Booklet of invited talks including abstracts sorted chronologically

Tom Bienaimé, Université de Strasbourg and CNRS, France
Quantum Fluids of Light: from warm atomic vapors to cold Rydberg gases
Location: Stätzerhorn, Time: 13.30 -14.10

In the paraxial approximation, light propagating through atomic media acquires an effective mass and tunable photon-photon interactions, enabling fluid-like behavior. Recent experiments in warm atomic vapors have revealed the quasiparticle excitation spectrum, photon precondensation, dispersive shock waves, vortex generation, and Sakharov oscillations following interaction quenches.
While warm atomic vapors provide only moderate photon-photon interaction strengths, Rydberg electromagnetically induced transparency in cold atomic gases enables interactions enhanced by several orders of magnitude through the combined effects of slow light and cooperative atomic dynamics. This regime provides a promising platform for exploring strongly correlated states of light, where a full quantum-field description is required. Moreover, the nonlocal and long-range nature of these interactions enables photonic analogs of modulation instability and crystallization.

Grazia Raciti, University Basel, Switzerland
Phonon Metrology by pump-probe spectroscopy
Location: Stätzerhorn, Time: 14.35 -15.15

Improving the performance of semiconductor devices requires a deep understanding of microscopic energy transfer mechanisms occurring on picosecond or even femtosecond timescales [1]. Pump-probe spectroscopy is a powerful method to investigate carrier and phonon dynamics in materials [2]. In these experiments, an ultrafast pump pulse excites the system, while a time-delayed probe pulse monitors the sample response after excitation, with a temporal resolution limited only by the laser pulse duration.

We present a pump-probe setup capable of performing both transient reflectivity (TR) and time-resolved Raman spectroscopy (TRRS), providing complementary insights into the energy flow between charge carriers and lattice. While reflectivity measurements track changes in the reflected probe intensity induced by the pump excitation, TRRS can directly probe the evolution of active Raman optical phonon modes after the pump pulse excitation.

We apply this approach to investigate energy relaxation in semiconductor systems. In bulk Germanium, we observe that the temperature, Raman frequency and linewidth of the phonon mode show completely different decay dynamics. We attributed these differences to the thermal strain induced by the pump excitation. We also observe Brillouin oscillations, arising from the strain pulse propagating through the Ge, whose damping rate matches the one of the Raman broadening. These findings are supported by density functional theory and molecular dynamics simulations. We extend this study to nanostructures, such as Ge/SiGe quantum wells and atomically thin materials as graphene, showing how reduced dimensionality and interfaces affects carrier-phonon interactions.

We demonstrate that the combination of TR and TRRS techniques offers deeper insight into the different dynamic processes occurring in the material systems. This knowledge is relevant for the development of optoelectronic, thermoelectric, and quantum technologies.

References

[1] A. Othonos, “Probing ultrafast carrier and phonon dynamics in semiconductors,” Journal of Applied Physics, 1998.

[2] Maiuri et al., “Ultrafast Spectroscopy: State of the Art and Open Challenges,” J. Am. Chem. Soc., 2020.

Tomas Wellens, Fraunhofer IAF, Germany
Discrete adiabatic quantum optimization
Location: Stätzerhorn, Time: 15.15 -15.55

The quantum approximate optimization algorithm (QAOA) has been suggested as a promising candidate for the solution of combinatorial optimization problems. Yet, whether — or under what conditions — it may offer an advantage compared with classical algorithms remains to be proven. Using the standard variational form of QAOA requires a high number of circuit parameters that have to be optimized at a sufficiently large depth, which constitutes a bottleneck for achieving a potential scaling advantage. The linear-ramp QAOA has been proposed to address this issue, as it relies on only two parameters that have to be optimized. Based on this, we develop a method to estimate suitable values for those parameters through extrapolation, starting from smaller Problem sizes (number of qubits) toward larger problem sizes.We apply this method to several use cases, such as portfolio optimization, feature selection, clustering, and weighted maxcut. From results obtained on a noiseless Quantum emulator, we evaluate the quantum runtime scaling for finding the optimal solution and compare it with that of classical methods. In the case of portfolio optimization, we demonstrate superior scaling compared with the classical runtime for the problem sizes of up to 28 qubits that we consider in this work.

Floris Braakman, University Basel, Switzerland
Imaging of Nanomagnetism, Quantum Transport, and Beyond
Location: Stätzerhorn, Time: 09.00 -09.40

Bernd v. Issendorf, Universität Freiburg, Germany

Dissipation induced semiclassical photoemission from simple metal clusters

Location: Stätzerhorn, Time: 09.40 -10.20

Photoemission is an archetypical quantum effect, which often can be described surprisingly well in terms of effective single particle initial and final states. Nevertheless the emission from a multi-electron system involves many-particle dynamics with a pletora of possible final states, which can render a detailed theoretical description rather difficult.

It is therefore desirable to study such effects on well defined finite size Fermi system. Simple metal clusters are ideal model systems in this respect, as they can be relatively well described as spherical box potentials filled with a well defined number of electrons. Photoelectron spectra of cluster can be well interpreted in terms of approximate angular momentum eigenstates of the electrons, that is Eigenstates of the box potential. Here we show that the photoelectron angular distributions of sodium, silver and copper clusters show a universal behavior which is not at all in accordance with a simple particle-in-a-box behavior exhibiting strong interference effects, but is instead in very good with a simple semiclassical model based on electrons circulating within the cluster with a given angular momentum and retaining their linear momentum upon emission. The same results can be obtained in a full quantum treatment if the cluster is assumed to be intransparent for photoelectrons, that is if interference between electron partial wave emitted from opposite sides of the cluster is suppressed. This is therefore an example of a system where multi-particle dynamics suppresses interference and leads to a rather classical behavior of a system with a radius comparable to the Fermi wavelength of the electron.

Tomasz Smolenski, University Basel, Switzerland
Optical control over correlated phases of matter
Location: Stätzerhorn, Time: 11.00 -11.40

Controlling strongly correlated electronic phases at the nanoscale is a key challenge in modern physics. Recently, van der Waals (vdW) heterostructures consisting of mono- or bilayers of transition metal dichalcogenides (TMDs) have emerged as a breakthrough platform for exploring this frontier. With their flat electronic bands and gate tunability, these materials host a variety of intertwined collective phases, such as ferromagnets, correlated insulators, and superconductors, whose properties can not only be detected but also controlled with light.

In this talk, I will review our recent ultra-low-temperature optical experiments focused on the control of correlated electronic phases in gate-tunable TMD-based heterostructures. In the first part, I will demonstrate that strong interactions between elementary optical excitations — excitons — and electrons forming a Wigner crystal in lead to the formation of Wigner polarons [1]. These novel light-matter excitations not only enable optical sensing of the Wigner crystal lattice, but also provide access to its collective excitations. In the second part, I will discuss our experiments on the dynamical control of correlated ferromagnets hosted by topological Chern bands in twisted MoTe2 bilayers [2]. In particular, I will show that we can create spatially reconfigurable magnetic domains with light, paving the way for the all-optical generation of topological Chern junctions.

[1] L. Wang, F. Menzel, F. Pichler, (…), and T. Smolenski, arXiv:2512.16552 (2025).
[2] O. Huber, (…), and T. Smolenski, Nature 649, 1153 (2026)

Valeri Kozin, University Basel, Switzerland
Cavity-Induced Phenomena in Various Dimensions
Location: Stätzerhorn, Time: 11.40 -12.20

I will discuss several unconventional manifestations of light-matter interactions in quantum many-body systems. First, I will show how cavity-mediated interactions can drive collective ordering and generate macroscopic quantum superposition states in arrays of semiconductor quantum dots. I will then discuss cavity-enhanced superconductivity arising from photon-induced modifications of electronic dynamics beyond conventional weak-coupling scenarios. Finally, I will present a mechanism for cavity-induced Schottky anomalies in double quantum wells, where emergent low-energy degrees of freedom produce pronounced thermodynamic signatures. Together, these examples illustrate how collective quantum phenomena can emerge from the interplay of interactions, confinement, and coupling to quantized electromagnetic fields.

Alvaro Mitchell Galvão de Melo, University Basel, Switzerland
non-reciprocal interactions between a mechanical oscillator and an atomic spin system
Location: Stätzerhorn, Time: 12.20 -13.00

Non-reciprocal interactions violate the action-reaction symmetry of Newton's third law, giving rise to phenomena such as amplification, synchronization, and spontaneous parity-time symmetry breaking. In quantum systems, non-reciprocal interactions have recently attracted significant interest as a new tool to engineer functionality, with potential for sensing and signal processing applications. Here we report experiments on non-reciprocal interactions in a hybrid mechanical-atomic system coupled by light. We observe spontaneous coupled oscillations, two-mode squeezing dynamics and limit cycle oscillations.

Gabriel Dufour, Universität Freiburg, Germany
Totally destructive many-body interference, beyond bosons and fermions
Location: Stätzerhorn, Time: 10.00 - 10.40

The suppression of coincidence events in the Hong-Ou-Mandel experiment is a striking example of totally destructive many-body interference of two bosons. Similar effects have been described for greater numbers of bosons or fermions in larger interferometers. Here, we predict suppressions of certain outputs of a Fourier interferometer when the many-body state transforms under a specific irreducible representation of the symmetric group of particle permutations, which need not be bosonic or fermionic.

Christoph Dittel, Universität Freiburg, Germany
Quantum Coherence and Interference in Attosecond Photoionization
Location: Stätzerhorn, Time: 10.40 - 11.20

Interference and coherence are defining features of quantum mechanics, linking wave-like superpositions to particle-like detection statistics. In this talk, I explore how these features manifest in attosecond photoionization, providing access to quantum coherence on the timescale of electron motion. I discuss how single-electron interference enables quantum-state tomography of photoelectron states in the continuum and provides new opportunities to probe electronic correlations in ultrafast dynamics. I further investigate interference between two photoelectrons, examining how exchange antisymmetry and Coulomb repulsion shape the joint detection statistics of indistinguishable electrons. Together, these studies demonstrate how quantum interference serves both as a sensitive probe of ultrafast electron dynamics and as a powerful resource for revealing correlations in complex quantum systems.

Guido Pupillo, University of Strasbourg and CNRS, France
Towards fault tolerant quantum computing with neutral atoms
Location: Stätzerhorn, Time: 11.20 - 12.00

Neutral atoms have emerged as a leading platform for digital quantum simulations and quantum computing, with present-day systems surpassing a thousand qubits and achieving gate fidelities at the 99.9% level. As the field transitions toward scalable, fault-tolerant quantum computing, robust quantum error correction becomes increasingly important. In this talk, I will describe recent work developing architectures for efficient quantum error correction tailored to Rydberg-atom arrays. I will present new ideas and codes for performing error correction, highlighting conditions under which the latter offer advantages over conventional schemes. One example is low-density parity-check codes that can encode more information and protect better from physical errors with respect to conventional surface codes. Both challenges and new ideas for performing error-corrected logical quantum computation within this framework are discussed.