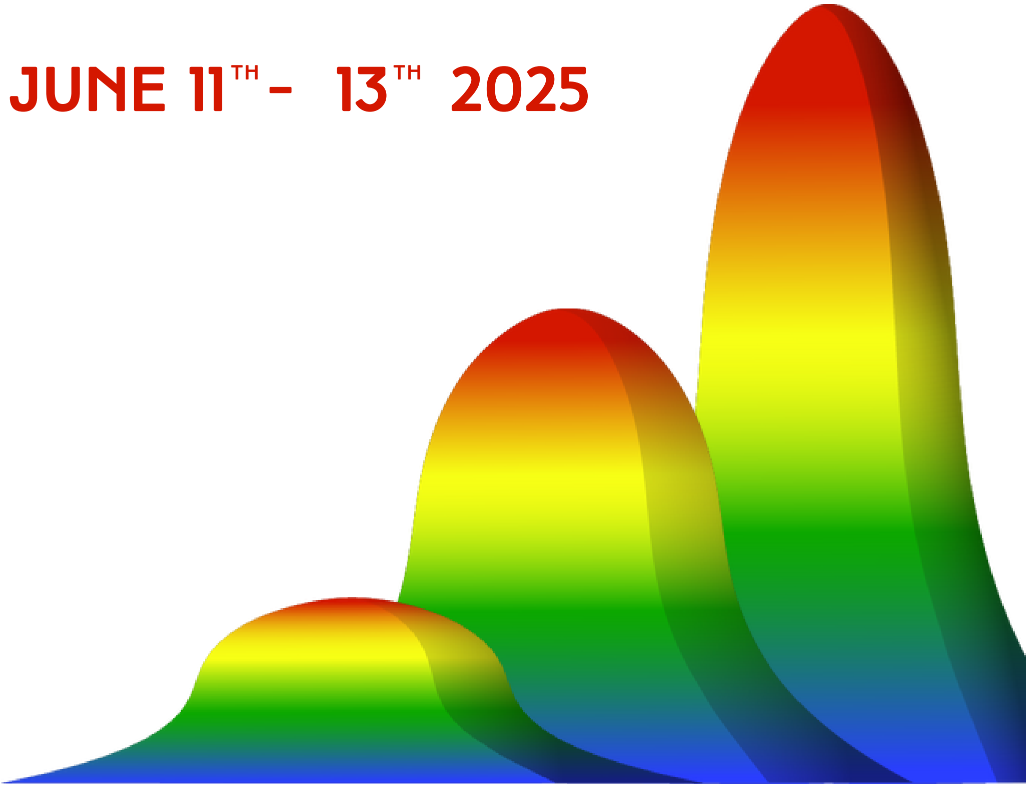
POLISH-FRENCH SYMPOSIUM III: ADVANCES IN THE PHYSICS OF ULTRACOLD MATTER

JUNE 11TH - 13TH 2025



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INSTYTUT FIZYKI POLSKIEJ AKADEMII NAUK

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Paris
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AGENDA

WEDNESDAY, 11TH MAY

9:30 - 10:50 CHAIR: EMILIA WITKOWSKA

KRZYSTOF SACHA, JAGIELLONIAN UNIVERSITY
Time-tronics: from temporal printed circuit board to quantum computer

JÉRÔME BEUGNON, LKB-CDF, COLLÈGE DE FRANCE
Bloch oscillations of a soliton in a 1D BEC without a lattice

10:50 - 11:10 **COFFEE BREAK**

11:10 - 12:30 CHAIR: MARIUSZ GAJDA

TOMMASO ROSCILDE, ÉCOLE NORMALE SUPÉRIEURE DE LYON
Scaling multipartite entanglement in atomic systems: presto vs. adagio

MICHAŁ PARNIAK, UNIVERSITY OF WARSAW
Quantum sensing with cold interacting Rydberg atoms

12:30 - 14:00 **LUNCH**

14:00 - 15:20 CHAIR: JÉRÔME BEUGNON

KAZIMIERZ RZĄŻEWSKI, CENTER FOR THEORETICAL PHYSICS PAS
The Hybrid Sampling Method for the Statistics of a Bose Gas

YVAN CASTIN, LKB-ENS, ECOLE NORMALE SUPÉRIEURE
Phonon damping in a 2D superfluid: insufficiency of Fermi's golden rule at low temperature

15:20 - 15:40 **COFFEE BREAK**

15:40 - 17:00 CHAIR: MICHAŁ KARPIŃSKI

JAKOB REICHEL, LKB-ENS, ÉCOLE NORMALE SUPÉRIEURE
Entangling atoms in cavities: From quantum Zeno dynamics to metrology

PIOTR DEUAR, INSTITUTE OF PHYSICS PAS
Self organisation and metastability of cavity bosons beyond the adiabatic elimination approximation

17:00 - 18:30 **POSTER SESSION I** (WITH REFRESHMENTS)

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	ROMAN CIURYŁO, NICOLAUS COPERNICUS UNIVERSITY IN TORUŃ *Hg clock transition affected by collisions with cold atoms*
10:50 - 11:10	**COFFEE BREAK**
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	JAKUB ZAKRZEWSKI, JAGIELLONIAN UNIVERSITY *Nonergodic dynamics in interacting many-body systems*
	TARIK YEFSAH, LKB-ENS, ECOLE NORMALE SUPÉRIEURE *Quantum Gas Microscopy of Fermions in the Continuum*
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	ANNA MINGUZZI, LPMMC, UNIVERSITÉ GRENOBLE-ALPES *Symmetry oscillations in strongly interacting one-dimensional mixtures*
	MICHAŁ KARPIŃSKI, UNIVERSITY OF WARSAW *Phase-only spectral-temporal shaping of single-photon pulses*
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15:40 - 17:00	CHAIR: JAKUB ZAKRZEWSKI
	HÉLÈNE PERRIN, LPL, UNIVERSITÉ SORBONNE PARIS-NORD *Microwave spectroscopy of ultracold sodium least-bound molecular states*
	DMITRY PETROV, LPTMS, UNIVERSITÉ PARIS-SACLAY *Townes soliton beyond mean field*
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	JAN KOŁODYŃSKI, INSTITUTE OF PHYSICS PAS
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	LUDOVIC PRICOUPENKO, LPTMC, SORBONNE UNIVERSITÉ
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	The role of exchange interactions in superradiant phenomena
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BOOK OF ABSTRACTS

ABSTRACTS INDEX

KRZYSTOF SACHA
JAGIELLONIAN UNIVERSITY

Time-tronics: from temporal printed circuit board to quantum computer

Time crystalline structures can be created in periodically driven systems. They are temporal lattices which can reveal different condensed matter behaviours ranging from Anderson localization in time to temporal analogues of many-body localization or topological insulators. However, the potential practical applications of time crystalline structures have yet to be explored. We pave the way for time-tronics where temporal lattices are like printed circuit boards for realization of a broad range of quantum devices. The elements of these devices can correspond to structures of dimensions higher than three and can be arbitrarily connected and reconfigured at any moment. Moreover, our approach allows for the construction of a quantum computer, enabling quantum gate operations for all possible pairs of qubits. This research indicates that the limitations faced in building devices using conventional spatial crystals can be overcome by adopting crystalline structures in time.

JÉRÔME BEUGNON
LKB-CDF, COLLÈGE DE FRANCE

Bloch oscillations of a soliton in a 1D BEC without a lattice

I will describe recent experiments in which we observe the oscillatory motion of a solitonic atomic wave packet in a bath when submitted to a constant and uniform force. We explore these Bloch oscillations in linear and ring geometries. In the latter case, we show that the motion of the wave packet is associated with the generation of quantized superfluid currents in the bath. This work opens up interesting perspectives for the study of the dynamics of 1D quantum systems.

TOMMASO ROSCILDE
ENS-LYON, ECOLE NORMALE SUPÉRIEURE DE LYON

Scaling multipartite entanglement in atomic systems: presto vs. adagio

Synthetic many-body systems, based e.g. on neutral atoms or trapped ions, develop at an impressive pace, and they promise the preparation and control of entangled states on unprecedented scales. But is scalability of many-body entanglement achievable without resorting to quantum error correction?

In this talk I will discuss two opposite strategies to scale up entanglement:

1) looking for the fastest possible entanglement dynamics, so as to run faster than the environment. This is possible by exploiting exponentially fast entangling protocols, allowed in the case of qubit/qudit networks with sufficiently high connectivity; and 2) coping with the environment, and taking a quasi-adiabatic route towards the preparation of highly entangled states. This route requires one to focus on entanglement forms such as squeezing, which is potentially robust to decoherence and losses.

Making use of analytical approximations and variational approaches, we will show that both strategies (the "presto" one and the "adagio" one) appear very promising for systems with power-law interactions, with particular focus on two-dimensional arrays of dipolar spins.

MICHAŁ PARNIAK

UNIVERSITY OF WARSAW

Quantum sensing with cold interacting Rydberg atoms

The excellent sensitivity of Rydberg atoms to external electric fields is both their curse and one of the strongest feats. In our lab we exploit this feature to engineer very sensitive microwave sensors and microwave-optical transducers. However, simple scheme do not take any advantage of Rydberg-Rydberg interaction. Now we would like to present a sensing scheme, in which interactions are used to prepare the atomic state in such a way that the retrieved quantum state of light is less susceptible to inherent losses in the setup. The scheme utilized long-range dipolar interactions, and surprisingly allows for a very significant interaction even though the atomic ensemble is large and somewhat dilute. We cast our protocol in a quantum-metrological framework, and demonstrate that it is in fact an optimal solution to the given quantum error-correction problem. In the experiment, we show that interaction allow us to achieve a threefold enhancement in the Fisher information per detected photon. With future enhancements we project that the sensor will reach a sensitivity at the level of single microwave or mm-wave photons.

KAZIMIERZ RZĄŻEWSKI
CENTER FOR THEORETICAL PHYSICS PAS

The Hybrid Sampling Method for the Statistics of a Bose Gas

While the statistical properties of an ideal Bose gas are well understood, accounting for interaction induced corrections remains a challenging and unresolved problem. We propose a fundamentally different approach: instead of calculating partition functions, we construct models of the canonical and microcanonical ensembles directly. Previously, to this end, we developed two sampling techniques—one based on the classical field approximation and the other on Fock State Sampling (FSS). Each method offers significant advantages but also suffers from critical limitations: the classical field approach is plagued by ultraviolet divergence, while FSS neglects changes to the condensate wave function. In this talk, we introduce a new Hybrid Sampling method that overcomes these issues, combining the strengths of both earlier approaches while avoiding their respective shortcomings.

YVAN CASTIN

LKB-ENS, ECOLE NORMALE SUPÉRIEURE

Phonon damping in a 2D superfluid: insufficiency of Fermi's golden rule at low temperature

In three dimensions, it is generally accepted that the phonon gas of a superfluid always enters a weak coupling regime at sufficiently low temperatures, regardless of the strength of the interactions between the constituent particles of the superfluid. Thus, in this limit, one should always be able to calculate the damping rate of thermal phonons by applying Fermi's golden rule to the cubic phonon-phonon coupling Hamiltonian H_3 (at least in the collisionless regime). With the many-body Green function method, we predict, for a convex acoustic branch and by simple power counting, that this is not true in two dimensions. We quantitatively confirm this prediction by classical phonon field simulations and by a nonperturbative theory in H_3. For a weakly interacting fluid, we predict at long wavelengths a damping rate about three times lower than that of the golden rule.

YVAN CASTIN

LKB-ENS, ECOLE NORMALE SUPÉRIEURE

Amortissement des phonons dans un superfluide 2D : insuffisance de la règle d'or de Fermi à basse température

En dimension trois, il est en général admis que le gaz de phonons d'un superfluide entre toujours dans un régime de couplage faible à suffisamment basse température, quelle que soit la force des interactions entre les particules constitutives du superfluide. Ainsi, dans cette limite, on devrait pouvoir toujours calculer le taux d'amortissement des phonons thermiques en appliquant la règle d'or de Fermi à l'hamiltonien H_3 de couplage cubique phonon-phonon (du moins dans le régime faiblement collisionnel). Avec la méthode des fonctions de Green à N corps, nous prédisons, pour une branche acoustique convexe et par simple comptage de puissances, que ceci n'est pas vrai en dimension deux. Nous confirmons quantitativement cette prédiction par des simulations de champ phononique classique et par une théorie non perturbative en H_3. Pour un fluide en interaction faible, nous prédisons aux grandes longueurs d'onde un taux d'amortissement environ trois fois plus faible que celui de la règle d'or.

JAKOB REICHEL

LKB-ENS, ECOLE NORMALE SUPÉRIEURE

Entangling atoms in cavities: From quantum Zeno dynamics to metrology

N three-level atoms coupled to a single mode of a high-finesse optical cavity provide a rich setting for quantum physics and technology. Highly entangled atomic states naturally occur due to nonlocal coupling mediated by the cavity mode, but also through collective coupling to the environment. I will describe some experiments performed at ENS with such systems, and will discuss some perspectives for quantum simulation with cavity-mediated interactions.

PIOTR DEUAR
INSTITUTE OF PHYSICS PAS

Self organisation and metastability of cavity bosons beyond the adiabatic elimination approximation

Phase-space formulations of quantum mechanics like the positive-P and truncated Wigner can give access to the full quantum behaviour of very large systems. In particular, the full distribution of single-shot configurations can be obtained from a stochastic simulation. This is particularly useful for dissipative systems for which direct simulation is harder but phase space methods become stable [1].

In a recent work [2] we have looked at the very long-time behaviour and self-organisation of weakly interacting bosons in a 2d optical lattice coupled to a lossy cavity, in the regime of high filling similar to experiments at ETH [3]. The truncated Wigner representation allows us to go orders of magnitude longer in time compared to earlier numerical work. It takes into account the dynamics and correlation of the cavity mode, quantum fluctuations, and self-organisation of individual runs, and has been benchmarked by us for this system.

We observe metastability at very long times and superfluid quasi-long range order, in sharp contrast with the true long range order found in the ground state of the Bose-Hubbard model with extended interactions obtained by adiabatically eliminating the cavity. The metastability appears to be dependent on the relaxation of the adiabatic elimination constraint. As the strength of the cavity coupling increases in a superfluid, the system first becomes (lattice) supersolid at the superradiant transition and then turns into a charge-density wave via the BKT mechanism. Notably, experimental preparation times have often been comparable with the very long times simulated here, so the metastable effects may be relevant in practice.

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ROMAN CIURYŁO

NICOLAUS COPERNICUS UNIVERSITY IN TORUŃ

Hg clock transition affected by collisions with cold atoms

R. Bala[1], A. Linek[1], M. Witkowski[1], P. Żuchowski[1], P. S. Julienne[2], M. Zawada[1], R. Ciuryło[1*]

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The experimental setup for the study of Hg-Rb [1,2] ultra-cold collisions is designed to explore optical Feshbach resonances as well as provide basic information about interaction potentials and scattering properties at ultra-low collision energies. This system will be used to search for spectroscopic evidence [3,4,5] of possible new hadron-hadron interactions beyond Standard Model. On the other hand, such experimental set up gives an unique opportunity to study perturbation of Hg clock transition [6,7]by collisions with cold Rb atoms. We use Hg-Rb system as a case study for variation of collisional width and shift of clock transition with respect to reduced mass of colliding partners.

Our full quantum scattering calculations were carried out in the range of collision energies corresponding to temperatures from 1 nK to 1 K. We found significant variations of line shape parameters which are related to the shape resonances [8] in excited and ground electronic scattering states of colliding pairs of atoms.

The parameters governing the magnitude of collisional width and shift of spectral lines at ultralow collision energies are s-wave scattering lengths. Unfortunately, these key parameters are not known for Hg-Rb system. Nevertheless, our study shows possible magnitude of variation of collisional width and shift of clock transition when temperature and reduced mass of colliding atoms is changing. Moreover, approximations based on s-wave scattering lengths [9,10] and the semi-classical approximation [11] for collisional widths and shifts were tested in confrontation with full quantum scattering calculations. We also indicate the possible influence of inelasticity of collisions on obtained results.

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NICOLAS CHERRORET
LABORATOIRE KASTLER BROSSEL, CNRS

Coarsening of binary Bose superfluids: an effective theory

When a system is quenched across a symmetry-breaking phase transition, it exhibits a phenomenon of phase separation, characterized by the coarsening of growing ordered-phase domains. In the last decades, the coarsening dynamics of binary Bose superfluids quenched into their immiscible phase has attracted increasing interest, with ab initio studies demonstrating a dynamic scaling of correlations controlled by a domain size growing as $L(t) \sim t^{2/3}$. While this behavior was initially suggested to coincide with the long-time inertial regime of classical binary fluids, here we show that superfluid coarsening is actually governed by a fundamentally different physics, driven uniquely by quantum effects: the competition between interspecies interactions and quantum pressure. To demonstrate this, we derive an effective equation of motion for the order parameters of binary Bose mixtures, starting from the microscopic Hamiltonian. This equation can be viewed as a generalization of the celebrated Cahn-Hilliard description of classical binary fluids to superfluid systems. Our effective theory captures key properties of superfluid coarsening, including domain growth, Porod's la, and interfacial properties. More broadly, it provides a new intuitive framework for understanding phase separation dynamics in superfluid mixtures, at least in the regime of weak segregation.

JAKUB ZAKRZEWSKI
JAGIELLONIAN UNIVERSITY

Nonergodic dynamics in interacting many-body systems

While typical interacting many body systems thermalize internally, there exist several exceptions. The most robust one is probably the many-body localization phenomenon. Its existence in the thermodynamic limit remains unproven yet for finite, experimentally accessible quantum simulators localization due to disorder, strong interactions or external potentials has been verified. Specific properties of dynamics in quasiperiodic disorder, typical for optical lattice experiments will be discussed in detail. Similarly, we shall describe a non-standard localization for systems with positional disorder that may be realized in optical tweezers arrays. Other interesting topics may also be touched.

TARIK YEFSAH

LKB-ENS, ECOLE NORMALE SUPÉRIEURE

Quantum Gas Microscopy of Fermions in the Continuum

Quantum gas microscopy has emerged in the last 15 years as a powerful technique to probe and manipulate quantum many-body systems at the single-atom level. While this technique was initially developed for the study of lattice and spin chain physics, prominently to explore the Hubbard model and its generalizations, our group has recently introduced its use for continuum systems.

In this talk, I will present our recent work on quantum gas microscopy of fermionic many-body systems in the continuum, and how we can characterize them at previously inaccessible levels of resolution and control. Our approach offers radically new possibilities for the exploration of strongly interacting Fermi gases at the single-atom level.

ANNA MINGUZZI

LPMMC, UNIVERSITÉ GRENOBLE-ALPES

Symmetry oscillations in strongly interacting one-dimensional mixtures

Multicomponent quantum mixtures in one dimension can be characterized by their symmetry under particle exchange. We consider a strongly interacting, two-component Bose-Bose mixture and compare the case of same inter- and intra-species interactions, displaying SU(2) symmetry, to the one where inter- and intra-component interactions are both strong but different, thereby breaking SU(2) symmetry, both cases being exactly solvable at strong repulsive interactions. Starting from an initially spin-demixed state, we follow the time evolution of the total momentum distribution of the mixture. We show that the momentum distribution is quasiconstant for the SU(2) symmetry conserving case, while it displays large oscillations in time for the symmetry-breaking case. Using the property that the momentum distribution operator at strong interactions commutes with the class-sum operator, the latter acting as a symmetry witness, we show that the momentum distribution oscillations correspond to symmetry oscillations, with a mechanism analogous to neutrino flavor oscillations.

MICHAŁ KARPIŃSKI

UNIVERSITY OF WARSAW

Phase-only spectral-temporal shaping of single-photon pulses

Spectral-temporal modes of quantum light have been recognized as a promising platform for quantum information processing and metrology [1]. However, a simple general tool for efficient conversion between spectral-temporal modes is still missing. A phase-only, i.e. in-principle lossless, approach is required for quantum light. I will show that transformations between spectral-temporal modes can be realized by a single application of arbitrary temporal phase modulation and a single application of arbitrary spectral phase modulation. The required arbitrary phases can be found by means of the well-known phase retrieval algorithm, such as the Gerchberg-Saxton algorithm. We apply machine learning-based optimization to find slowly varying phases, opening the way to experimental implementation using wide-bandwidth electro-optic phase modulation [2]. I will also discuss strategies to detect temporal properties of short single-photon optical pulses [3,4].

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DMITRY PETROV
LPTMS, UNIVERSITÉ PARIS-SACLAY

Townes soliton beyond mean field

By using the Bogoliubov perturbation theory we describe the self-bound ground state and excited breathing states of N two-dimensional bosons with zero-range attractive interactions. Our results for the ground state energy B_N and size R_N improve previously known large-N asymptotes and we better understand the crossover to the few-body regime. The oscillatory breathing motion results from the quantum-mechanical breaking of the mean-field scaling symmetry. The breathing-mode frequency scales as $\Omega \propto |B_N|/\sqrt{N}$ at large N.

HÉLÈNE PERRIN
LPL, UNIVERSITÉ SORBONNE PARIS-NORD

Microwave spectroscopy of ultracold sodium least-bound molecular states

Controlling the interactions between cold atoms is a key feature of quantum gases, in particular in the context of quantum simulation. The scattering length, which characterizes the interaction strength at low temperature, is generally tuned with a magnetic field through a magnetic Feshbach resonance. While very convenient in an optical trap, this method is not adapted to magnetically trapped atoms, for which the magnetic field is not tunable independently from the trapping potential. It has been proposed by Papoular, Dalibard and Shlyapnikov to use instead a microwave field in the vicinity of a molecular photoassociation resonance to manipulate the scattering length of magnetically trapped atoms. Motivated by this proposal, we have studied by microwave photoassociation spectroscopy the relevant molecular states of sodium. The microwave field is produced by a waveguide lying directly on an atom chip, distant by less than 20 micrometers from the atomic cloud, which gives us access to very strong microwave field amplitudes. We identify several molecular lines and measure their frequency with an unprecedent accuracy. We observe very fast atom losses at the vicinity of the resonance, and discuss the feasibility of tuning the scattering length with a microwave field.

SYLVAIN NASCIMBENE

LKB-CDF, COLLÈGE DE FRANCE

Exploring quantum Hall physics with ultracold dysprosium atoms

Ultracold atomic gases can be used to study a wide range of phenomena relevant to quantum matter, including topological states related to the quantum Hall effect. Because of the charge neutrality of atoms, the simulation of the quantum Hall effect relies on the application of an artificial magnetic field, whose generation can be greatly facilitated in systems with synthetic dimensions.

In this talk, I will present an experimental realization of a quantum Hall system using ultracold gases of dysprosium atoms. We use the large spin J = 8 of this atom to encode a synthetic dimension in the magnetic projection states m. We couple the spin to the atomic motion using two-photon optical transitions, which leads to an effective magnetic field. We measure characteristic features of the quantum Hall effect, namely a quantized Hall response and gapless chiral edge modes.

I will then present a more complex experiment probing spatial entanglement properties, by simulating the so-called entanglement Hamiltonian. This experiment relies on the Bisognano-Wichmann theorem, which states that the entanglement Hamiltonian is given by a spatial deformation of the system, which we implement along the synthetic dimension.

JAN KOŁODYŃSKI
INSTITUTE OF PHYSICS PAS

Bayesian inference tools for atomic experiments with continuous light detection

From gravitational-wave detectors to cryogenically cooled microresonators, quantum effects have been shown to enhance capabilities of various devices in sensing external perturbations. Although this fact has led to important breakthroughs in the field of quantum metrology, one often forgets that the vast majority of real-life applications require quantum sensors to track signals that vary over time—e.g., gravitational waves generated by black holes merging, or fluctuating magnetic fields generated by the human brain.

In my talk, I will summarise recent results obtained within my group, in which we combine the description of continuously monitored quantum sensors with methods of signal processing, so that quantum effects can still be used to boost the sensitivity in "real time".

Although I will focus on the setting of hot atomic vapours and the task of fluctuating and transient magnetic-field signals, the methods I will present (Extended, Cubature Kalman Filters) can be used to interpret homodyne signals for other quantum systems, as long as the dynamics does not deviate significantly from the Gaussian description. If time permits, I will also summarise the complementary setting of experiments involving photodetection, in which case brute-force Bayesian inference is computationally intractable. However, I will show how one may resort to resampling techniques and machine learning to bypass this bottleneck.

BRUNO LABURTHE-TORLA
LPL, UNIVERSITÉ SORBONNE PARIS-NORD

Generalized Ramsey interferometry with large spin atoms

Atoms typically possess rich internal degrees of freedom that allow exploring physics beyond that of spin ½ particles. In our experiments, we have thus developed new tools to manipulate and probe the magnetic properties of ensembles of large spin F=9/2 strontium and S=3 chromium atoms.

First, using strontium atoms with nuclear spin F=9/2, we have used a tensor light shift to perform rotations within a restricted Hilbert space spanned by two isolated spin states among the 2F+1 = 10 possible states. These manipulations correspond to engineering unitary operations deriving from generators of the SU(N) algebra beyond what can be done by simple spin precession. We demonstrated that one can implement two Ramsey interferometer schemes simultaneously, using four states. The first scheme senses in parallel two external fields acting on the atoms, and the second scheme simultaneously measures two non-commuting observables of a collective atomic state.

In a second series of experiments, we have used advanced dynamical decoupling techniques to efficiently suppress the sensitivity to magnetic field fluctuations of large spin Cr atoms. Using a Ramsey interferometer scheme, we thus measured the spin coherence of an itinerant spin 3 Bose dipolar gas throughout a quantum phase transition from a superfluid phase to a Mott insulating phase. A dynamical instability breaking ferromagnetism is observed in the superfluid regime as the lattice depth approaches the critical depth for the Mott transition. In the insulating phase, quantum thermalization towards a paramagnetic state is driven by an interplay between intersite and superexchange interactions.

LUDOVIC PRICOUPENKO
LPTMC, UNIVERSITÉ SORBONNE

Universality in isolated few-body resonances

In the vicinity of the unitary limit where there is a clear scale separation between the range of the interactions and their effects at large distance, one expects the existence of a "universality", i.e. the possibility to describe low-energy properties using a small number of parameters, regardless of the short-range details. Due to its very general character, this universality can occur in completely different contexts ranging from nuclear physics to cold atoms. Efimov states are a prominent example of universal states and have been studied in detail since their discovery in cold atom experiments. They appear in certain specific configurations depending on the particle statistics and their masses, regardless of the interaction details. In absence of Efimov effect, isolated few-body resonances are other weakly bound or quasi-bound few-body states, which exist for sufficiently attractive short-range interparticle potentials. These states have been much less studied and we will explain why they too have a universal character. We will consider a class of three-body systems where exact solutions of the contact model, which by construction are universal, can be successfully compared to calculations using finite-range potentials.

KRZYSZTOF JACHYMSKI
UNIVERSITY OF WARSAW

The role of exchange interactions in superradiant phenomena

Competing interactions in complex quantum systems can lead to exotic correlated phases of matter. We consider a hybrid system of spins coupled to a quantum photonic field, where light-induced processes and direct spin-spin interactions drive the system towards different orders. We approach the problem using a combined variational ansatz utilizing tensor network description of the spins and a Gaussian photonic state, with intercomponent correlations accounted for by a suitable entangling transformation. This method is highly accurate from weak to strong coupling regime and allows to take into account large photon number. Our study reveals that distinct ferromagnetic and antiferromagnetic regions exhibit different orders of phase transitions. Most notably, in the presence of anisotropic interactions, we identify an intriguing phase where spin order and superradiance coexist even in one dimension.

FÉLIX WERNER
LKB-ENS, ECOLE NORMALE SUPÉRIEURE

Three-body losses and three-body contact of fermionic atoms at unitarity

After reviewing the notion of three-body contact C_3 for two-component fermions, including the derivation of the relation between C_3 and the three-body loss rate Γ_3 [1], I will report our preliminary results on the determination of C_3 for the unitary Fermi gas [2].

[1] FW and X. Leyronas, C. R. Phys. 25, 179 (2024)
[2] in collaboration with P. Lunt, C. Heinze, M. Galka, E. Bräutigam, S. Jochim, K. Oi and S. Endo

ISABELLE BOUCHOULE
LCF, UNIVERSITÉ PARIS-SACLAY

Proving the local rapidity distribution of a one-dimensional Bose gas

TBA

MARIUSZ GAJDA

INSTITUTE OF PHYSICS PAS

Simple Model for Monitoring the Motion of a Quantum Particle

I present a model that focuses on the frequent, repeated measurement of a quantum particle's position and momentum, addressing certain aspects of the measurement problem in quantum mechanics. The model is formulated within an open system framework, describing a particle under interrogation by a grid of detectors uniformly distributed in phase space. The density operator of the particle, coupled to the 'reservoir' of detectors, is assumed to evolve according to the Gorini-Kossakowski-Sudarshan-Lindblad (GKSL) equation, with jump operators representing the measurement process.

The formalism incorporates a wavefunction collapse postulate, in which, after measurement, the system is assumed to be in one of the meter's states—assumed here to be coherent states of a local quantum oscillator[1]. We present trajectories of observables generated using the Wave Function Quantum Monte Carlo method as straightforward illustrative examples.

The Zeno effect is predicted, particularly for a relatively sparse spatial grid of detectors, while in a limit of very frequent detection and densely distributed meters the quantum dynamics of monitored particles is equivalent to the classical stochastic process.

In this case, the statistical characteristics of the monitored trajectories are analogous to those obtained in the classical dynamics of a particle undergoing Brownian motion[2].

[1] Filip Gampel and Mariusz Gajda, Continuous simultaneous measurement of position and momentum of a particle, Phys. Rev. A 107, 012420 (2023).
[2] Filip Gampel, Mariusz Gajda, On Repeated Measurements of a Quantum Particle in a Harmonic Potential, Acta Phys. Pol. A 143, S131 (2023).

POSTERS

DAY 1

BUĞRA TÜZEMEN, INSTITUTE OF PHYSICS, PAS

Equilibrium and Dynamical Features of Unconventional Fermi Superfluids

MATEUSZ ŚLUSARCZYK, CENTER FOR THEORETICAL PHYSICS PAS

Vortices in the Many-Body Excited States of Interacting Bosons in Two Dimension

ALI MOSHIRI, LABORATOIRE KASTLER BROSSEL

Spin squeezing with large spin atoms

HUBERT DUNIKOWSKI, INSTITUTE OF PHYSICS PAS

Effective light-induced Hamiltonian for nuclear spin of alkaline earth atoms

KARTHIK ESWARAN, THE JAGIELLONIAN UNIVERSITY IN KRAKÓW

Anderson localization in photonic time crystals

DAMIAN WŁODZYŃSKI, JAGIELLONIAN UNIVERSITY

Floquet engineering of Bose mixture with interactions of any shape

PIOTR KULIK, FACULTY OF PHYSICS UNIVERSITY OF WARSAW

Towards efficient numerical description of hybrid quantum systems: a study of extended Hubbard-Holstein model

PASCAL NAIDON, RIKEN

Stabilization of few-body resonances to bound states in a continuum

DAY 2

MARCIN KOŹBIAŁ, CENTRE OF NEW TECHNOLOGIES, UNIVERSITY OF WARSAW

Spin noise spectroscopy of an alignment-based atomic magnetometer

MACIEJ MARCINIAK, CENTER FOR THEORETICAL PHYSICS PAS

Fermionization of an Ideal Bose Gas via the Super-Tonks-Girardeau Quench

MACIEJ BARTŁOMIEJ KRUK, INSTITUTE OF PHYSICS, PAS

Hybrid Sampling Method for BEC Fluctuations

KING LUN NG, INSTITUTE OF PHYSICS PAS

One-dimensional quantum droplet in phase-space representation

JOSEPH DELPY, LUMIN, ENS PARIS-SACLAY

Hallmarks of collective spin noise in a strongly-interacting Rb vapor

TEJAS JOSHI, INSTITUTE OF PHYSICS, PAS

Condensate dynamics of wave dark matter after a disturbance

DAWID HRYNIUK, UCL/CTP

Variational tensor network Monte Carlo approach to open many-body quantum systems

ABOUT

THIS IS THE THIRD EDITION OF THE SYMPOSIUM ORGANIZED AT THE POLISH ACADEMY OF SCIENCES SCIENTIFIC CENTER IN PARIS. THE SYMPOSIUM WILL EXPLORE THE PHYSICS OF ULTRACOLD ATOMIC GASES, COVERING BOTH FUNDAMENTAL ASPECTS AND APPLICATIONS IN EMERGING QUANTUM TECHNOLOGIES. IT WILL EQUALLY ADDRESS EXPERIMENTAL AND THEORETICAL PERSPECTIVES, FOCUSING ON NONLINEAR PHENOMENA, MANY-BODY EFFECTS, AND ENTANGLEMENT IN ULTRACOLD BOSONIC AND FERMIONIC ATOMS, AS WELL AS THEIR STATISTICAL PROPERTIES.

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M 6 Boissière (3 min)

M 1 Charles de Gaulle – Étoile (9 min)

M 2 Victor Hugo (7 min)

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