



The Abdus Salam
International Centre
for Theoretical Physics



Workshop on Impurity Problems in Quantum Mixtures: from Ultracold Gases to Electron Matter



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How the properties of impurities are modified by their interaction with a surrounding medium is a fundamental question across several research areas and different physical systems. Yet, a common set of ideas and technical tools can be applied to these seemingly different frameworks, the investigation of one system yielding information on another. The workshop schedule will combine pedagogical and cross-disciplinary presentations with more technical ones, leaving ample time for spontaneous discussions and thus fostering new collaborations and approaches in the study of impurity problems in emerging quantum science platforms.

Topics of interest

- Impurities and Polarons in Ultracold Quantum Gases
- Excitons, Polarons, and Exciton-Polaritons in 2D and Solid-State Systems
- Polaron Formation, Dynamics, and Non-Equilibrium Phenomena
- Impurities with Long-Range or Tunable Interactions
- Impurities as Quantum Probes of Many-Body Systems
- Quantum Simulation and Information Approaches to Impurity Physics

Organizing committee

DIRECTORS:

L. Ardila, University of Trieste, Italy

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LOCAL ORGANISER:

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Keynote lectures: 35' + 10'
 Invited presentations: 25' + 5'

Time	Monday 23/2	Tuesday 24/2	Wednesday 25/2
09:00 - 09:45	Keynote: Jacques Tempere	Keynote: Cheng Chin	Keynote: Eugene Demler
09:45 - 10:15	Richard Schmidt	Cesare Franchini	Daniele Fausti
10:15 - 10:45	Pietro Massignan	Mona Berciu	Artur Widera
10:45 - 11:30	☕ Coffee Break	☕ Coffee Break	☕ Coffee Break
11:30 - 12:00	Xiaoling Cui	Andrea Bergschneider	Jan Aarlt
12:00 - 12:30	Georg Bruun	Martin Lebrat	Sergei Skipetrov
12:30 - 14:00	🍴 Lunch Break	🍴 Lunch Break	🍴 Lunch Break
14:00 - 14:30	Christoph Eigen	→ Transfer to Leonardo building	Lab tours (Basovizza)
14:30 - 15:00	Cosetta Baroni	Alessio Recati	
15:00 - 15:30	Richard Fletcher	Denis Golež	
15:30 - 16:00	☕ Coffee Break	☕ Coffee Break	Departure
16:00 - 17:00	POSTER SESSION	ICTP Colloquium: Ataç Imamoglu	
17:00 - 18:00		Refreshments & free discussions	
18:00 - open	Aperitivo with light buffet		

Deeply bound polaronic states

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The physics of strongly interacting quantum systems remains a central challenge in many-body physics. We explore this regime by creating impurities with strong attractive or repulsive interactions in a quantum-degenerate gas of 39K atoms. This system supports two well-known quasiparticles: attractive and repulsive polarons. I first review previous spectroscopic and interferometric measurements of these states. Ramsey interferometry reveals distinct dynamical regimes associated with polaron formation and demonstrates how many-body states can be probed in the time domain.

More recently, we employed an ejection spectroscopy sequence that reveals a pronounced spectral feature at energies well below the polaron energy. We measure both the energy and spectral weight of this signal and compare our results to two theoretical scenarios: a low-energy polaron dressed by many bosons, and a bipolaron formed by two polarons bound via BEC-mediated interactions. Our observations provide evidence for deeply bound states below the conventional polaron branch, opening new perspectives on strong coupling physics in Bose gases.

The moving Fermi polaron

Cosetta Baroni^{1,2}, Johanna Hennebichler^{1,2}, Ruben Erlenstedt^{1,2}, Erich Martin Dobler^{1,2},
Rudolf Grimm^{1,2}, Matteo Caldara^{3,4}, Pietro Massignan⁵, Georg Bruun⁶

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ABSTRACT

A single impurity interacting with a many-body environment represents a minimal yet powerful paradigm for exploring strongly correlated quantum systems and is described in terms of quasiparticles known as polarons. Ultracold atomic gases provide an exceptionally tunable platform for realizing and probing such impurity problems. In our experiments, we study bosonic 41K atoms immersed in a spin-polarized, degenerate Fermi gas of 6Li, forming a system of Fermi polarons in the regime of strong interactions. While previous work has largely focused on the static and dynamical properties of these quasiparticles [1,2], access to their kinetic properties—such as dispersion relations and effective masses—requires momentum-resolved probes. To this end, we recently developed a Raman setup with which we can impart a well-defined and tunable momentum to the impurities, allowing to explore the system from the paradigmatic zero-momentum polaron to the regime of large momenta, where the impurity increasingly behaves like a bare particle. We present measurements of the momentum-dependent polaron energy for different interaction strengths. For repulsive polarons, we observe a smooth and monotonic evolution between these two regimes of momenta, whereas the attractive branch exhibits a non-monotonic dispersion, which we attribute to the influence of a molecule-hole continuum and the resulting breakdown of the simple polaron picture at low momenta.

[1] Fritsche *et al.*, *Phys. Rev. A* **103**, 053314 (2021).

[2] Baroni *et al.*, *Nat. Phys.* **20**, 68–73 (2024).

Insights about the ground-state of liquids of incoherent bipolarons obtained from single-electron removal spectral weights

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ABSTRACT

We use density matrix renormalization group (DMRG) and variational exact diagonalization (VED) to calculate the single-electron removal spectral weight for the Hubbard-Holstein model at low electron densities. Tuning the strength of the electron-phonon coupling and of the Hubbard repulsion allows us to contrast the results for a liquid of polarons versus a liquid of bipolarons. The former shows spectral weight up to the Fermi energy, as expected for a metal. The latter has a gap in its spectral weight, set by the bipolaron binding energy, although this is also a (strongly correlated) metal. This difference suggests that angle-resolved photoemission spectroscopy could be used to identify liquids of pre-formed pairs. Furthermore, we show that the one-dimensional liquid of incoherent bipolarons is well approximated by a "Bose sea" of bosons that are hard-core in momentum space, occupying the momenta inside the Fermi sea but otherwise non-interacting. This new proposal for a strongly-correlated many-body wavefunction opens the way for studying various other properties of incoherent (non-superconducting) liquids of pre-formed pairs in any dimension.

Characterizing interactions between excitons in monolayer semiconductors

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ABSTRACT

Strongly bound excitons in transition metal dichalcogenides offer an interesting platform for investigating many-body interactions. Excitons with ground state as well as excited state wavefunctions can be created with resonant light and the different valley degrees of freedom can be addressed by different polarization of light and the intra and interspecies exciton-exciton interaction vary in strength and sign.

Recently, we utilized the optical Stark effect in semiconductors to measure exciton-exciton interactions with pump-probe spectroscopy in MoSe₂ as well as in WSe₂ [1]. With a red-detuned pump pulse we generate a virtual population of excitons and extract the coherent interaction with the excitons resonantly excited by the probe pulse from the measured resonance shift. With copolarized pulses, we observe repulsive interaction between 1s excitons and between 2s and 1s excitons. In addition, we were able to observe the existence of the 2s-1s biexciton bound state for cross-polarized pulses.

[1] M. Wegerhoff, M. Scharfstädt, S. Linden and A. Bergschneider, „Coherent interaction of 2s and 1s exciton states in Transition-Metal Dichalcogenide Monolayers“, Phys. Rev. Lett. 134, 236901 (2025).

Emerging Fermions in a Quantum Spin Liquid

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ABSTRACT

We explore the dynamics of holes in a single band extended tJ model where the background spins form a quantum spin liquid (QSL). Using a field theory approach based on a parton construction, we show that while the electrons for most momenta fractionalize into uncorrelated charge carrying holons and spin carrying spinons as generally expected for a QSL, they can form long lived spinon-holon bound states for certain momenta. We then show that quantum gas microscopy with atoms in optical lattices provides an excellent platform for verifying and probing the internal spatial structure of these emergent fermions. The fermions will furthermore show up as clear quasiparticle peaks in angle-resolved photoemission spectroscopy with an intensity determined by their internal structure. For a non-zero hole concentration, the fermions form hole pockets with qualitatively the same location, shape, and intensity variation in the Brillouin zone as the so-called Fermi arcs observed in the pseudogap phase. Our results provide a microscopic mechanism for the conjectured fractionalized Fermi liquid and open up new pathways for exploring the pseudogap phase and high temperature superconductivity as arising from a QSL.

When Impurities Meet Efimov Physics: Fermion-Mediated Pairing in a Quantum Gas

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ABSTRACT

Interactions mediated by a surrounding medium appear across physics, from magnetic impurities in metals to few-body bound states in nuclear systems. Two well-known examples are the Ruderman–Kittel–Kasuya–Yosida (RKKY) interaction, where fermions induce correlations between impurities, and Efimov physics, which describes universal three-body bound states near resonant interactions. These phenomena are usually studied in very different physical regimes.

In this talk, I will show how ultracold Bose–Fermi mixtures connect these two limits. Using a mixture of bosonic cesium and fermionic lithium atoms with tunable interactions, we explore the crossover from weakly interacting, RKKY-like behavior to strongly interacting Efimov physics. Measurements of collective excitations and relaxation dynamics reveal fermion-mediated scattering resonances in the many-body system, which continuously evolve into Efimov resonances in the dilute thermal regime, highlighting the interplay of two-, three-, and many-body physics in a single quantum platform.

Transition or Crossover: Visualizing competitive few-body correlations in Fermi polarons via energy dispersion

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In this talk, I will show that the destiny of Fermi polaron as increasing impurity-fermion attraction is closely related to their mass imbalance and can be directly visualized through the impurity dispersion in momentum space (Q). Specifically, small mass imbalance leads to a first-order transition from polaron to molecule, corresponding to an energy competition between $Q = 0$ and $Q = k_F$ states in the dispersion (k_F is the majority Fermi momentum); large mass imbalance gives rise to a smooth crossover from polaron to dressed clusters, where the ground state always stays at $Q = 0$ while its wavefunction gradually changes. Further, we propose to measure the impurity dispersion by engineering spin-orbit coupling (SOC) on the impurity, which induces spin flip with finite momentum transfer. The polaron and molecule states can be individually probed by setting the SOC momentum to be near zero and k_F . This method clearly identifies the nature of such a first-order transition and overcomes practical difficulty for its detection in realistic experiments due to polaron-molecule coexistence.

- [1] X. Cui, Phys. Rev. A 102, 061301(R) (2020).
- [2] C. Peng, R. Liu, W. Zhang, X. Cui, Phys. Rev. A 103, 063312 (2021).
- [3] R. Liu, C. Peng, X. Cui, Cell Reports Physical Science 3, 100993 (2022).
- [4] T. Shi, X. Cui, arXiv:2512.23918.

Spectroscopy of magnetic polarons in geometrically frustrated systems

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The emergence of quasiparticles that differ qualitatively from their constituent particles is a hallmark of strongly correlated quantum many-body states. In doped ferromagnetic insulators, a paradigmatic example of such an emergent quasiparticle is a bound state of a mobile charge carrier and a magnon. This is a special kind of magnetic polaron that carries charge $Q = 1$ and spin $S = 3/2$. These composite objects underlie several critical phenomena in geometrically frustrated systems, including magnetization plateaus and superconductivity. While experiments with moire electron systems, ultracold atoms in optical lattices, and Rydberg arrays have recently provided evidence of the existence of these magnetic polarons, measurements of the single-particle spectral function - which provides crucial information on binding energy and dispersion-have been lacking. In this talk, we will discuss a novel spectroscopic protocol that enables the measurement of spectral functions in Rydberg arrays. This method can be configured to measure spectral functions in momentum space, analogous to ARPES, or locally in real space, similar to STM experiments in solids. We will review experimental measurements of single-particle spectral functions in frustrated $t - J$ Hamiltonians using a Rydberg tweezer array. Leveraging single-atom resolution, these experiments go beyond canonical spectroscopic measurements to directly visualize photoexcited states, confirming their magnetic character, spatial localization, and composite nature.

Impurities strongly interacting with Bose gases

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Emergent polaronic quasiparticle descriptions underpin our understanding of conventional quantum many-body systems, a paradigm first introduced by Landau and Pekar. Here, I will showcase a series of recent experiments on mobile impurities in homogeneous ^{39}K Bose gases. We study the impurities both spectroscopically and interferometrically, and explore a wide range of impurity-bath interactions as well as bath densities and temperatures.

We first show that the behavior of impurities in weakly interacting degenerate baths is remarkably universal, controlled only by the bath density and a single dimensionless interaction parameter. For attractive interactions, the impurity spectrum features a single branch, which away from the resonance corresponds to a well-defined attractive polaron; near the resonance we observe dramatic broadening of this branch, suggesting a breakdown of the quasiparticle picture. Instead, for repulsive interactions, the spectrum features two branches: the attractive branch, that is dominated by excitations with energy close to that of the Feshbach dimer but has a many-body character, and the repulsive polaron branch.

We then study the fate of the quasiparticle branches as we heat the system and cross the BEC transition temperature of the bath. Counterintuitively, we find that for strong impurity-bath interactions the spectra narrow with increasing temperature, while the impurity energy shift is suppressed. Near the critical temperature for condensation, many-body effects still play an important role, and only for a nondegenerate bath, the system approaches the classical Boltzmann-gas behavior. We compare our results to bosonic functional determinant approach (FDA) calculations for an ideal Bose polaron, finding excellent qualitative agreement.

Small polarons in solid state systems by first principles

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Polarons are quasiparticles arising from the coupling of excess electrons or holes with ionic vibrations in polarizable materials, and they have a profound impact on material properties and functionality [1]. The role of polarons in materials can be investigated at the microscopic level using atomistic simulations based on density functional theory, and recent advances, particularly the integration of machine-learning techniques, have significantly expanded the scope and accuracy of these ab initio approaches.

In this seminar, we will discuss several examples of polaron-mediated phenomena in transition-metal oxides, where theoretical predictions are supported by a variety of spectroscopic, optical, and transport measurements. These include: (i) hole bipolarons as precursors of the superconducting state in doped BaBiO₃ [2]; (ii) electron polaron formation and dynamics at TiO₂ surfaces [3, 4]; and (iii) spin-orbit polarons acting as inhibitors of a Mott transition in the double perovskite Ba₂NaOsO₆ [5].

[1] C. Franchini, M. Reticcioli, M Setvin & U. Diebold, *Nat. Rev. Mater.* 6, 560 (2021).

[2] C. Franchini, G. Kresse, R. Podloucky, *Phys. Rev. Lett.* 102, 256402 (2009).

[3] M. Setvin, et al., *Phys. Rev. Lett.* 113, 086402 (2014).

[4] V. C. Birschitzky, et al., *Phys. Rev. Lett.* 134, 216301 (2025).

[5] L. Celiberti, et al., *Nat. Commun.* 15, 2429 (2024).

Controlling the functionality of quantum materials by light

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The properties of complex quantum materials (QM), such as transition metal oxides, arise from the interplay of electrons, phonons, and magnons, making them highly sensitive to external parameters like pressure, doping, applied fields, and temperature. This susceptibility makes QM ideal for experiments where tailored electromagnetic fields can be used to induce novel properties on ultra-fast timescales [1]. I will present our efforts to manipulate material properties through light, both in free space and optical cavities. Building on our recent demonstration that a metal-insulator transition in 1T-TaS can be controlled by resonant cavity coupling, I will outline recent results aimed at using optical cavities to sustain quantum coherence in high temperature superconductors.

Realization of chiral edge transport in a rotating Bose gas

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In this talk, I will present recent results from MIT along two fronts regarding impurity physics. In the first, we demonstrate robust flow around an obstacle of a propagating edge mode in a quantum fluid subject to an artificial gauge field. In the second, I will present a new platform for the realization of a quantum degenerate mixture of erbium and lithium atoms, featuring a very large mass ratio, tunable inter- and intraspecies interactions, and free choice of quantum statistics. This platform recently came online, producing a dual BEC of these two elements.

Optical and cavity engineering of driven excitonic condensates

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Bilayer materials hosting interlayer excitons—comprising electrons in one layer and holes in the other—are a promising experimental platform for realising high-temperature condensates and studying their dynamical properties. Imposing a chemical potential bias through optical pumping or electrical contacts drives exciton condensates into distinct dynamical regimes. We investigate how these regimes manifest in emitted light and how they are influenced by placing the material within an optical cavity.

We show that in a bilayer system where the charge can tunnel between the layers, the chemical potential bias means that an exciton condensate is in the dynamical regime of the Josephson effect. By increasing the bias voltage, the system undergoes a transition from the phase-trapped to phase-delocalized dynamical condensation. Optical spectroscopy can identify these phases, with a strong response to weak fields near the transition due to the instability in the order parameter dynamics [1].

If such a system is placed in an optical cavity within the phase-trapped regime, coupling to photons favours a superradiant state. The phenomenon allows the device to convert DC currents into coherent photons at tunable frequencies determined by the bias and material thickness. These findings highlight mechanisms to control and harness excitonic condensates for optoelectronic applications [2].

[1] Alexander Osterkorn, Yuta Murakami, Tatsuya Kaneko, Zhiyuan Sun, Andrew J Millis, Denis Golež, *Physical Review Letters* 135 (10), 106902 (2025).

[2] Zhiyuan Sun, Yuta Murakami, Fengyuan Xuan, Tatsuya Kaneko, Denis Golež and Andrew J. Millis, *Phys. Rev. Lett.* 133, 217002 (2024).

Novel Spectroscopic Probes for Quantum Materials and Simulators

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ABSTRACT

The physics of impurities lies at the heart of many fundamental and applied problems in quantum matter. In materials, static defects modify electronic structure and determine device performance, while in lattice systems described by the Hubbard model, mobile dopants in a Mott insulator give rise to exotic, strongly correlated phases at low temperatures. Spectroscopic techniques that can experimentally resolve the signatures of doping and disorder are essential for understanding how quantum phenomena emerge, whether in real materials or their cold-atom analogs.

In this talk, I will illustrate how advances in spectroscopy are forging new connections between condensed-matter systems and cold-atom quantum simulators, drawing on my work in both areas. I will first describe efforts to develop a table-top ultraviolet photoemission system with applications to quantum materials and semiconductor heterostructures. The light source, based on efficient nonlinear photon upconversion to sub-150 nm wavelengths, combines high photon flux with excellent energy resolution and opens new frontiers for probing AMO systems. In the second part, I will present recent work in a Fermi-Hubbard quantum simulator based on ultracold atoms in optical lattices, including the observation of a pseudogap metal at ultralow temperatures through spectroscopic and thermodynamic measurements.

Fermi and Bose polarons in ultracold gases: universal concepts and key differences

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Impurities immersed in a quantum bath form quasiparticles called polarons. I will start revising the properties of dilute impurities in a Fermi sea, which are by now fairly well understood. Then I will switch to impurities in a dilute BEC, where the absence of Pauli blocking favours correlations between the impurity and multiple excitations in the medium, making their description particularly complex. I will present some general and exact thermodynamic relations, and I will discuss the Gross-Pitaevskii description of Bose polarons, which permits to characterize self-consistently heavy impurities surrounded by large dressing clouds.

- [1] "Polarons in atomic gases and two-dimensional semiconductors", P. Massignan, R. Schmidt, G.E. Astrakharchik, A. Imamoglu, M. Zwierlein, J.J. Arlt, and G.M. Bruun, arXiv:2501.09618 (long review paper, to be published in Rev. Mod. Phys.)

Lattice Bose polarons at strong coupling and quantum criticality

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We study the physics of an impurity confined in a lattice coupled to a Bose-Hubbard bath at zero temperature. Within the Quantum Gutzwiller formalism [1], we develop a beyond-Fröhlich model of the bath-impurity interaction. Results for the properties of the polaronic quasiparticle due to the dressing of the impurity by quantum fluctuations of the bath are presented throughout the entire phase diagram, focusing on the quantum phase transition between the superfluid and Mott insulating phases [2]. In the case of strong bath-impurity interaction we develop a new diagrammatic approach based on the quantum Gutzwiller Hamiltonian and the results for the ground state energy is benchmarked via Quantum Monte-Carlo (QMC) calculations [3]. We find that the modification of the impurity properties is highly sensitive to the presence of the Mott-Superfluid phase transition. A final short discussion on the dephasing model across the Mott-superfluid phase transition [4] should emphasize the role of an impurity as an unambiguous probe of the quantum criticality of the manybody environment.

- [1] F. Caleffi, M. Capone, C. Menotti, I. Carusotto, A. Recati, *Phys. Rev. Research* 2, 033276 (2020).
- [2] V. Colussi, F. Caleffi, C. Menotti, A. Recati, *Phys. Rev. Lett.* 130, 173002 (2023).
- [3] R. Alhyder, V. E. Colussi, M. Čufar, J. Brand, A. Recati, G. M. Bruun, *SciPost Phys.* 19, 002 (2025).
- [4] F. Caleffi, M. Capone, I. de Vega and A. Recati, *New J. Phys.* 23 033018 (2021)

Anderson localization in a disorder-free atomic mixture

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Anderson localization – the halt of quantum transport in a strongly disordered potential – has been observed for quantum gases in optical potentials. An important stage of experiments is the creation and characterization of the optical (speckle) potential that typically features nontrivial correlations complicating the interpretation of measurements. We realize an alternative route towards Anderson localization of cold atoms using a mixture of two strongly mass-imbalanced atomic species without any externally imposed disordered potential [1]. On short time scales, the heavy component can be considered immobile and creates a quasi-static scattering potential for the light component that experiences Anderson localization under appropriate conditions. Experimental results allow for a quantitative description based on the model of randomly distributed resonant point scatterers. This demonstrates an interesting and fruitful link between the phenomenon of (single-particle) Anderson localization and the so-called many-body localization that takes place in interacting quantum systems composed of many particles, which is the case of our experimental system.

[1]. S. Finelli, B. Restivo, A. Ciamei, A. Trenkwalder, M. Inguscio, D.S. Petrov, S.E. Skipetrov, M. Zaccanti, Anomalous diffusion and localization in a disorder-free atomic mixture, <https://doi.org/10.48550/arXiv.2601.13226>

Novel theoretical approaches to the Fermi polaron problem

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In this talk, I will present our recent work on developing a unified theory that connects the quasiparticle picture of Fermi polarons for mobile impurities to the Anderson orthogonality catastrophe for static impurities. By operator reordering of the underlying many-body Hamiltonian, we obtain a modified fermionic dispersion relation that features a recoil-induced energy gap, which we call the “mass gap.” We show that the resulting mean-field Hamiltonian exhibits an in-gap state for finite impurity mass, which takes a key role in Fermi polaron and molecule formation. We identify the mass gap as the microscopic origin of the quasiparticle weight of Fermi polarons and derive a power-law scaling of the weight with the impurity-to-fermion mass ratio. The associated in-gap state is shown to give rise to the emergence of the polaron-to-molecule transition away from the limiting case of the Anderson orthogonality catastrophe in which the transition is absent. I will then present further extensions to the theory that allows to describe Fermi polaron formation at arbitrary mass imbalance beyond state-of-the-art precision.

Polarons with nonlinear and long-range interactions with the bosonic bath

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This conference brings together two communities - solid state polarons and impurities in (superfluid) quantum gases. Mirroring this, my lecture will be split between reporting the results that we recently obtained for solid state polarons with nonlinear interactions on the one hand, and results we obtained for impurities with long-range interactions in quantum gases on the other hand. To bridge these two topics I will start with briefly reviewing the original polaron problem, indicating some open questions that still exist and directions in which the polaron problem can be generalized. One of these directions consists of taking into account nonlinearity in the electron-phonon interaction. Often these effects are negligible, but I will argue that in several materials of current technological importance the effects of nonlinear electron-phonon interaction matter. Impurities in quantum gases have inspired this progress in solid state polaron physics, but to be better at quantum simulating the polaron, it is important to consider longer-range interactions between the impurity and the atoms, such as ion-atom or dipolar interactions. This brings me to the second part of the talk, where I present our recent work on optical absorption of ionic impurities in a condensate, and of impurities in a dipolar gas across the transition between superfluid and supersolid. Here I will show that the polaron optical absorption could be used to measure the two goldstone modes related to the two broken symmetries of the supersolid.

Forming a bound state in the continuum by interference of Floquet-Feshbach resonances

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ABSTRACT

Open quantum systems are exposed to their environment, leading to dissipation and loss that limit control and coherence. This impacts specifically impurities coupled to many-body systems in quantum information processing, sensing or simulation.

In my talk, I show how we use tight control of scattering resonances to suppress this coupling to the environment via destructive interference, realizing a long-sought quantum mechanical bound state in the continuum. Using Floquet engineering in an ultracold atomic gas, we coherently couple two tunable Feshbach resonances and induce an avoided crossing. At a critical parameter point, all coupling to the continuum vanishes, yielding a molecular state above the dissociation threshold. Loss spectroscopy, quench dynamics, and rf-photoassociation directly reveal suppressed decay and vanishing overlap with scattering states. Full coupled-channel calculations and a minimal non-Hermitian model quantitatively capture the observations, identifying a Friedrich-Wintgen bound state in the continuum. Our results establish quantum interference as a tool for controlling openness and engineering non-Hermitian Hamiltonians.

