SEL2025

9th INTERNATIONAL SUMMER SCHOOL

Son et Lumière

18 - 29 August 2025

Banyuls-sur-Mer, France

BOOK OF ABSTRACTS

The Summer School 'Son et Lumière' provides in-depth training across fundamental concepts and experimental techniques for the next generation of researchers and scientists. We believe that the informal school atmosphere and beautiful environment, which always accompany the school's scientific program, facilitate networking and promote international and inter-generational communication.

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Topics covered by the school in 2025:

- Laser Ultrasound / Non-destructive testing
- Monitoring of transient processes (chemical reaction, phase transitions)
- Bio sensing/cells
- Inelastic scattering of light by phonons (Brillouin/Raman scattering)
- Fourier Spectroscopy
- Time-resolved X-ray diffraction
- THz spectroscopy and techniques
- Quantum opto- & nanomechanics
- Polaritons/HF Optomechanics
- Collective excitations (strong coupling) / Magnetism
- Dispersion engineering/phononic crystals
- Surface acoustic waves
- 2D (vdW) materials/arrays/Moire
- Extreme conditions
- Thermal transport
- Non-reciprocity and topological acoustics
- Tip-assisted light-matter interaction at the nanoscale (TERS, nanoFTIR, SNOM)

Son et Lumière 2025

We are delighted to welcome you to the 9th edition of the CNRS thematic school Son et Lumière, taking place from August 18 to 29, 2025, at the Observatoire Océanologique in Banyuls-sur-Mer, France.

This summer school continues a series launched in 2006, aiming to explore the fundamental and applied aspects of interactions between electromagnetic waves (light), elastic waves (sound), and other elementary excitations such as charge carriers, spins, and phonons. These couplings play a central role in many modern fields of condensed matter physics and underpin numerous advances in materials science, photonics, spintronics, optomechanics, and bio-imaging.

One of the unique aspects of Son et Lumière is its strongly interdisciplinary nature, which brings together researchers from physics, materials science, engineering, and biology, fostering a rich scientific dialogue. This year's program reflects this diversity, with a selection of lectures on emerging and interdisciplinary topics (see the full list in the Program). Lectures will be given by internationally renowned scientists in their respective fields. The scientific program also includes two poster sessions, open discussions, and informal opportunities for participants to interact with experts and peers in a relaxed and collaborative environment.

This Book of Abstracts gathers the summaries of all invited lectures and the abstracts submitted by poster presenters. It is intended to serve both as a guide during the school and as a reference for future exchanges and collaborations.

A key objective of this school series is also to support the next generation of scientists by facilitating access through low registration fees and travel grants. Thanks to the support of our institutional and industrial partners (see Sponsor List) and discussions with the school scientific committee, we are able to offer a stimulating and inclusive scientific event open to students and researchers from diverse backgrounds, including strong participation from both France and Germany in the framework of the support we received for this edition from the Université Franco-Allemande/Deutsch-Französische Hochschule (UFA/DFH).

We warmly thank all participants for their involvement, and all speakers and sponsors for their commitment to making this event a success. We wish you an inspiring and enriching experience during these two weeks in Banyuls-sur-Mer.

With our best regards,
Samuel Raetz and Alexey Scherbakov
Co-chairs of Son et Lumière 2025
On behalf of the organizing committee.

PROGRAM

Week 1: 18-23 August 2025

	Monday 18.08	Tuesday 19.08	Wednesday 20.08	Thursday 21.08	Friday 22.08	Saturday 23.08
7:00–8:30	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast
9:00	Arrival	**Vitalyi Gusev**	**Alexei Maznev**	**Silvia Boccato**	**Vassos Achilleos**	**Rainer Hillenbrand**
10:00		Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break
11:00		**Vitalyi Gusev**	**Alexei Maznev**	**Silvia Boccato**	**Vassos Achilleos**	**Rainer Hillenbrand**
12:00–13:00	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch
13:00–14:00	Arrival	Free time	Free time	Free time	Free time	Free time
14:00	**Opening**					
15:00	**Alexey Kimel**			**Keith Nelson**		**Excursion**
16:00	Coffee Break	**Matias Bargheer**	**Andrei Kirilyuk**	Coffee Break	**Rémy Braive**	
17:00	**Alexey Kimel**	Coffee Break	Coffee Break	**Keith Nelson**	Coffee Break	
18:00	**Happy Time**	**Matias Bargheer**	**Andrei Kirilyuk**	**Dinner & Poster session A**	**Rémy Braive**	
19:00–20:00	Dinner	Dinner	Dinner		Dinner	**Dinner & Animation**
20:00–21:00				**Poster session A** discussion		
22:00						

PROGRAM

Week 2: 24-29 August 2025

	Sunday 24.08	Monday 25.08	Tuesday 26.08	Wednesday 27.08	Thursday 28.08	Friday 29.08
7:00						
8:00	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast
9:00	Free time	**Andrea Bragas**	**Oliver Wright**	**Wenqi Li**	**Ivan Pelivanov**	**Alex Fainstein**
10:00		Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break
11:00		**Andrea Bragas**	**Oliver Wright**	**Wenqi Li**	**Ivan Pelivanov**	**Alex Fainstein**
12:00	Lunch					
13:00		Lunch	Lunch	Lunch	Lunch	Lunch
14:00	Free time	Free time	Free time	Free time	Free time	Departure
15:00				**Thomas Dehoux**	**Workshop & Round table discussion**	
16:00		**Theodosia Stratoudaki**	**Klaas-Jan Tielrooij**	Coffee Break		
17:00		Coffee Break	Coffee Break	**Thomas Dehoux**		
18:00		**Theodosia Stratoudaki**	**Klaas-Jan Tielrooij**		Free time	
19:00	Dinner	Dinner	Dinner	**Dinner & Poster session B**	Dinner	
20:00						
21:00				**Poster session B** discussion		
22:00						

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Photo-ferroic recording: from thermodynamics to terra incognita beyond the conventional approximation

Alexey Kimel

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The ability to switch ferroics (ferro-, ferri-, antiferromagnets, ferroelectrics, multiferroics) between two stable bit states is one of the keystones of modern data storage technology. Due to many new ideas, originating from fundamental research during the last 50 years, this technology has developed in a breath-taking fashion. Finding a conceptually new way to control ferroic state of a medium with the lowest possible production of heat and at the fastest possible timescale is a new challenge in fundamental condensed matter research. Controlling ferroic state of media by light is a promising approach to this problem as laser pulse is the shortest stimulus in contemporary experimental physics of condensed matter [1]. In the lecture, I will start reviewing the basics approximations allowing to describe photo-ferroic recording in terms of thermodynamics. Afterwards I will show that ultrashort (sub-100 ps) stimuli push magnetic media into a strongly non-equilibrium state, where the conventional description of ferroic phenomena in terms of equilibrium thermodynamics fail and the experimentally observed ultrafast dynamics challenge the current theories. For instance, while conventionally accepted Curie-Neumann's principle states that "the symmetries of the causes are to be found in the effects" [2], in ultrafast magnetism this principle fails, and magnetization dynamics becomes counter-intuitive. We will demonstrate that ultrafast (sub-100 ps) heating with the help of ultrashort laser pulses causes magnetization reversal without any magnetic fields [3], laser-induced spin dynamics is strongly non-linear, where new channels of spin-lattice interaction open-up [4,5], the principle of superposition fails i.e. 1+1>2 [6] and the approximation of macrospin is no longer adequate [7].

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Picosecond laser ultrasonics: Theoretical backgrounds and applications to materials characterization and imaging

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Picosecond laser ultrasonics (PLU) is a pump-probe opto-acousto-optic technique, which uses ultrafast lasers to generate and detect coherent acoustic waves at GHz – THz frequencies and suits well for the diagnostics of nanostructures, imaging of inhomogeneous materials with nanoscale spatial resolution and fundamental studies of interactions of phonons with other constituents of solid state, such as electrical charges, excitons, spins, …

PLU is an extension of laser ultrasonics, a technique based on excitation of acoustic waves in ultrasonic frequency band by lasers, to higher frequencies. In this presentation the required modifications in theoretical description of the involved physical processes and in the optical approaches to generation and detection of the coherent acoustic waves are discussed.

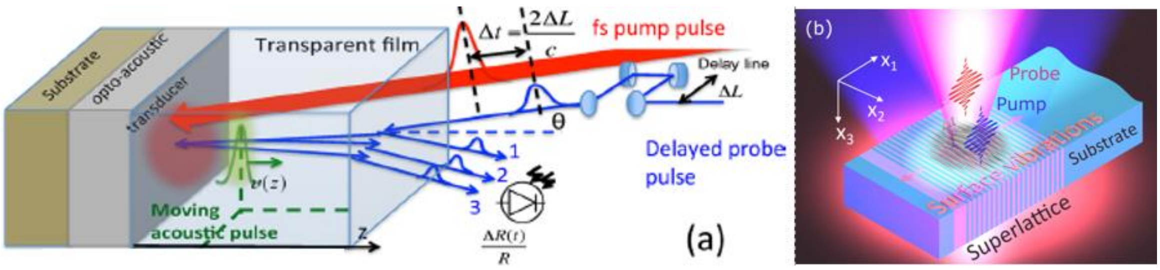

Figure 1. Applications of picosecond laser ultrasonics to imaging of transparent inhomogeneous materials with nanoscale depth resolution (a) and to monitoring of GHz – sub-THz surface and surface skimming coherent acoustic waves

Starting from the pioneering experiments reported about 40 years ago the PLU is applied for all optical monitoring of the wide-frequency-band acoustic echo pulses, detectable in the material layers which are opaque for the probe optical radiation [1, 2], of the so-called Brillouin oscillations, detectable when the coherent acoustic pulses are propagating in the materials transparent for probe optical radiation [2], and of the periodic vibrations of the nanostructures [3]. More recently, the applications of the PLU to monitoring of the coherent surface [4] and Lamb waves [5] in the GHz – sub-THz frequency range and to imaging of inhomogeneous materials with nanometers depth resolution [6 - 8] (Fig. 1 (a)) were started. In this presentation some of the latest examples of the PLU applications in materials imaging and monitoring of the coherent acoustic waves and vibrations (Fig. 1 (b)) will be discussed [9 - 10].

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Picosecond ultrasonics with x-rays: Applications to energy transport and magnetization dynamics

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Picosecond ultrasonics with x-ray probe pulses (PUX) provide unique access to coherent longitudinal acoustic phonons (coherent strain wave packets) and heat transport at the nanoscale (flow of incoherent excitations)[1]. Bragg-peak shifts are especially useful experimental observables in nano-layered systems, where all layers can be simultaneously probed and identified by their Bragg angle. Contemporary laser-based sources of hard x-rays with femtosecond pulse duration have sufficient x-ray flux and stability to analyze the dynamics of films with single-digit nanometer thickness , and large-scale facilities even yield access to nanoparticle dynamics. This lecture will show that Ultrafast X-ray diffraction (UXRD) and extensions to Ultrafast Reciprocal Space Mapping (URSM) are broadly applicable to fundamental physics question and materials science. Wherever possible, all-optical pump-probe data such as time-domain Brillouin scattering, transient reflectivity and transient magneto-optics will be discussed for comparison.[2,3]

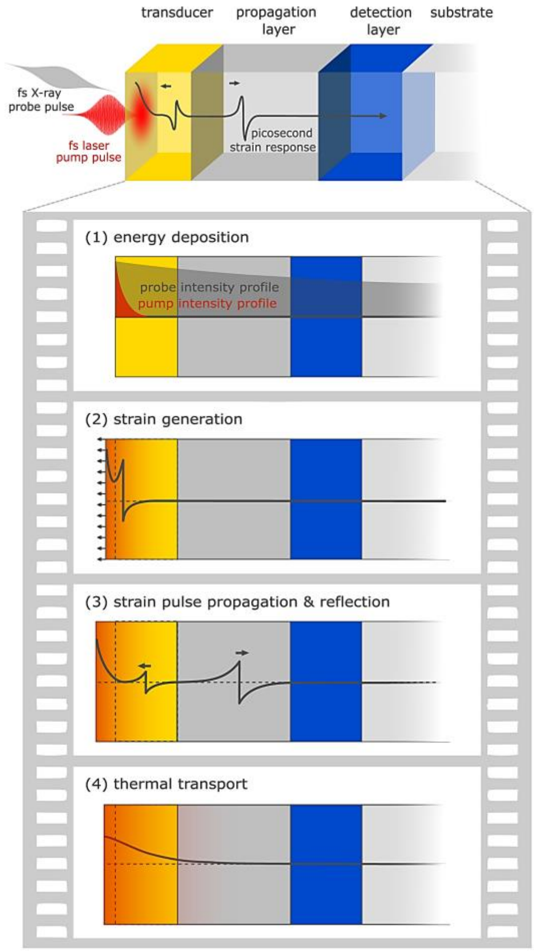

Figure 1. Functional heterostructures are ubiquitous in many realms of science. The schematic shows ultrafast optical excitation of a thin transducer (panel 1), which heats up the material. This leads to a quasi-static expansion (panel 4) on the timescale of heat transport. This strain profile develops only after the ultrashort strain-wave launched by the stress imbalance has propagated through the multilayer, including reflections at the interfaces (panels 2 and 3). Typical PUX experiments probe the transducer, a propagation layer and a detection layer simultaneously by UXRD (panel 1). Modeling the observed strain wave and finally the quasi-static limit yield precise information about the amplitude, phase and timing of the strain wave as well as about thermal transport. The three layers often have functional properties, such as carrying spin waves, transporting electrons or blocking electronic heat transport. Figure reproduced from [1].

The lecture will introduce the techniques of UXRD and URSM by examples, and the standard modeling approaches, e.g. via the open source numerical toolbox udkm1Dsim, will be described. In order to establish a basis of our analysis of ultrafast (non-)thermal expansion, I will discuss the concept of macroscopic Grüneisen-parameters for the electronic, magnetic, and phononic system as well as a thermodynamic framework of thermal expansion.

We will highlight fascinating phenomena such as the counterintuitive localization of heat via dissipation [4], generation and observation of unipolar or inverted bipolar strain waves, nonlinear propagation and damping of strain waves. We shall discuss coupling of strain and heat to magnetization dynamics and magnetic phase transitions [5]. Ultrathin metal superlattices are introduced as a means to transduce large amplitude terahertz strain waves.

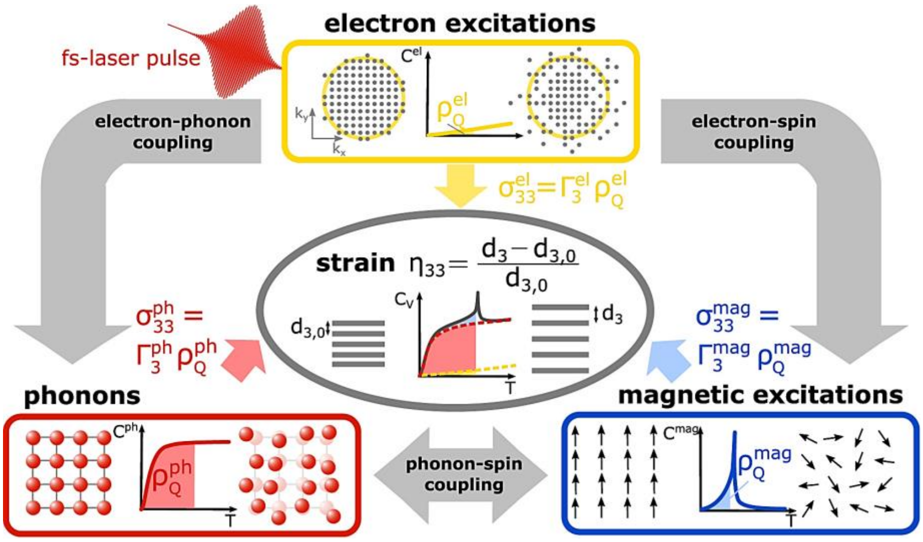

Figure 2. Schematic of the strain actuation by excitation various quasiparticles. We focus on metals with excited electrons, phonons and spins [6]. (Figure reproduced from [1])

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Thermal transport by phonons on micro/nano scale

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In non-metallic solids, heat is predominantly carried by high-frequency sound waves, or phonons. Yet as long as the phonon mean free path (MFP) is much shorter than the characteristic length scale, thermal transport is described by the ubiquitous heat diffusion equation and one does not need to know anything about phonons to solve it. The situation changes dramatically when the phonon MFP becomes comparable to the characteristic length, which can happen either at low temperatures or at the nanoscale. The first observations of size effects in thermal conductivity were made at liquid He temperatures, and for the most part of the 20^{th} century phonon physics was predominantly a low temperature field. In the 21^{st} century, the focus shifted towards nanoscale heat transport at non-cryogenic temperatures. This shift was largely stimulated by practical applications such as thermal management of microelectronic devices and the use of nanostructuring to improve the performance of thermoelectrics, but there are many basic physics problems presenting exciting challenges for both experimentalists and theoreticians.

We will start by reviewing the main concepts in nanoscale thermal transport by phonons and discussing the role of various phonon scattering processes. We will talk about experimental methods, with an emphasis on optical techniques for thermal transport measurements such as time- and frequency-domain thermoreflectance, laser-induced transient gratings, Raman thermometry and time-resolved x-ray diffraction, as well as methods for measuring the phonon MFP involving either thermal phonons (inelastic x-ray and neutron scattering) or laser-excited coherent phonons, and take a look at theoretical analysis tools such as Peierls-Boltzmann transport equation and molecular dynamics simulations. We will review major results obtained in the last two decades in thermal transport involving thin films, nanowires, superlattices, nanostructured membranes and micro/nanoscale heat sources.

In the second unit of the lecture, we will take a closer look at one experimental technique, namely, transient thermal gratings. We will consider experimental aspects and discuss a number of results including size effects in thermal transport in silicon membranes, the break-down of the Fourier law in silicon on the microscale and transition to the ballistic regime on the nanoscale, and second sound in graphite. Particular attention will be given to recent experiments with extreme ultraviolet and x-ray transient gratings conducted at free electron laser facilities. Finally, we will briefly review some very recent important papers in the field and discuss future directions.

Ultrafast switching of magnetic and crystallographic order via phononic resonances

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Vibrations of the crystal lattice have a significant impact on the orbital dynamics of the electrons, and through it, on spins. Recently, ultrafast optical techniques have provided new insights into the coherent coupling of individual phonon and spin modes [1]. Ultrafast excitation of phonons resulting in drastic repopulation of phononic system was even shown to be able to modify the fundamental magnetic interactions [2]. And last but not least, very recently time-resolved X-ray scattering and electron diffraction experiments demonstrated the angular momentum transfer from magnetization to the phonon system, on a femtosecond time scale, dubbed ultrafast Einstein-de-Haas effect [3]. It should therefore be possible to realize the opposite process, by changing the lattice and thus controlling the magnetization, on the same time scale - in femtoseconds!

In view of these developments particularly interesting is the area of **nonlinear phononics** [4]. This technique uses long-wavelength light pulses to resonantly drive infrared-active optical phonons to large amplitudes. As a consequence, the anharmonicities of the crystal lattice result in the modification of the equilibrium state and induce strongly non-equilibrium atomic structures.

Recent experiments have demonstrated the power of this method to produce and control a wide variety of phases [5], including superconductivity, ferroelectricity, and magnetism. The strength of the dynamical structural deformations can even be orders of magnitude larger than those achievable using static techniques. The nonlinear, coherent optical manipulation of the crystal lattice provides unique control, not only in terms of the new functionalities that can be unlocked, but also because of the ultrafast time scales in which they arise, within femto- or picoseconds.

Another, complementary mechanism, are 'phono-magnetic' effects that are the phononic analogue of the opto-magnetic effects [6], where circularly-polarized excitation triggers circular motion of ions, and via this exerts direct magnetic-like force on spins.

Recently, we attempted to follow the nonlinear phononics route to excite the magnetization of garnets [9]. However, instead of using broadband high-repetition rate pulses from a femtosecond difference-frequency source, we applied **single narrow-band pulses** with high pulse energy from a free electron laser. We discovered, for the first time, a complete and permanent switching of magnetic order in ferrimagnetic samples [7], manipulation of antiferromagnetic domains [8], and switching of ferroelectric polarization [9]. Mysteriously, not the frequency of the infrared-active transverse optical (TO) phonon, but rather the longitudinal optical (LO) one, was shown to produce the switching effect in both cases. At normal incidence, such as used in our experiments, the LO phonon mode is not even excited, and thus the nonlinear phononic mechanism is not applicable. We propose that the role of the LO phonon frequency lies in the fact that at this frequency, the real part of the dielectric permittivity ε of the material is equal to zero. The spectral range in the vicinity of this point is named ε-near-zero (eNZ) range in literature [10]. This regime gained a significant attention in the area of nonlinear optics and metamaterials for its unusual behaviour and very strong nonlinear optical effects.

The strongly nonlinear scenario stems from the fact that, in the eNZ regime, the field is spatially slowly varying and thus not characterized by a large number of ”nodes” around which its amplitude is small. In other words, to attain a highly nonlinear response, the eNZ condition drastically increases the physical volume over which the nonlinearity is effective, as opposed to standard approaches that resort to field enhancement or giant nonlinear parameters. As a result, the interplay between the eNZ condition and the optical nonlinearity triggers a novel nonlinear matter-wave coupling that literally unlocks the full potential of the generally weak matter nonlinear response [11].

Changing the polarization of the excitation pulse from linear to circular brings the whole new twist to the problem. Exciting phonons with non-zero angular momentum can result in phono-magnetic effects that drastically exceed their electronic counterparts [12], with real potential for the efficient control of magnetization. This is proven by our very recent experiments applying circularly-polarized infrared pulses to 20 nm-thin GdFeCo films [13]. The helicity-dependence of the switching implies that the lattice vibrations excited in the substrate deliver a directional field that pushes the magnetization towards a switched or non-switched state. This is a stimulus of a totally different kind than discussed above as here not the potential, but the magnetization itself is modified during the pulse. The nature of such directional field is completely unknown at present.

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Picosecond acoustics for the determination of thermo-elastic properties of solids and liquids at high pressure and high temperature

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Picosecond acoustics is a time-resolved optical pump-probe technique used to investigate the propagation of acoustic echoes in a wide range of materials under varying pressure and temperature conditions. This method enables the determination of melting curves, the full set of elastic moduli for single crystals, and longitudinal sound velocities in polycrystalline samples.

I will highlight the significance of these experiments for Earth and high-pressure sciences, providing examples of studies directly relevant to these fields. These include measurements on iron [1] and its alloys [2], metallic liquids [3], diamond as well as hydrogen and deuterium [4]. I will present recent instrumental developments made at the IMPMC that have enabled us to reach the extreme pressure and temperature conditions [5] found in planetary interiors. Finally, I will present our most recent advancements in the determination of thermal conductivity.

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Controlling and monitoring molecular and collective excursions away from equilibrium

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Spectroscopists have long dreamed of exerting fine control over the dynamical motions of molecules and materials as they move away from equilibrium configurations, extending even to far-from-equilibrium excursions that may lead to chemical or physical transformations. In some systems those aspirations can now be realized, and in many others there are tantalizing prospects for extensive control and also incisive monitoring of complex dynamical behavior. Some of the methods ranging from THz to optical to x-ray spectral ranges and their mechanistic underpinnings will be discussed. Multimodal control over multiple, coupled degrees of freedom will unlock new capabilities far beyond the limits of our current dreams and imaginations.

Topology and non-hermiticity in acoustics

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This course introduces the emerging field of topological acoustics [1,2], with a focus on phenomena observable in the audible frequency range. Drawing inspiration from topological phases in condensed matter physics, we will explore how concepts such as Berry phase, topological invariants, and edge states can be applied to acoustic wave propagation. The course will cover theoretical foundations and present some practical implementations in various acoustic configurations. Whenever applicable, examples from optics will also be presented in parallel.

A significant part of the theoretical framework in this course will be built around the Su–Schrieffer–Heeger (SSH) model. Despite its apparent simplicity, this one-dimensional tight-binding model captures the essential ingredients of topological physics, such as bulk-boundary correspondence, topological phase transitions, and the role of symmetry. The SSH model serves as a pedagogical and physically meaningful platform to introduce students to the core ideas of topological band theory, which we will later extend to acoustic systems. Its adaptability to experimental implementations in acoustics makes it especially relevant for understanding how topology manifests in real-world sound propagation. We will also briefly discuss non-Hermitian extensions of the SSH model, which are particularly relevant for acoustics due to the presence of losses and open boundary conditions, and which give rise to novel phenomena such as the non-Hermitian skin effect and complex topological invariants.

We will also take a closer look to a method of mapping discrete topological models into systems of acoustic waveguide networks and some experimental realizations of them [3,4] that have been a subject of research in LAUM for the last couple of years.

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Optomechanical crystals: hybrid devices for applications from quantum physics to metrology

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Optomechanics is the field devoted to the study of interactions between optical and mechanical degrees of freedom. This field emerged in the context of the study of the fundamental processes involved in interferometric measurements, and their implications for the detection of gravitational waves. This booming field allows to investigate innovative concepts taking advantage of the strong interaction between optics and acoustics in microscopic objects are within reach.

The essential effect of the optomechanical coupling is the fact that a mechanical displacement of a cavity induces a change in the state of light confined in it [1]. Such an interaction becomes considerable at micro and nanoscale where the effective mass of the mechanical resonator can be significantly reduced. This is particularly the case in device limited by diffraction such as photonic crystal. Moreover, such device also confines displacement field at the same place as their optical counterpart thus enhancing the coupling. Such devices are now called optomechanical crystal (OMC).

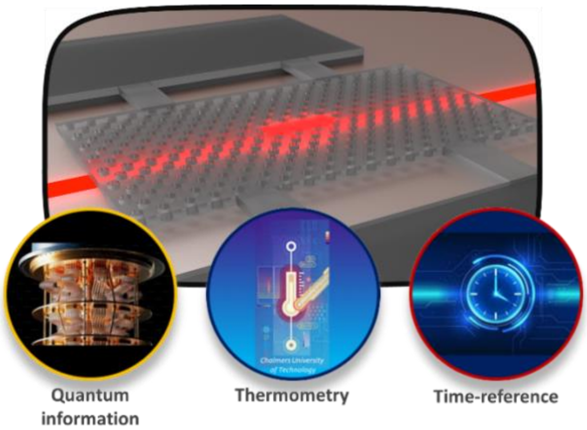

Figure 1. Artistic view of an optomechanical crystal integrated on top of a waveguide for quantum and metrological applications

Potential fields of applications cover on one hand fundamental physics studies, proposing a basis for the applications in quantum information processing, serving as a coherent interface between light and matter qubits [2,3]. Nano-optomechanics is also exploited in metrology for implementing high precision measurements for the optical measurement of temperature; detection of mass, acceleration [4], etc. and the use in microwave photonics for integrated time reference sources [4].

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Optical near-field nanoscopy and nanospectroscopy

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Scattering-type scanning near-field optical microscopy (s-SNOM) and nanoscale Fourier transform infrared spectroscopy (nano-FTIR) represent a transformative advance in modern nanoanalytics. These techniques enable chemical identification of both organic and inorganic materials, mapping of protein secondary structures, profiling of free carriers in semiconductors, and visualization of polaritons in two-dimensional (2D) materials such as graphene and hexagonal boron nitride (h-BN)—all with an impressive spatial resolution around 20 nm [1].

Both s-SNOM and nano-FTIR rely on elastic light scattering at the apex of an atomic force microscope (AFM) tip, typically illuminated by monochromatic or broadband laser sources. Acting as a nanoscale optical antenna, the tip concentrates the incident light into a highly localized near field—referred to as a nanofocus—at the tip apex. This intense near field enables local excitation of molecular vibrations, plasmons, or phonons at the sample surface, and their response becomes encoded in the tip-scattered field for subsequent detection and analysis.

By recording the tip-scattered field as a function of sample position under monochromatic illumination, one obtains images with nanoscale resolution in the broad spectral range between visible and terahertz frequencies. When using broadband illumination, Fourier-transform spectroscopy of the scattered signal enables nanoscale spectroscopy and hyperspectral nanoimaging.

In this lecture, I will introduce the fundamental principles of these microscopy techniques and highlight their applications in materials sciences and polaritonics.

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Acousto-plasmonics & optically driven surface-acoustic waves (SAWs)

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Plasmonic nanoantennas, typically made of noble metals, have emerged as promising platforms for integrating optical and mechanical functionalities at the nanoscale [1]. When a femtosecond laser pulse excites the conduction electrons, their rapid thermalization with the lattice launches coherent acoustic phonons whose frequencies, f, set mainly by the antenna shape and dimensions, span 1–100 GHz [1,2]. A delayed probe pulse in a pump-probe geometry reads these vibrations through acousto-plasmonic modulation of the optical response, granting single-antenna access to picometre displacements with µeV spectral precision [2,3]. Over the past decade and a half, this ultrafast nanophononic toolbox, which has expanded from plasmonic to high-index dielectric nanostructures [4], has evolved from a purely spectroscopic approach into a proposal for chip-scale surface acoustic wave (SAW) technology. Optically driven nanoantennas emit Rayleigh waves that propagate tens of microns [5], can be focused down to several hundred nanometers by a nanoantenna hypersonic lens [6], and reconverted to light in remote receivers, thereby realizing photon-phonon transduction lines [7]. Elastic coupling between neighboring antennas gives rise to molecular-style vibrational hybridization and, at room temperature, GHz-strength mode splitting [3,8]. Mechanical coherence, quantified by the quality factor Q, is controlled by internal losses, vibrational symmetry, substrate nature and anchoring, adhesion layers, and temperature. For instance, while polycrystalline lithographic gold plateaus at a Q of a few tens [9], aspect-ratio tuning and porous supports boost the Q to higher values [10], and low temperatures may push it above 100 [11].

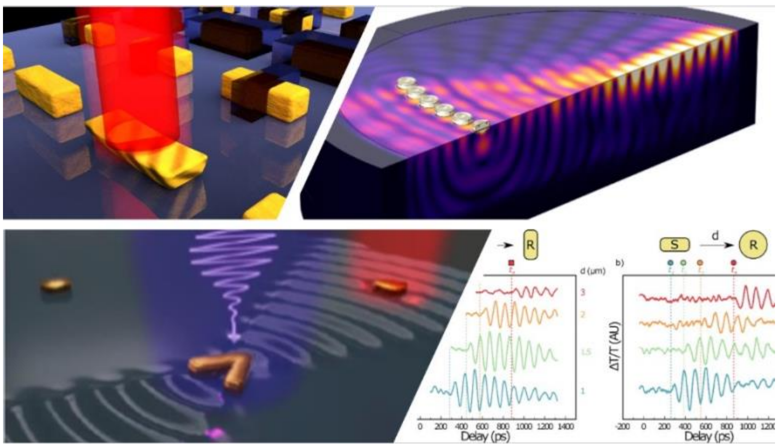

Figure 1. Ultrafast acousto-plasmonic landscape. Schematic overview of plasmonic and dielectric mechanical nanoresonators, hypersound at the nanoscale, optically-driven surface acoustic waves (SAW), controlled directionality, and focusing.

These advances have unlocked quantitative nanometrology [12] and enabled the development of the first photonic circuit with an integrated nanoantenna-driven Mach–Zehnder SAW modulator [13]. Bringing these strands together, the lecture will guide participants from the study of the thermo-elastic source term and mode asignemet through SAW generation and its focusing, to device-level applications in RF photonics, highlighting open challenges such as achieving $f \cdot Q > 6 \times 10^{12}$ Hz for quantum-coherent room-temperature operation and extending control beyond 100 GHz.

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Ultrasonic phased array engineering using light for non-destructive evaluation

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Ultrasound is a powerful, cost effective and safe technique and these characteristics have made it the most commonly used imaging modality for medical and industrial applications when it comes to imaging beyond what lies on the surface. The impact of ultrasound imaging in our society has been made possible because of the technological advancements in ultrasonic equipment: transducer materials, electronics, signal generators and computational capabilities are at the heart of all ultrasonic imaging achievements. Consequently, it is no wonder that aspects of ultrasonic imaging such as data acquisition and signal processing methods have been developed to conform with the available instrumentation capabilities, which are transducer-based ultrasonic phased arrays in their vast majority. In short, our capabilities and limitations in phased array imaging are defined by the available instrumentation. My talk will introduce another side of thinking: how would the world of ultrasonic phased array imaging be if the ultrasonic instrumentation were different? An alternative array technology to transducer-based arrays is Laser Induced Phased Arrays (LIPAs), where ultrasound is generated and detected by lasers and the array is produced by scanning a single generation and a single detection laser independently of each other [1]. Utilizing such an acquisition method allows for changing the array parameters, such as number of elements and their position, thus prototyping and experimentally evaluating different array designs can be done fast [2-3]. My talk will present examples of ultrasonic array designs using LIPAs in 1D and 2D geometries, advantages and limitations as well as industrial applications of this technology for non-destructive evaluation.

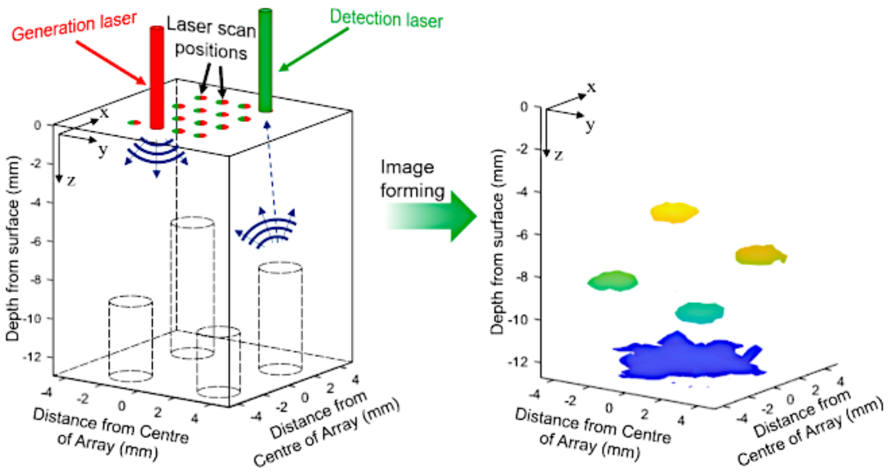

Figure 1. Volumetric Imaging using 2D Laser Induced Phased Arrays. (Left) schematic representation of the experimental data acquisition. (Right) experimental volumetric image using the total focusing method imaging algorithm and shear-longitudinal wave arrival, from 16x16 element 2D LIPA on an aluminium sample with 4 flat bottom holes (2 mm diam.) at various depths. Figure reproduced from [3].

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Bringing sound waves to life on surfaces: Exploring crystals, phononic crystals, waveguides, nanorod arrays, metamaterials, and cavities

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I present work on laser-based GHz acoustic waves, encompassing: (1) experiments and theory for bulk wave generation and detection; (2) imaging studies of surface waves in crystals, phononic crystals, waveguides, metamaterials, and cavities, as well as experiments on nanoscale plasmonic structures interacting with surface acoustic waves.

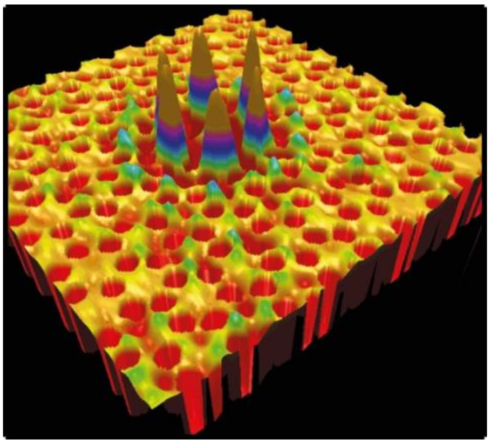

Figure 1. Experimental time-resolved image of the acoustic field at 6.9 ns after excitation in the center of a microscopic phononic crystal cavity. This 3D rendering made by combining out-of-plane surface velocity and reflected probe intensity fields.

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Phononics and photonics in 2D materials

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After a brief introduction to 2D layered materials, in particular semi-metallic graphene, semiconducting transition metal dichalcogenides (TMDs), topological insulators, MXenes, and (twisted) Van der Waals stacks, we will look deeper into the properties of these materials that are related to heat (phononics) and light (photonics). We will also discuss phenomena that lie at the intersections between phononics, photonics and electronics – where heat, light, and charge meet. Examples are optothermal, optoelectronic, and thermoelectric phenomena. We will also discuss a range of (ultrafast) experimental techniques that can be used to study these material properties and physical phenomena.

The second part will focus on recent studies related to phonons, photons, and electrons in 2D layered materials, metamaterials, and stacks, see Figure 1.

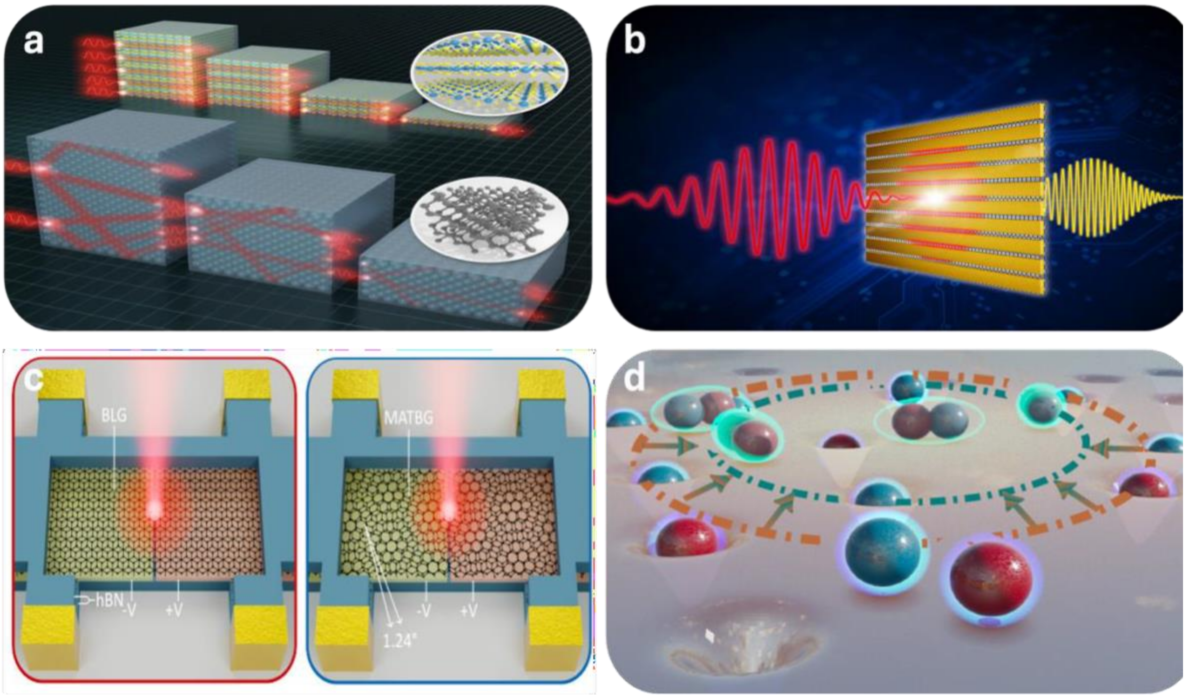

Figure 1. a) Thermal transport in TMDs (as compared to silicon), studied using a range of optothermal techniques, including a recently developed spatiotemporal pump-probe technique [1- 4]. **b)** Terahertz nonlinear photonics, exploiting the ultrafast thermodynamic properties of graphene and topological [5-9]. **c)** Ultrafast hot carrier cooling in photodetector devices based on normal bilayer graphene and twisted bilayer graphene near the magic angle [10]. **d)** Ultrafast spatiotemporal transport dynamics in TMDs, with an interplay between charges, excitons and defects [11].

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Spatially resolved acoustic spectroscopy imaging: utilizing the link between acoustic wave velocity, crystal orientation and elastic constants

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Spatially Resolved Acoustic Spectroscopy (SRAS) is an acoustic microscopy technique capable of imaging the microstructure of materials. By combining multiple measurements with theoretical predictions of surface acoustic wave (SAW) velocities, SRAS can determine the crystallographic orientation of individual grains [1]. More recently, the technique has been further extended to enable the determination of the single-crystal elasticity of a material.

This lecture will introduce the fundamentals of SRAS, focusing on its applications in grain imaging across a variety of prepared and industrially relevant surface finishes [2]. The technique operates by measuring the velocity of SAWs through the acoustic spectrum. These waves are generated by a patterned pulsed laser using a grating and are detected by another continuous wave laser at a nearby point. Measuring the velocity via the acoustic spectrum, rather than time-of-flight, offers several practical advantages, including enhanced robustness, faster processing, and superior spatial resolution. Combining the measurements with forward models that calculate the expected SAW velocities, SRAS can determine the crystallographic orientation of grains for a wide range of crystal symmetries, including cubic, hexagonal, and tetragonal systems. This lecture will showcase results across these symmetries and highlight recent advancements that enable the determination of single-crystal elasticity matrices [3]. The lecture will conclude with a discussion of future applications, including the potential for real-time monitoring of material processes.

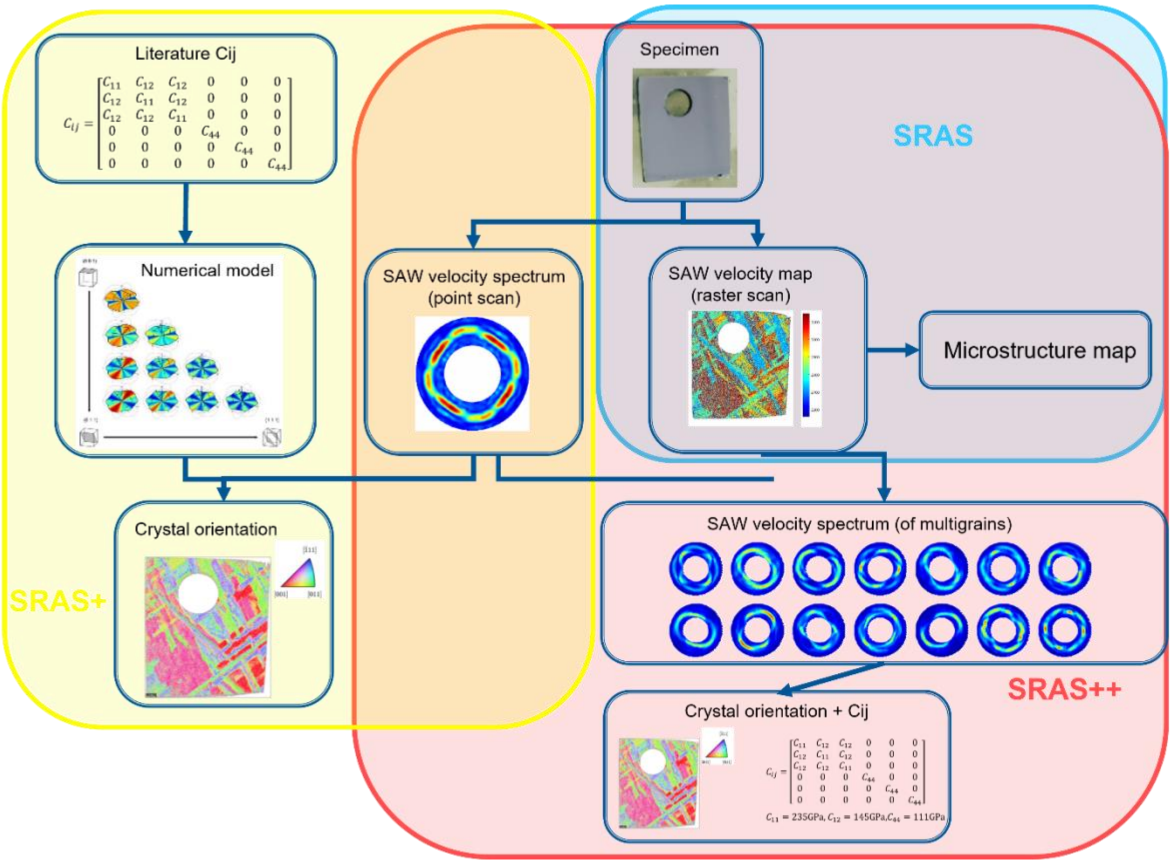

Figure 1. SRAS technique-based applications illustration.

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Brillouin light scattering for biology

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It is key to understand how cells and tissues respond to mechanical stimuli. Such cues include the stiffness of the environment, notably involved in pathological morphogenesis, but also the forces and deformation that are exerted on the sample. At the heart of these processes is the ability of cells to convert mechanical stimuli into biochemical signals driven, in part, by their mechanical properties, i. e. stiffness and viscosity. A partial approach to this problem is to observe the biochemical cascade triggered by mechanical perturbation (either a force or a deformation) with biomolecular tools. If however one wants to further characterize the inherent mechanical properties of cells, it necessary to probe imposed force and the resulting deformation simultaneously. To do this, techniques mostly inherited from material sciences have been favoured, using microrheometers based on parallel plates or rotating beads for instance. In the subcellular realm, Atomic force microscopy (AFM) remains king due to its ability to image at a nanometer scale.

At the nanoscale too, but until recently limited to solid-state physics, Brillouin light scattering (BLS) has emerged as a promising tool in mechanobiology. Since the first reports of its underlying physical principles in 1922, BLS has been developed and widely utilized in the context of material science, where it became a powerful and well-established technique for the investigation of condensed matter. It provides the sound velocity and attenuation in the GHz frequency range, which can be converted into an elastic modulus as well. In biology, the recent introduction of confocal Brillouin microscopy based on a fully parallel spectrometer has allowed the imaging of single cells with a micrometer resolution. These developments stimulated the booming field of mechanobiology, with the promise of directly imaging viscoelastic properties of living matter in 3D and in a noncontact, label-free and high-resolution fashion.

Because AFM and BLS share the ability to uncover mechanical material properties within living samples, and because BLS applications to life sciences remains in its infancy, it prompted a direct comparison. Since AFM data is usually interpreted as the response of the underlying elastic network of biopolymers, a similar conclusion was drawn for BLS. Subsequent works later pointed out that water content also plays a crucial role in the response of biorelevant hydrogels, and that the coordinated response of biopolymer network and intracellular fluids could lead to intricate non-linear acoustic behavior in multicellular tissues. To this day, no consensus has emerged on the interpretation of BLS spectra in hydrated biological samples.

In this presentation, I will first review the chronological evolution of the field, from a solid-state physics tool to a bioimaging modality, and give some examples of the current applications. To elucidate the nuances in the interpretation, I will finally discuss an experiment in which we vary the water content in cells, and identify the richness of mechanical behaviors BLS can capture.

Dynamic optical coherence elastrography: Principles and applications

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For nearly thirty years, elastography has been used to spatially map the shear/Young's modulus (or elasticity) of soft materials such as biological tissue. Multiple deformation sources (e.g., vibrator, static compressor, air-puff and acoustic radiation force) can create material displacements and numerous imaging systems (e.g., US, MRI, and OCT) can track these displacements leading to spatial elasticity maps. Recent work combining phase-sensitive (PhS-) OCT with several different deformation sources created a new OCE technique in which propagating mechanical waves are tracked to map elasticity with unprecedented sensitivity and spatial resolution. Unfortunately, nearly all elastography approaches require direct contact with the material under study. For OCE to be used clinically, robust noncontact technology is needed. Non-contact mechanical wave generation in soft media has been demonstrated in a limited number of studies.

Recently, we were the first to demonstrate that an air-coupled US beam reflected from an air/soft-medium interface can generate significant vertical displacement through reflection-based acoustic radiation force (ARF). Building on this observation, we pioneered a fully non-contact, non-invasive and clinically translatable AmT technique launching through air an US beam focused onto the interface. The US beam reflection can efficiently convert acoustic intensity into propagating mechanical waves. This action is like a hammer tapping wood or a stick beating a drum where a localized, transient force on the target creates significant displacement transverse to the force direction. For our case, the transient displacement needs only be less than a mm and the acoustic pressure only a few kPa, a level far below any potential damage thresholds for tissue and, thus, non-invasive. For true clinical translation of AmT-OCE, an appropriate PhS-OCT system must track high bandwidth mechanical waves propagating in four dimensions (i.e., three space dimensions plus time – 4D). Therefore, we developed a 16 kHz B-scan frame rate PhS-OCT system and combined it with the AmT source.

This talk will describe fundamentals and summarize the latest results on AmT-OCE (including in vivo elasticity quantification in skin and cornea) and answer several important questions related to dynamic elastography, including: what is the best spatial resolution that can be achieved in dynamic OCE? How should propagation speed be measured in soft tissue, especially in layered or bounded media? How should tissue anisotropy be accounted for? How can tissue elastic properties be properly reconstructed from experimental data? What is the potential for clinical translation and what barriers remain?

Polariton time crystals with a mechanical clock

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Time crystals (TCs) are quantum systems that spontaneously break time-translation symmetry, mirroring the spatial symmetry breaking that defines conventional crystals. Within this broad category, *discrete time crystals* (DTCs) have been experimentally demonstrated in diverse platforms, including cold atomic ensembles, magnon systems in superfluid helium-3, nuclear spins and photonic devices. Their hallmark is a period-doubled response to an external time-periodic drive.

More recently, *continuous time crystals* (CTCs) have been proposed in open quantum systems driven away from equilibrium by a time-independent perturbation [1]. In this talk, I will introduce the concepts underlying time crystals and present experimental evidence of time-crystalline behavior in the pseudo-spin degree of freedom of a trapped exciton-polariton condensate. This condensate exhibits self-sustained oscillations—manifested as a persistent, Larmor-like precession of its pseudospin—which establish a stable limit cycle.

Remarkably, this oscillatory behavior is strongly influenced by mechanical degrees of freedom, leading to signatures that bridge the characteristics of both DTCs and CTCs [2]. The time-crystalline order is revealed through high-resolution spectroscopy and time-resolved measurements of the first-order coherence function $g^{(1)}(\tau)$ (see Fig. 1). The spontaneous breaking of time symmetry arises from the interplay of non-Hermiticity, nonlinearity, dissipative coupling between polariton pseudospin states, and non-adiabatic feedback from a dynamic exciton reservoir—highlighting the rich physics of non-equilibrium many-body open quantum systems.

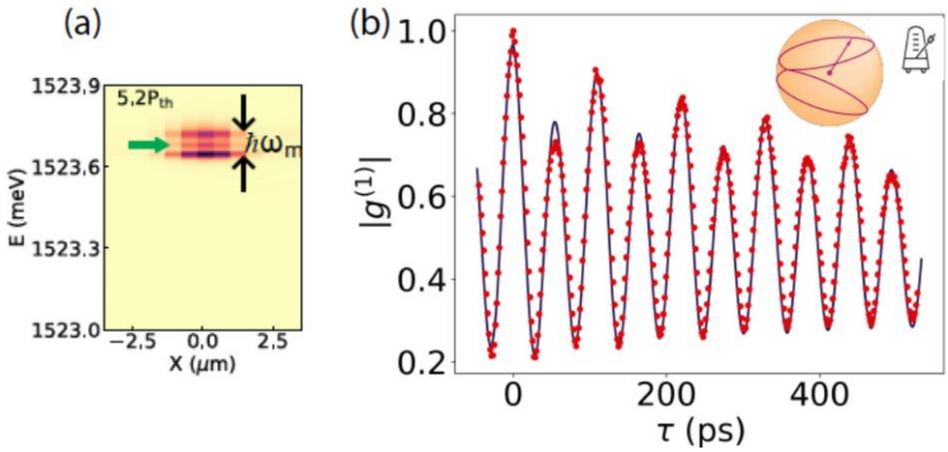

Figure 1. (a) Spatially resolved spectrum, and (b) time-resolved autocorrelation function $g^{(1)}(\tau)$ for a 2x2 mm polariton trap, evidencing the time-crystalline phase.

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Poster Session A

Poster A1 Spin-Photon Interfaces for Quantum Tech

Vitalie Nedelea; *Technische Universität Dortmund, Dortmund, Germany*

Harnessing coherent spins and single photons is not just a step forward—it is the key to unlocking the next generation of scalable quantum technologies. Our research delves into two pioneering areas critical to this vision: (1) coherent spin dynamics in semiconductor nanostructures, and (2) chip-integrated single-photon sources exploiting strong light-matter interactions.

In the realm of spins, we use pump-probe spectroscopy techniques such as time-resolved Faraday/Kerr rotation to achieve something remarkable: the extension of electron spin coherence times into the millisecond range. By synchronizing precession frequencies with laser pulses through mode-locking protocols, we overcome dephasing caused by inhomogeneous broadening—achieving unprecedented coherence times by synchronizing precession frequencies with laser pulses. Finally, ultrafast optical methods allow directional manipulation of individual spins at unprecedented speeds.

Meanwhile, at the photonic frontier, our nanophotonic platform integrates III-V semiconductor emitters into waveguides and cavities to create efficient single-photon sources operating at gigahertz repetition rates. High-fidelity unidirectional emission further enhances scalability by enabling seamless interfacing between photons and other components within a chip-scale architecture.

By combining advances in coherent spin dynamics with cutting-edge photonics, we present a unified framework that bridges stationary matter qubits with flying photonic qubits—laying the foundation for robust hybrid quantum architectures.

Poster A2 Ultrafast generation of coherent soft-shear phonons in tetragonal perovskites via anisotropic photostriction

Dmytro Horiachyi; *Technische Universität Dortmund, Dortmund, Germany*

Optical generation of transverse coherent phonons with femtosecond pulses is appealing for high speed sub-THz active control of material properties. Lead-free double perovskite semiconductors, such as Cs_2AgBiBr_6, attract particular interest due to cubic to tetragonal phase transition below room temperature and strong polaron effects. Here, we demonstrate that along with the compressive strain the anisotropic photostriction in tetragonal phase leads to the appearance of strong shear strain. Using time-domain Brillouin spectroscopy we detect coherent transverse and longitudinal acoustic phonons with comparable amplitudes in tetragonal phase, while in cubic phase only longitudinal phonons are generated. The polarization of photoinduced transverse phonons is dictated by the projection of c-axis on the surface plane which leads to prominent anisotropic polarization response in the detection. The generated strain pulses correspond to transverse acoustic soft eigenmodes with strong temperature dependence of dispersion which provides additional degree of freedom for active ultrasonic control.By combining advances in coherent spin dynamics with cutting-edge photonics, we present a unified framework that bridges stationary matter qubits with flying photonic qubits—laying the foundation for robust hybrid quantum architectures.

Poster A3 All-optical effective generation and detection of GHz surface acoustic waves

Olga Ken; *Technische Universität Dortmund, Dortmund, Germany*

Surface acoustic waves (SAWs) find more and more applications in signal processing, characterization of interfaces and optomechanics. However, ultrahigh-frequency SAWs still pose a challenge with regard of their efficient generation and detection. Their interaction with charge carriers and excitons in semiconductors has not been yet entirely investigated.

We perform all-optical generation and detection of high-frequency (up to 30 GHz) SAWs in the GaAs/AlGaAs heterostructures using Au gratings with suboptical wavelength periods. Femtosecond laser pump pulses hit the surface and are absorbed by Au grating (the pump wavelength is chosen in the GaAs transparency region). Thermal expansion of the Au stripes launches both bulk coherent LA phonons and SAWs in the heterostructure, which are detected simultaneously in the time-domain. The role of plasmon resonance of the Au grating in launching of SAWs is revealed.

We also present a sensitive method of SAWs detection by means of polarization-sensitive pump-probe technique, which exploits a narrow exciton resonance in a high-quality GaAs. Elastic strain of the SAW causes modulation of the exciton energy in the time domain. As a result, even a small deformation leads to a noticeable change in the dielectric function at the detection wavelength. It accounts for an order of magnitude increase in the detection sensitivity as compared to detection apart from the exciton resonance. Instead of conventional measurements of the reflection intensity, we detect polarization rotation angle of the reflected probe light, the same as in the Kerr rotation experiments.

Poster A4 Resonant effects for phonon generation

Michal Kobecki; *University of Warsaw, Warsaw, Poland*

This work focuses on using a novel experimental method based on the optical open cavity to excite and detect coherent phonons in materials from the II-VI group of semiconductors. The samples are grown with an acoustic cavity enclosed in Distributed Bragg Reflectors (DBR), which support the cavity acoustic mode. By placing the sample inside the open optical cavity and adjusting its length, we can sweep the energy of the excitation photon, allowing comprehensive studies on the influence of photon energy on phonon generation efficiency. Additionally, we can achieve resonant excitation in time domain, by implementing a high repetition rate laser that matches a frequency of the mode supported in the acoustic cavity. This experimental scheme allows us to enhance the efficiency of phonon excitation by exploiting four resonances for coherent phonon generation: acoustic cavity resonance, optical cavity resonance, excitonic resonance, and in-phase (temporal) resonant excitation (Fig.1). As a result of the project, we expect to provide a comprehensive study on the efficiency of the high-frequency coherent phonon generation in the II-VI semiconductor nanostructures obtained by pump-probe experimental technique exploiting optical open cavity. First samples of 100nm Al thin films deposited on GaAs substrates were prepared and implemented into the pump-probe set-up where we look for excitation and detection of acoustic phonons.

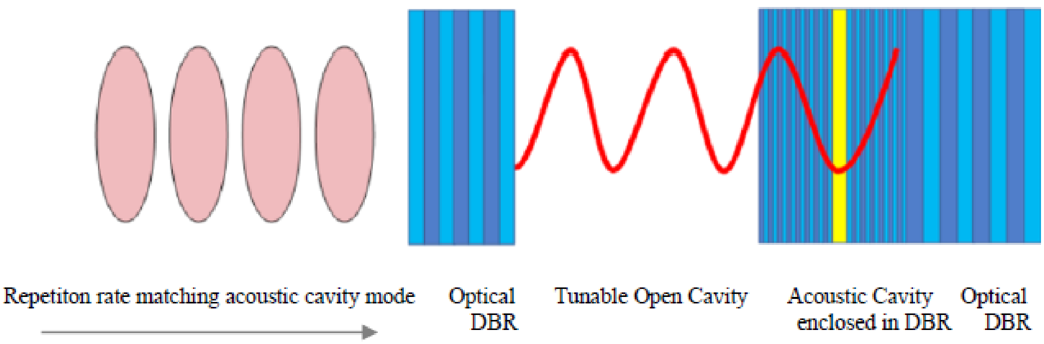

Fig.1 Resonant phonon generation in the acoustic cavity by exploiting open optical cavity.

Poster A5 Control of acoustic field generated by a laser source

Marion Caumartin; *Institute Langevin, Paris, France*

Laser ultrasonic technique offers an original, non-contact method to measure guided elastic waves in solids. By analyzing these waves, we can assess material properties non-destructively. Typically, a focused laser beam is used to generate elastic waves, acting as a point source that emits waves in all directions and excites multiple modes simultaneously. However, some modes may be too weak to be detected due to the noise level. While increasing energy input could improve the signal-to-noise ratio (SNR), the energy density must remain below the ablation threshold to avoid damaging the material.

To address this challenge, we shape the laser source to selectively generate specific modes. We achieve this by using a continuous-wave (cw) laser modulated in intensity at a set frequency, generating an elastic wave at that frequency. A spatial light modulator (SLM) then controls the wavenumber, allowing precise selection of (frequency, wavenumber) pairs along dispersion curves. This method concentrates energy on the desired mode while staying below the ablation threshold.

In this poster, we will present a study of anisotropy in plates using this approach. Since dispersion curves vary with propagation direction in anisotropic materials, our method enables directional control and mode selection. We will experimentally demonstrate selective mode generation, such as the zero-group velocity Lamb mode, in various sub-millimetric plates (e.g., metal alloys and monocrystalline materials) within the 2–15 MHz range.

Poster A6 Laser ultrasound imaging of metallic structures

Patrycja Pyzik; *AGH University of Krakow, Krakow, Poland*

Laser ultrasound (LU) is already recognized for its broadband nature yielding high-resolution imaging capabilities and, which exceeds the possibilities of traditional ultrasonic techniques. While strong compressional waves are efficiently generated in CRFP by circular beams, such an approach is infeasible for the metal inspection in thermoelastic regime.

My research focuses on the inspection of metallic, multilayered components, where multiple wave modes, reflections, and mode conversions create complex wavefields that hinder the analysis of obtained scans. The challenge in LU-based inspection of these structures lies in enhancing image quality by suppressing undesired wave modes. To address this, I employ advanced signal processing techniques, including deconvolution, coherent noise suppression, as well as the synthetic aperture focusing technique (SAFT), to refine LU images and improve defect detection. By combining these methods, my work aims to enhance the clarity and reliability of LU imaging of challenging metallic and multilayered components, advancing the effectiveness of non-destructive evaluation (NDE) for industrial applications. These include for instance imaging of bonded joints between aluminium plates or damage detection in thin sheet metal welded joints. In this poster I will present a comprehensive description of these works starting from numerical modelling through experiments to profound analysis of developed methods' resolution.

Poster A7 Optical study of acoustic dynamics of single metallic nanoparticles

Nathan Berrit; *Institute of Light and Matter, Villeurbanne, France*

Mechanical resonators are often compared based on the product fQ of their frequency f and quality factor Q. While metal nanoparticles exhibit high vibrational frequencies in the GHz-THz range, their relatively low quality factor results in fQ values that remain insufficient for applications such as ultrasensitive sensing or observing quantum behaviour at room temperature [1]. To address this limitation, a deeper understanding of vibrational mode damping (arising from both internal processes and acoustic emission into the environment) is necessary.

In this context, we conduct an optical investigation of gold nanodisks. Combining ultrafast pump-probe time-resolved spectroscopy and spatial modulation spectroscopy, this approach enables the detection of individual nano-objects while providing quantitative measurements of their linear optical properties and ultrafast dynamics, thereby avoiding the inhomogeneous effects that obscure ensemble measurements. Previous studies in our group have shown that the vibrational quality factors of supported nanodisks are strongly dependent on morphology, with enhanced values observed for specific diameter/thickness ratios [2]. These observations could later be ascribed to the radiative coupling of two distinct vibrational modes of the nanodisk [3]. We present here new experimental studies on this theme, addressing the roles played both by the composition and thickness of the substrate and the approach used for nanodisk synthesis. Additionally, we explore the transient optical response induced by nano-object vibrations by tuning the probe wavelength.

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Poster A8 Thermal Dynamics of a Single Gold Nanoparticle

Noëlle Lascoux; *Institute of Light and Matter, Villeurbanne Cedex, France*

Time-resolved pump-probe optical spectroscopy on metal nano-objects is a powerful tool to investigate the specific modalities of nanoscale heat transfer, which plays a crucial role in many applicative fields such as electronics, thermoelectricity and nanomedicine [1]. It enables non-contact studies of energy exchange mechanisms between the nano-objects and their environment, whose kinetics generally depends on both the thermal conductance of the interface between the nano-objects and their environment and the thermal properties of the latter. Such experiments can now be performed at the single-particle level, allowing to follow the cooling dynamics and quantitatively measure its induced transient optical response [2,3].

We studied the cooling dynamics of single gold nanodisks synthesized using colloidal chemistry and deposited on various dielectric substrates differing by their composition, thermal properties and thickness, including nanometric membranes.

The detailed analysis of the cooling dynamics was performed using finite-element simulations in the frequency domain. This modeling approach provided a better understanding of the phenomena involved, and allowed us to quantitatively estimate the thermal conductances of nanodisk/membrane interfaces and the thermal conductivities of the used thin membranes. The role of the heating of the environment was also highlighted.

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Poster A9 Controlling the propagation of 20 GHz coherent acoustic phonons in an optophononic waveguide

Edson Cardozo de Oliveira; *Centre de Nanosciences et de Nanotechnologies, Palaiseau, France*

Acoustic phonons at ultrahigh frequencies can be employed as information carriers in the solid state, being an asset for signal processing and quantum technologies. During the past decade, confinement of ultrahigh-frequency acoustic phonons in planar structures and micropillars has been achieved. However, coherent manipulation of propagation and dynamics of ultrahigh frequency phonons remains challenging. We studied the propagation of ultrahigh frequency coherent acoustic phonons in a ridge waveguide based on multilayered GaAs/AlAs optophononic Fabry-Perot resonator confining acoustic phonons at ~20 GHz and light at ~840 nm. Additionally, by optically generating two distant phonon sources, we demonstrated the interference of the propagating coherent phonons in such system. These results constitute a promising avenue for revealing the fundamental properties of phonon dynamics and manipulating phonon propagation in more complex structures. They also correspond to a significant step forward in the development of phononic networks for telecommunications and quantum applications.

Poster A10 Time-resolved study of two-dimensional phononic crystals based on self-assembled nanospheres

Sandeep Sathyan; *C2N, Université Paris-Saclay, Paris, France*

Phononic crystals, elastic analogues of photonic crystals, promise significant advances in controlling elastic energy propagation, crucial for tunable filters, heat management, and acousto-optical devices. By influencing phonon flow, they could control thermal conductivity. Colloidal self-assembly offers a cost-effective method to engineer phononic crystals with desired properties [1,2]. This study investigates the hypersonic phononic properties of self-assembled two-dimensional colloidal crystals composed of polystyrene (PS) nanospheres on a silicon substrate. We demonstrate tunable hypersonic phononic bandgaps by varying interactions between neighboring PS nanospheres. Ultrafast pump-probe transient reflectivity techniques explore phononic modes across various frequency ranges [3]. Phonon transport analysis via pump-probe methods confirms the phonon-insulating properties. Experimental observations are supported by a finite element method model. These findings underscore the potential of self-assembled colloidal crystals in creating tunable hypersonic phononic insulators, paving the way for advanced phononic applications.

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Poster A11 Polaritonic Detection of Nano-Strain Pulses

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Visualizing lattice dynamics is a powerful tool for investigating ultrafast processes in crystalline solids. Examples of such ultrafast processes occurring on the time scale of less than one picosecond are photoinduced phase transitions, electron gas heating in metals, carrier generation in semiconductor nanostructures, or modifications of magnetic order. These processes correspond to the spatially localized generation of stress, which leads to the injection of acoustic pulses into the surrounding volume. Here, we demonstrate the ultimate sensitivity of detecting such acoustic pulses at a distance from the initial process, exploiting a polaritonic nanostructure.

In the pump-probe experiment, acoustic pulses are generated by the photoinduced ultrafast thermal expansion of a 100-nm Al film. The pulses are injected into the adjacent GaAs substrate and detected in a semiconductor nanostructure consisting of 30 identical GaAs/GaAlAs quantum wells, which serve as an effective medium hosting a narrow exciton-polariton resonance. The ultimate detection sensitivity is achieved by probing the acoustic pulse induced modulation of optical reflectivity in the spectral vicinity of the polariton resonance, whose energy shift results in significant changes of the refractive index. We confidently detect the pulses generated by the heating of the Al film on ~0.1 K and its corresponding expansion on only 100 attometers, which carry dynamical strain as small as η = 10-9 [1].

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Poster A12 Phonon Dynamics in Novel Materials and Hybrid Structures

Ornella Colmegna; *C2N, Université Paris-Saclay, Paris, France*

We investigate phonon dynamics in hybrid nanostructures engineered for tunable acoustic resonances in the gigahertz to sub-terahertz range. Our work focuses on open-cavity resonators incorporating non-standard nanophononic materials, such as mesoporous oxides and superconductors. Specifically, we design and characterize devices based on YBCO/STO Distributed Bragg Reflectors (DBRs) with nickel resonating layers. These structures leverage the temperature-dependent properties of YBCO and STO to enable multifunctional devices, with transient reflectivity pump-probe experiments revealing acoustic resonances around 120 GHz.

In parallel, we explore Pt/Co superlattices exhibiting short-lived acoustic modes up to 900 GHz, where hypersonic phononic bandgaps are tunably engineered via layer thickness and composition. Ultrafast laser techniques provide insight into the dynamics across these systems.

Additionally, we propose DBR-based acoustic resonators incorporating mesoporous SiO_2 thin films, whose porosity and sensitivity to environmental humidity allow modulation of acoustic response. Experiments highlight how pore size affects gigahertz-range resonances, advancing strategies for cost-effective, tunable nanoacoustic devices.

Together, these results demonstrate the potential of hybrid nanostructures for adaptable phononic applications, establishing design principles for high-frequency acoustic resonators with external tunability.

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Poster A13 Phonon Dynamics in Novel Materials and Hybrid Structures

Carlos Montenegro La Torre; *C2N, Université Paris-Saclay, Paris, France*

The growing interest in acoustic phonon engineering in microstructures is motivated by applications in fields such as optoelectronics, quantum technologies and simulation of solid-state systems [1]. Brillouin spectroscopy techniques take on the challenge of measuring high-frequency acoustic phonons in the technologically relevant sub-THz regime [2,3].

In this work, we present our advancements on an experimental scheme for measuring Time-Dependent Brillouin Scattering on GaAs/AlAs-based Fabry-Perot optophononic resonators using single photon detectors (SPDs). We use the Double Optical Resonance condition [2,4] in these microstructures to simultaneously enhance the Brillouin Stokes and anti-Stokes scattering processes excited with two different pulsed laser sources. Further spectral filtering of these two Brillouin signals is done by using a triple spectrometer. Both filtered Brillouin signals are then sent to different SPDs. Our proposed setup can be used to study the dynamics of the confined phonons in engineered opto-phononic resonators.

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Poster A14 Optical frequency up-conversion of the ferromagnetic resonance in an ultrathin garnet mediated by magnetoelastic coupling

Lucile Soumah; *Université du Mans (CNRS), Le Mans, France*

Magnetization dynamics is attractive for technology with a frequency that can be tuned from the GHz to the THz range by the choice of different materials, magnetic modes or by using both the direction and the amplitude of an externally applied magnetic field. This collective oscillation of spin can be used to encode and transport information without Joules heating and are thus very promising for technology. Since 1996 [1] ultrashort light pulses have emerged as an efficient tool to initiate and probe magnetization dynamics on the (sub)-picosecond time-scale. Another interesting aspect of the use of optical light pulse is the possibility to control the magnetic properties of the material via the generation of strain wave[2], modification of anisotropy[3], optical phonons [4] or simply pure heating of the material.

In this poster we present ultrafast pump-probe measurements on a nanometer-thick magnetic garnet, insulating material widely known for its versatility and its very low magnetic losses[5]. Tuning the photon energy of the pump laser pulses above and below the material's bandgap, we trigger ultrafast optical and spin dynamics via both one- and two-photon absorption. Contrary to the common scenario, the optically-induced heating of the system induces an increase up to 20% of the ferromagnetic resonance frequency. We explain this unexpected result in terms of a photo-induced modification of the magnetic anisotropy, i.e. of the effective field, identifying the necessary conditions to observe this effect[6].

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[5] L. Soumah et al., Ultra-low damping insulating magnetic thin films get perpendicular, *Nature Commun.* **9**, 3355 (2018).
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Poster A15 Ultrafast switching of the ferroic order parameter

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The spontaneous polarization of ferroelectrics is a critically important order parameter for a broad range of electronics, optical and electro-mechanical appliances, with clear potential to produce novel functionalities, from high-density non-volatile memories to neuromorphic-inspired computational schemes and energy harvesting.

We demonstrate a permanent switching of the ferroelectric polarization in BaTiO3 by applying ultrashort, intense laser pulses from the FELIX free electron laser at the frequencies of optical phonons [1]. Subsequent studies prove that the domains actually appear on picosecond timescales, simultaneously with phonon-polaritons. Surprisingly, switching was not achieved at the IR-active frequencies of the transverse phonon modes as one would expect. Instead, it happened at frequencies where the dielectric function approaches zero, i.e. at the frequency of a longitudinal optical phonon, which is known for its strong light-matter interaction.

Both domain switching, strain and polariton dynamics have been probed with single-shot time-resolved pump-probe microscopy using both optical birefringence and second harmonic generation as a probe. After excitation with light pulses from FELIX, the responses were probed with a pulsed laser that was synchronized with the FEL and captured on a CMOS camera.

Our results indicate that the switching process is driven by ultrafast laser-induced strains. This mechanism is universal and can work in vary different systems, such as magnetic dielectrics. Last but not least, we also demonstrate that the ferroelastic order parameter can be switched by the same approach [2].

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[2] D.G. Lourens et al, in preparation.

Poster A16 Ultrafast switching of the ferroic order parameter

Lisa Mehner; *University of Potsdam, Potsdam, Germany*

Picosecond ultrasonics is a well-established, non-contact, and non-destructive technique for characterizing high-frequency acoustic pulses, their reflections, energy transfer processes, and phase transitions in the near-surface regions of thin films and heterostructures. When the optical probe is replaced with hard X-ray pulses, ultrafast diffraction experiments can directly and quantitatively probe material-specific Bragg peaks, enabling the measurement of average strain even in nanoscopic layers buried within optically opaque structures.[1] This strain response serves as a sensitive proxy for laser-driven picosecond strain pulses and reveals unexpected energy transfer mechanisms in multilayer systems. Such studies are feasible in specialized laboratories using table-top, laser-driven plasma X-ray sources.

Here, we revisit the remarkably fast energy transfer via “hot” electrons from a laser-excited Pt layer, through optically opaque Cu layers, into a buried Ni film.[2] Although the energy is absorbed in the front-end Pt layer, it is the backside Ni behind the Cu layer which heats up and expands before the Cu layer. Using picosecond ultrasonics with X-rays (PUX) at the FemtoMAX beamline of the MAX IV synchrotron in Sweden, we systematically test the predictions and limitations of the established diffusive two-temperature model across different Cu thicknesses and excitation fluences. Furthermore, we analyze the necessary prerequisites to discern ballistic from diffusive energy transport in metallic heterostructures.

PUX at FemtoMAX opens new opportunities for gaining deeper insights into nanoscale energy transfer processes and strain waves triggered by light-matter interactions.

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[2] J.-E. Pudell et al., Heat Transport without Heating? - An Ultrafast X-Ray Perspective into a Metal Heterostructure *Adv. Funct. Mater.* **30**, 2004555 (2020).

Poster A17 Ultrafast thermometry by picosecond ultrasonics with X-rays

Florian Baltrusch; *University of Potsdam, Potsdam, Germany*

Picosecond ultrasonics with X-rays is an emerging material-specific method to study ultrafast strain dynamics and temperatures in heterostructures. Here we focus on a quantitative comparison of two distinct X-ray diffraction-based methods for ultrafast thermometry in laser-excited metal heterostructures: the change in X-ray diffraction intensity governed by the Debye-Waller effect exclusively probes phononic excitations, and the Bragg peak shift results from transient lattice expansion, that can be driven by, phonons, electrons, spins or phase transitions. This distinction is crucial for interpreting nanoscale energy transfer in heterostructures, which plays a key role in phase transitions, ultrafast magnetism, and light-driven heterogeneous catalysis.

We present results for Au and Pt thin-films, which exhibit distinct electron-phonon coupling time scales. We discuss experiments conducted at the FemtoMAX beam line of the Max IV facility in Lund, and the plasma X-ray source at the University of Potsdam, that investigate the interplay of temperature and (negative) lattice expansion.

Poster A18 Coherent 600 GHz phonons in metal-only Au/Pt superlattices probed by ultrafast X-ray diffraction

Constantin Walz; *University of Potsdam, Potsdam, Germany*

Superlattice (SL) structures are interesting because they allow for the generation of coherent, spectrally narrow strain pulses up to the THz regime. Traditionally, SL structures comprise alternating metal and insulator layers, where the difference in light absorption leads to an inhomogeneous stress profile that drives the high-frequency SL oscillation.

Here, we demonstrate and discuss the laser-induced superlattice oscillation of a metal-only Au/Pt SL with ultrafast x-ray diffraction (UXRD). In contrast to all-optical methods, UXRD allows to directly probe the material-specific lattice constant and thus strain amplitude.

Although the electron temperature is expected to quickly equilibrate across the metals on a sub-ps timescale following laser excitation, the majority of the energy density is localized in Pt due to a larger heat capacity. In the Grüneisen model, this energy density creates an electronic stress that initiates the SL oscillation. On longer timescales, the faster electron-phonon coupling in Pt leads to an additional phononic stress that further contributes to the SL oscillation.

Remarkably, we observe a strong 600 GHz mode regardless of the chosen excitation conditions, even in the case of nearly uniform absorption across the metallic layer stack. This demonstrates that differing heat capacities and electron-phonon-coupling times between Au and Pt alone can efficiently drive coherent SL oscillations. These findings establish metal-only SLs as a new and flexible platform for tunable picosecond acoustics, which allows to study the interplay of electronic and phononic stresses when discussing high-frequency strain dynamics in multilayer structures.

Poster Session B

Poster B1 Optoacoustic characterization of the anisotropy and mechanical nonlinearity of developing roots

Lou-Anne Goutier; *Université Claude Bernard Lyon 1, Villeurbanne, France*

Plant roots are intricate, multiscale, hierarchical structures. While biological studies provide extensive insights into root development, the implications of this complex mechanical landscape for growth and behavior are often underexplored. In these systems, classical techniques such as tensile tests, or state-of-the-art Atomic Force Microscopy (AFM) have revealed unusual properties, including nonlinear mechanics, auxecity and anisotropy. However, such approaches face significant challenges in probing mechanical properties in depth. Our approach aims to characterize the mechanical properties of growing roots across different structural scales, from the tissue to the subcellular level, by leveraging optoacoustics.

To this end, we focus on two complementary techniques. At the subcellular and tissue scales, Brillouin Light Scattering (BLS) is utilized to image sound velocity and attenuation in three dimensions. This method provides spatially resolved insight into local mechanical properties, such as stiffness and viscosity, while preserving the sample's integrity. The preliminary results obtained from model samples as well as more complex plant structures during the first year of this PhD thesis are presented herein.

Concurrently, Transient-Grating Spectroscopy (TGS) will be employed to probe structural effects and local mechanical gradients. The objective of this method is to identify emergent properties that may play a role in root growth and adaptation by examining how tissue organization affects the mechanical response.

By comparing the results of these techniques at different scales, we hope to elucidate the role of microscale mechanics in plant roots, thereby establishing the foundation for a more comprehensive multi-scale mechanical characterization of root tissues.

Poster B2 Ultrahigh resolution phonon-endoscopy for cancer diagnosis

Andrea Faúndez-Quezada; *University of Nottingham, Nottingham, United Kingdom*

Cancer is a leading cause of death worldwide, with pancreatic cancer being especially lethal, as only 5% of those diagnosed in England survive for ten or more years. This is largely due to late-stage diagnosis, when treatment options are limited. Early detection is therefore crucial to improving survival rates, but current methods are invasive and lack quantification. In this context, phonon microscopy emerges as a promising non-contact, label-free, in-vivo technique for imaging and characterising biological samples at the nanoscale level. This technique leverages opto-acoustic transducers and picosecond lasers to measure elasticity through Brillouin scattering. At the same wavelength, the speed of sound is five orders of magnitude smaller than the speed of light, enabling GHz frequencies to provide higher resolution compared to optical microscopes, while overcoming the low refractive index contrast between the cells and their surrounding medium.

The acquired Brillouin scattering signal has shown promise in distinguishing cancerous from non-cancerous cells, with AI applied for classification. However, several challenges remain, including improving penetration depth (currently about 5.5 μm), acquisition speed, and enhancing the explainability of AI classifiers. For clinical applications it is known that cancer modifies the local viscoelastic properties of cells, and measuring these changes endoscopically could provide a non-invasive method for early detection. To pave the way for clinical use, future work will focus on overcoming these challenges and advancing the technology.

Poster B3 **Classification of cell fundamentals using phonon microscopy using AI**

Shai Israel; *University of Nottingham, Nottingham, United Kingdom*

Phonon microscopy, a time-resolved Brillouin scattering technique, provides a unique capability for imaging and characterizing the mechanical properties of biological cells at subcellular resolution. My research focuses on using this technology to investigate the biomechanical properties of cancer and normal cells, with the aim of identifying previously untapped markers for cell classification. This work builds upon recent findings that demonstrate the effectiveness of phonon microscopy in differentiating cancerous and normal breast cell lines with high accuracy using deep learning.

A convolutional neural network (CNN) has been trained on large-scale phonon-derived datasets, achieving 93% accuracy in distinguishing between MDA-MB-231 (cancerous) and MCF10a (normal) cells. Preliminary analyses suggest the existence of biomechanical markers beyond conventional elasticity metrics, which could improve cancer diagnostics. My research explores the underlying features extracted by the CNN, seeking to bridge the gap between data-driven classification and the physical properties of cells. Additionally, I am contributing to the development of a fibre-based phonon probe, which could facilitate in vivo applications through endoscopic or needle-based cancer diagnostics.

Beyond classification, my work aims to explore the broader implications of elasticity as a biomarker in oncology. By investigating how cancer progression alters mechanical properties at the cellular level, I seek to refine phonon microscopy's sensitivity to biomechanical variations. This involves analyzing diverse cancer cell types and treatment-induced modifications to determine whether specific phonon-derived features can serve as universal or subtype-specific indicators. Understanding these mechanisms could contribute to the development of non-invasive diagnostic tools and improve the integration of elasticity-based imaging into clinical workflows.

Poster B4 **Ultra-thin opto-acoustic fibre optic probe for cancer characterisation**

Samuel Karet; *University of Nottingham, Nottingham, United Kingdom*

There is a huge scope for medical applications of laser ultrasonics, and research is increasingly focused on leveraging its non-invasive, high-resolution capabilities to enable new diagnostic tools. This work explores the development of fibre-mounted opto-acoustic transducers in order to characterise the mechanical properties of soft biological matter, aiming to differentiate between cancerous and healthy cells based on their distinct elastic properties.

Picosecond ultrasonics makes use of Time Resolved Brillouin Scattering (TRBS), using ultrashort pump-probe laser pulses and a delay line, allowing work to be done at multi-GHz acoustic frequencies for high spatial resolution, but with a comparatively low acquisition speed. These GHz frequencies are particularly well-suited for resolving mechanical properties in smaller samples, such as individual cells, where high spatial resolution is critical. At lower acoustic frequencies, a continuous wave laser can be used as part of a knife-edge detector setup, enabling faster acquisition speeds but with reduced spatial resolution. This MHz frequency range is better suited for larger samples, such as tissues, where a broader field of view is required. By combining these approaches, the system can be adapted to a wide range of biological applications, from cellular to tissue-level characterisation.

As such, our approach is to develop transducers for use at both GHz acoustic frequencies, as well as for MHz acoustic frequencies, with the appropriate pump-probe setup, using novel nanofabrication techniques to mount them on the fibre tip for easier transition into eventual clinical use.

Poster B5 Optoacoustic probing of surface acoustic waves in quasi-periodic plant-based structures

Loan Tricaud; *Université Claude Bernard Lyon 1, Villeurbanne, France*

Plant-based materials are emerging as sustainable alternatives to conventional synthetic materials, due to their intricate multifunctionality and biocompatibility. While many applications have been developed in photonics, soft electronics, and energy harvesting, their potential in the field of phononics remains relatively unexplored.

In plant epidermises, cells are encased between rigid micron-thick walls that form a honeycomb-like structure. In a recent study, we have examined interactions of Surface Acoustic Waves (SAWs) with the structural vibrations of these walls in dehydrated onion epidermises, showing the appearance of locally resonant phononic band gaps in the MHz range. In this work, we investigate the role of the structural periodicity formed by these walls at the tissue scale. We use a photo-deflection, scanning-probe laser ultrasonics setup to generate and scan SAW propagation. We observe multiple phononic features in the lower MHz range, including band gaps, band folding, and modes exhibiting negative group velocity. We compare our measurements to numerical simulations with periodic and quasi-periodic geometries. Our findings reveal a coupling between the average periodicity of cellular structure and locally resonant effects induced by the geometry and microstructure of the cell walls. Compared to our previous work, this interaction leads to a richer phononic landscape.

These observations underline the potential of exploiting plant-based materials and structures to interact with and control high frequency elastic waves. Our research paves the way for the development of bio-based and sustainable materials with advanced phononic properties, opening up new possibilities for applications in ultrasonic energy harvesting, wave filtering, and sensing.

Poster B6 Impact of Nanoparticle Self-Assembly on Acoustic Propagation: Structural and Mechanical Variations Investigated through Brillouin Spectroscopy Using VIPA

Shaik Mohammad Imran; *Institute Lumière Matière, Lyon, France*

Nanoparticle self-assembly significantly affects acoustic properties, influencing their mechanical behaviour and applications. In this study, we explore the impact of self-assembly on acoustic propagation using a novel home-built confocal spontaneous Brillouin microscopy system based on Virtual Image Phase Array (VIPA). Unlike traditional techniques like Tandem Fabry-Pérot interferometers (TFP), which require long acquisition times, our system captures Brillouin spectra in just one second, improving both speed and reliability.

Using polystyrene (PS) nanoparticles, we observed self-assembled periodic lattices upon deposition. Measurements from different sample positions revealed variations in Brillouin frequency, indicating structural and mechanical changes in nanoparticle arrangement, density, or stiffness. These variations highlight the importance of nanoparticle organization in acoustic propagation.

The VIPA spectra showed high reproducibility and excellent agreement with TFP results, validating the efficiency of our technique. This work enhances Brillouin spectroscopy for nanoparticle analysis, providing a faster, more efficient method for measuring acoustic vibrations. Future research will investigate the mechanisms behind the frequency variations and their implications for nanoparticle applications.

Poster B7 Acousto-optic characterization of van der Waals systems

Felix Ehring; *University of Münster, Münster, Germany*

With wavelengths in the micrometer range at GHz frequencies, surface acoustic waves (SAWs) are a versatile tool for radio frequency control and probing of charge carrier dynamics in novel semiconductor nanostructures. They are generated on a piezoelectric chip and routed over long distances to couple either mechanically or electrically to many solid-state nanosystems [1]. In our experiments, we fabricated hybrid lithium niobate SAW-devices in which different mechanically exfoliated transition metal dichalcogenide (TMDC) 2D materials were transferred. The focus of the experiments was the investigation of the impact of the SAW dynamic electric and strain fields on the photoluminescence and charge carrier dynamics in MoSe2-WSe2 heterostructures.

[1] P. Delsing et al., The 2019 surface acoustic waves roadmap, *J. Phys. D:Appl. Phys.* **52**, 353001 (2019).

Poster B8 Resonant enhancement of optoacoustic response in van der Waals materials

Anton Samusev; *Technische Universität Dortmund, Dortmund, Germany*

Acoustic nanocavities with high (1 GHz – 1 THz) resonance frequencies can be exploited in sensing and quantum devices. The eigenfrequencies in this range, accompanied by high Q-factors, are achieved in nanocavities fabricated from van der Waals (vdW) materials. In the pump-probe experiments with vdW nanocavities composed of two to hundreds of monolayers, we reveal the role of exciton resonances in optical excitation and detection of the phonon eigenmodes. We show how the composition and design of the vdW structure and the parameters of the optical excitation determine the polarization and amplitude of the excited phonon modes and the efficiency of their detection.

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Poster B9 Magnetoelastic dynamics in magnetic 2D materials

Maurits Houmes; *Technische Universität Dortmund, Dortmund, Germany*

My research focusses on the interaction between the lattice and magnetic subsystems in 2D materials , which is crucial for applications like spintronics. Understanding and controlling these interactions allows for not only tuning of magnetic properties but also to minimize coherence losses from magnon-phonon scattering.

In my presentation, I will discuss my work on MPS3 compounds (M= Ni, Co, Fe), which serve as prototypical examples of antiferromagnetic van der Waals materials. I will show how by using optomechanical techniques it is possible to excite the vibration modes of nanoscale membranes of these materials. I will explain how by utilizing the anisotropic effects present in these systems it is possible to extract the critical exponents characterizing their phase transitions from the temperature dependence of these vibration modes.

Furthermore, I will outline my plans and initial results aimed at expanding these investigations into the ultra-fast domain through ultra-fast magnetoacoustics and time- and angle-resolved photoemission spectroscopy, providing further understanding into the dynamics of these interactions.

Poster B10 Surface acoustic waves modulation of excitonic complexes in MoSe2-based heterostructures

Pedro Matrone; *Gleb Wataghin Physics Institute, State University of Campinas*, *Campinas, Brazil*

Transition metal dichalcogenides-based van der Waals heterostructures (vdWHS) have been widely investigated due to their unconventional excitonic. To control and manipulate these excitons, surface acoustic waves (SAWs) can be a powerful tool because of their strong piezoelectric field and mechanical deformation. In this contribution, we study the SAW modulation of excitonic complexes in MoSe2-based vdWHs. We measured at low temperatures the optical response to SAWs of the excitons generated in MoSe2 monolayer (ML) exposed to three different dielectric environments: directly on top of LiNbO3, as well as partially and fully encapsulated with hexagonal boron nitride (hBN). For the fully encapsulated MoSe2, micro-photoluminescence (μ-PL) measurements reveals a metastable light-induced free carrier injection into the ML which depends on the laser power and leads to an exciton-to-trion conversion in a scale of minutes prior to the application of the SAW. At low laser powers, when the SAW is turned on, it dissociates neutral and charged excitons which is reflected in a μ-PL quenching of both emissions. At high laser power, we observe a quenching of the trion emission but a strong enhancement of the neutral exciton one. In this case, the SAW is able to quickly revert the laser-induced photo doping, thus working as an efficient way to control the exciton-trion population ratio. In partially encapsulated samples this effect is much less pronounced and the LiNbO3 substrate acts as a sink for electrons, decreasing the PL emission and the effects of the SAW.

Poster B11 Van der Waals 2D materials for sub-picosecond ultrasonics

Arthur Allen; *Institute Lumière Matière, Lyon, France*

Picosecond ultrasonics is an innovative research field with many applicative purposes from material science to biology for non-invasive, high-resolution, structural characterization [1]. The technique relies on the combination of a nanoscale thin film and delay-controlled optical laser pulses, forming an opto-acoustic transducer for the launching and the detection of ultrashort coherent acoustic phonon wavepackets. Recently, the use of van der Waals 2D materials, such as graphene or dichalcogenides (TMDCs) and their stacks, as transducers with a reduced thickness to the atomic scale, enabled the confinement of the opto-acoustic processes to the ultimate sub-nanometer resolution and terahertz frequencies [2,3].

Here we propose to precisely study the opto-acoustic response of atomically-thin MoSe2 exfoliated sheets with advanced pump-probe optical measurements, using beams focused to their diffraction limit and wavelengths of both pump and probe independently tuned in the UV-visible-NIR (400-1100nm) range [4]. With this approach, we aim to bring a comprehensive understanding of the fundamental opto-electro-mechanical processes involved and to further demonstrate and optimize the superior figures of merit (THz frequency, quality factor …) of these novel nano-mechanical oscillators.

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Poster B12 VO_2 thin-film transducer for steady-state thermal conductivity measurements

Jose Ordonez; *Institut des Nanosciences de Paris, Paris, France*

We develop and apply a technique to measure the thermal conductivity of solid materials by exploiting the strong optical contrast of the metallic and insulating domains of a VO_2 thin-film transducer. This is achieved by steady-state imaging of the laser-induced semiconductor-to-metal transition in an optical microscope. We derive an analytical model for the radius of the observed metallic region as a function of the intensity of the focused laser beam. Fitting this model to the experimental data accurately yields the thermal conductivity of the underlying substrate, relying only on readily accessible experimental input parameters. We demonstrate this method for model samples of silica, sapphire, and silicon whose thermal conductivities span a range both below and above that of the VO_2 transducer. The simplicity of the experimental setup makes it highly accessible and applicable to a wide range of bulk and thin film materials with perspectives for spatially-resolved thermal conductivity mapping.

Poster B13 Determination of Thermal Conductivity via Time-Domain Thermoreflectance on a Picosecond Acoustic Setup

Marie Pagès; *Institut de minéralogie, de physique des matériaux et de cosmochimie, Paris, France*

The objective of my doctoral research is to determine the thermal conductivity of iron under high-pressure conditions. To reach such pressures, we use diamond anvil cells, which constrain the sample dimensions to a few micrometers. However, thermal transport in metals occurs at very high velocities, hundreds of nanometers per picosecond, making it particularly challenging to probe a macroscopic property such as thermal conductivity within such confined geometries. To address this, we employ an ultrafast femtosecond laser source capable of resolving heat diffusion on picosecond time scales.

I will present the time-domain thermoreflectance (TDTR) pump-probe setup developed on the picosecond acoustics platform, which enables time-resolved measurements of the sample's thermal response following a pump excitation. The resulting signal comprises two contributions: a general thermal behaviour, which can be modeled using the framework developed by Cahill, and superimposed acoustic echoes that provide information about the thickness of the iron film. I will present how the Cahill model allows us to quantitatively extract the thermal properties from the experimental data.

To date, we have performed measurements at ambient pressure on 100 nm iron films deposited on either glass or alumina substrates, to assess the validity of our approach by comparison with the known thermal properties of iron under standard conditions. A high-pressure experiment is currently underway, with the objective of detecting potential changes in the thermal conductivity associated with the phase transition of iron near 10 GPa.

Poster B14 Ultrastrong coupling between optical phonons and surface plasmon polaritons controlled by dynamic doping

Nicolas Pajusco; *LAUM/CIC nanoGUNE, Donostia-San Sebastian, Spain*

Controlling light–matter interactions at the nanoscale is a key objective in advancing fields such as quantum technologies and polariton chemistry. One promising strategy to control light–matter interactions is to achieve strong or ultrastrong coupling (SC/USC) between optical and material excitations. In this work, we use pump–probe nano-Fourier transform infrared (nano-FTIR) spectroscopy to investigate the coupling between transverse optical (TO) phonons in a thin 3C-SiC layer and surface plasmon polaritons (SPPs) in a dynamically photo-doped InAs substrate.

A near-infrared pump pulse transiently increases the carrier concentration in InAs, thereby tuning the SPP dispersion ($\omega_{sp} \propto \sqrt{n}$, where n is the carrier density). A mid-infrared probe pulse is then used to image the surface polaritons and extract their dispersion with nanoscale resolution.

By tuning the SPP dispersion into resonance with the TO phonon, we observe the emergence of a hybrid polariton mode exhibiting characteristics of ultrastrong coupling (mode splitting > 20%). Remarkably, this hybrid mode spans a broad region of momentum space—unlike conventional SC/USC systems where mode hybridization is confined to a narrow wavevector range near the anticrossing point.

This observation introduces the concept of *flat-band ultrastrong coupling*, where the flat dispersion of the TO phonon enables a large number of SPP modes to participate in hybridization. Our results provide a pathway toward increasing the density of hybridized states in USC systems, with potential implications for enhancing polariton-mediated chemical reactivity and enabling ultrafast, tunable polaritonic devices.

Poster B15 Nonlinear Optical Response of a Plasmonic Nanoantenna to Circularly Polarized Light

Marina Quijada; *Universidad del País Vasco UPV/EHU, Donostia-San Sebastian, Spain*

The optical response of molecules and plasmonic nanostructures to circularly polarized light has gained significant interest in recent years due to its vast application potential from biosensing to quantum communication and engineering of optical fields. While many theoretical works have tackled the nonlinear response of plasmonic materials to linearly polarized illumination, the case of circular polarization is much less explored. Here, we use time-dependent density functional theory (TDDFT) to address from first principles the nonlinear response of a plasmonic nanoantenna to a circularly polarized electromagnetic pulse. The nanoantenna is represented by a free-electron cylindrical nanowire, and the electric field of the pulse rotates within the plane perpendicular to the nanowire axis. Our results reveal that the optical response at the n-th harmonic of the fundamental wave is governed by the n-th order multipole moment of the induced nonlinear charge density rotating at the fundamental frequency around the symmetry axis of the cylinder. As a result, the induced near fields are circularly polarized at all harmonics of the fundamental frequency with spin angular momentum opposite to the incident field, while frequency conversion in the far field is suppressed. Using an analytical approach, we fully explain these results in terms of the axial symmetry of the system. The understanding of the nonlinear optical response of this many-electron metallic system to spin-carrying electromagnetic fields offers new insights for the nanoscale manipulation of the angular momentum of light using highly symmetric plasmonic nanostructures.

Poster B16 Acoustic response of periodically time modulated ultrathin resistive sheet

Ioannis Stefanou; *l'Université du Mans, Le Mans, France*

Preliminary results will be presented on the acoustic scattering inside a finite duct caused by an ultrathin resistive sheet, a purely resistive wiremesh, when its resistance is periodically modulated in time. This modulation alters the interaction between the wiremesh and the acoustic wave, affecting its propagation. We investigate how the modulated resistance influences the cavity modes and demonstrate that wave amplitude amplification can be achieved, even in this inherently lossy system, along with other interesting effects.

Poster B17 Ultrasonic waves generated in heterogeneous media by absorption of laser line pulses

Antonio Boucher-Bellanger; *University of Bordeaux, Bordeaux, France*

Porous materials are widely used for industrial applications including acoustics, imaging, and defense because elastic waves can be damped due to multiple scattering. To improve the mechanical material response, it is of interest to understand this complex wave dynamics.

This purpose is investigated by means of both experimental and modeling approaches. On the experimental side, a nanosecond laser pulse is focused on the target front surface to generate elastic waves. Their amplitude is observed on the rear surface by using laser interferometry. Due to the complex dynamics, the temporal evolution of the measured signal is relatively complex, requiring an analysis based on modeling to achieve a fine understanding of processes at play. We thus have developed a high-order two-dimensional numerical scheme to solve the elastic wave propagation equation. The porosity is explicitly represented, thus including the multiple scattering. Various materials with different porosity have been studied.

Experimental results show strong discrepancies between the observed dynamics, highlighting the crucial role of porosity characteristics. This observation is confirmed by numerical simulations where the porosity parameters (density, geometry, and size of pores) have been varied. Experimental and theoretical results are then compared to extract information on the porosity of considered materials.

Poster B18 Probing Anisotropic Quasiparticle Dynamics and Topological Phase Transitions in Quasi-One-Dimensional Topological Insulator $ZrTe_5$

Yueying Hou; *Nanjing University, Nanjing, China*

The transition metal pentatelluride $ZrTe_5$ exhibits rich lattice-sensitive topological electronic states, and demonstrates great potential in photoelectric and thermoelectric devices. However, a comprehensive investigation of electron-phonon coupling and phonon scattering process is still lacking, despite their importance for transport properties and device optimization. In our work, we investigated the hot carrier dynamics and a 1.15 THz Ag mode coherent phonon in $ZrTe_5$ by femtosecond transient optical spectroscopy at the range of 10-300 K. Notably, a strong anisotropic transient response, attributed to both excited-state electron relaxation and reflectivity modulation by displacive excited coherent phonons, is revealed by polarization-dependent measurements. The temperature dependence of electron relaxation time in $ZrTe_5$ shows an inflection point, firstly providing the ultrafast dynamical signature of a temperature-driven Lifshitz transition. And at low temperatures, a long-lived electron relaxation component emerge in transient response, may providing the fingerprint of topological surface states in ZrTe5. In addition, we also analyse the temperature-dependent coherent phonon and discover that its scattering is dominated by three-phonon interactions and exhibits a relatively long lifetime compared to other modes. Our work advances the understanding of ultrafast processes in ZrTe5, resolving longstanding questions and paving the way for targeted manipulation of its electronic and phononic functionalities.

Poster B19 Optomechanical synchronization of coupled polariton time crystals

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Ga(Al)As semiconductor microcavities provide a versatile platform for studying the strong coupling between excitons and photons, as well as their interactions with GHz-frequency cavity phonons (bulk acoustic waves, BAWs). This coupling leads to the formation of exciton-polaritons—hybrid quasi-particles that combine the low effective mass and propagation properties of cavity photons with the strong non-linear interactions of excitons. Polaritons in these structures also exhibit efficient coupling to confined cavity phonons, with frequencies ranging from 7 to 100 GHz. Under non-resonant continuous-wave laser excitation, they undergo Bose-Einstein condensation above a critical pump power, forming polariton condensates with a well-defined pseudospin, which arises from the coupling between the light's polarization and the exciton's spin.

We show that the pseudospin can enter a self-sustained precessional motion, spontaneously breaking continuous time-translation symmetry—a defining characteristic of a continuous time crystal (CTC) [1]. When coupled to the mechanical modes of the cavity, the oscillations of the CTC generate an optical force. Increasing optical excitation enhances polariton nonlinearities, shifting the precession frequency toward resonance with a mechanical mode, ultimately triggering self-oscillations of the cavity's mechanical vibrations [2]. This back-action leads to frequency locking of the CTC to the phonon mode [1].

Expanding on this, we investigate interactions between two CTCs by non-resonantly exciting a pair of coupled polariton traps. Spectral analysis reveals individual CTC formation, as well as frequency locking between the respective trap energies at half the cavity phonon frequency. Numerical simulations based on coupled Gross-Pitaevskii equations support these findings, highlighting the roles of Josephson coupling, polariton-polariton interactions, and phonon-mediated coupling in controlling collective time-crystalline behavior in bosonic lattices.

[1] I. Carraro-Haddad et al., Solid-state continuous time crystal in a polariton condensate with a built-in mechanical clock, *Science* **384**, 995(2024).

[2] D. L. Chafatinos et al., Asynchronous locking in metamaterials of fluids of light and sound, *Nat. Commun.* **14**, 195310 (2023).

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