## Session 3: Materials Physics

**Name:** Michele Pigliapochi
**Co-Authors:** G. Gonçalves Dalkiranis, Ll. Abad, A. F. Lopeandia, J. Rodriguez-Viejo
**Title :** Photothermoelectric effect in Si thin films
**Abstract:**
Photothermoelectric effect (PTE) combines the photovoltaic and thermoelectric effects. PTE was first studied by Tauc, who discussed the changes in thermoelectric voltage of Ge single crystals when illuminated. [1] This phenomenon is based on the simultaneous temperature rise and enhancement of Seebeck coefficient, due to carrier injection in the thermoelectric material. In this work we explore the photoresponse of a Si ultrathin film device, designed and developed for this analysis. Measurements performed with this device confirmed a significant modification of the Seebeck coefficient caused by both the injection of photocarriers and the temperature gradients generated by the laser beam and resistive heater. This opens to interesting applications, among which photodetection and enhancement in thermoelectric generation.
[1] Tauc, J. The Thermal Photo-Electric Phenomenon in Semi-Conductors. Cechoslov. Fiz. Z. 1955, 5 (4), 528–535. https://doi.org/10.1007/.

**Name:** Martí Raya Moreno
**Co-Authors:** Riccardo Rurali and Xavier Cartoixà Soler
**Title :** Thermal transport in semiconductor bulk-unconventional phases
**Abstract:**
Most bulk semiconductors normally present either zinc-blende or wurtzite phase. Recent developments in nanofabrication, specially in the nanowire growth field, have allowed the access to both phases at normal conditions. In this work, a wide range of techniques are used to thermally characterize such materials phases ranging from first-principles to Monte Carlo techniques. Using first-principles, a comparison between bulk-stable and the unconventional phases is conducted for 8 semiconductors, focusing on the physical origin of the ratio between wurtzite and zinc-blende thermal conductivity. Furthermore, we present the results for their nanowire counterpart showing the possibility to tune the thermal conductivity ratio with the nanowire diameter. Finally, for device level simulations of such materials, we present a full-band cellular Monte Carlo code that exactly conserves the momentum for three-phonon collisions, using the first-principles data to obtain the scattering rate tables.

**Name:** Lluc Sendra Molins
**Co-Authors:** A. Beardo, J. Bafaluy, F. X. Álvarez, J. Camacho
**Title :** Hydrodynamic heat transport at the nanoscale
**Abstract:**
Hydrodynamics interest in the heat transport field has been growing during last years as a response to the failure of the Fourier's law. Even using the thermal conductivity of the Fourier's law as an effective parameter, there are several experiments at the nanoscale that cannot be explained. The scientific community usually tries to solve this problem with the microscopic interpretation using the Boltzmann Transport Equation (BTE). Nevertheless, this method is computationally unreachable due to the complexity of the equation. We propose the use of the Guyer-Krumhansl equation (GKE) to solve these complex experiments. The shape of the GKE has analogies with the Navier-Stokes equation for fluids, so we can introduce concepts as viscosity that it is not commonly used in this field. This equation can be derived from the BTE and it is a generalization of the Fourier's law. Furthermore, from its derivation, it is easy to obtain boundary conditions. The power of this method is that it can be easily implemented with finite elements and all the parameters appearing in the equation can be calculated with ab initio methods, so it is completely predictive. Here we present the model and we compare it with some experiments that we have been able to predict where Fourier's law fails.

**Name:** Ana Vila Costa
**Co-Authors:** Marta Gonzalez Silveira, Javier Rodríguez Viejo
**Title :** Glass transition in thin film ultrastable glasses: Analyzing the bulk transformation
**Abstract:**
Glasses prepared by physical vapour deposition at substrate temperatures around 0.85Tg present extraordinary thermodynamic and kinetic stabilities, comparable to those of ordinary glasses aged for thousands of years. Due to their improved packing, these thin film vapour deposited glasses transform into the supercooled liquid via parallel growth fronts that initiate at the free surface/interfaces, at least for the first stages of the transformation [J. Phys. Chem. B 118(36), 10795–801, (2015)]. Stability can be further increased by arresting these propagation fronts by capping the surfaces with a higher Tg material [Phys. Chem. Chem. Phys., 20, 29989-29995 (2018) ]. Using this strategy, the glass transition of these ultrastable glasses takes place via a homogeneous transformation mechanism. In this work we use quasi adiabatic fast-scanning nanocalorimetry to study the characteristics of this homogeneous mechanism in ultrastable glasses. The results show that the kinetic stability during annealing treatments increases by a factor 25-50 with respect to the uncapped stable glasses. In addition, we also identify the existence of two different glass transition mechanisms. Ultrastable glasses transform both via a rejuvenation process that is compatible with a cooperative mechanism, like the one observed in less stable glasses and via a nucleation and growth-like process which dominates the transformation rate.

## Session 2: High Energy Physics

**Name:** Marcel Algueró
**Co-Authors: ----**
**Title :** Flavour Changing Neutral Currents
**Abstract:**
We study from a phenomenological point of view flavour processes such as semileptonic B decays, where several anomalies showing deviations from Standard Model predictions have been consistenly experimentally measured. The fact that these kind of processes (so-called Flavour Changing Neutral Currents) happen at loop level offers a window to explore the structure of New Physics at energies that can be reach in current detectors.

**Name:** Miguel Ángel Caballero Pacheco
**Co-Authors:** Carles Domingo, Arnaud Devienne, María José García Fusté.
**Title :** Characterization of the neutron field at the ALBA synchrotron
**Abstract:**
Synchrotron light is produced at ALBA from electrons at 3 GeV in a storage ring of about 270 m circumference. Electrons are initially accelerated by a LINAC up to 110 MeV, then transferred to the booster where they are accelerated to 3 GeV, and are finally transferred to the storage ring where they produce the synchrotron radiation used at the experimental stations. Transfer lines between LINAC and booster and between booster and storage ring are the most likely places where electrons may interact with beam elements. Although cross sections for neutron production from electrons are small, a considerable number of neutrons may result from these interactions given the relatively high beam intensity. Neutrons also show up due to the interaction between Bremsstrahlung photons and matter. Neutron production was simulated at these places using FLUKA. Neutron fluence measurements were performed with the UAB Extended Range Bonner Sphere Spectrometer (BSS), able to detect neutrons from the thermal energy region up to at least 1 GeV. The response matrix of the spectrometer was extended to 3 GeV Measurements took place in a point at 149 cm from the scraper, inside the shielding tunnel, and in a point close to this position but outside the tunnel, in the

experimental hall. Spectrometric results from simulation and measurements will be presented, as well as fluence and ambient dose equivalent values. A discussion will be presented about the particularities and difficulties related to this type of measurements and simulation.

**Name:** Victor Cancer Castillo
**Co-Authors:** Oriol Pujolas, Matteo Baggioli
**Title :** Scale Invariant Solids
**Abstract:**
Scale invariance (SI) can in principle be realized in the elastic response of solid materials. There are two basic options: that SI is a manifest symmetry or that it is spontaneously broken. The manifest case corresponds physically to the existence of a non-trivial infrared fixed point with phonons among its degrees of freedom. We use simple bottom-up AdS/CFT constructions to model this case. We characterize the types of possible elastic response and discuss how the sound speeds can be realistic, that is, sufficiently small compared to the speed of light. We also study the spontaneously broken case using Effective Field Theory (EFT) methods. We present a new one-parameter family of nontrivial EFTs that includes the previously known `conformal solid' as a particular case as well as others which display small sound speeds. We also point out that an emergent Lorentz invariance at low energies could affect by order-one factors the relation between sound speeds and elastic moduli.

**Name:** Sebastian Pina-Otey
**Co-Authors:** Federico Sanchez-Nieto, Vicens Gaitan-Alcalde
**Title :** Likelihood-free inference on physical simulators using Deep Learning
**Abstract:**
In many areas of science, stochastic systems are modeled via simulators, which depend on meaningful parameters of such models, relating them to the observed quantities. These simulators often have inaccessible or intractable likelihoods, making the process of Bayesian inference difficult, having to resort to approximate methods such as binned likelihood. In this work we present a way of performing exact inference using autoregressive flows, a family of Neural Networks focused on the task of density estimation through data, including the conditional density of a likelihood. In particular, we will present such an inference task in the context of the T2K neutrino oscillation experiment analysis, showing our approach using Neural Spline Flows (a specific realization of the autoregressive flows) on a simplified oscillation problem. We compare the results of this method with standard binned Bayesian inference for this kind of problems, and assess the validity of it.

## Session 3: Quantun Information

**Name:** Matias Bilkis
**Co-Authors:** John Calsamiglia, Matteo Rosati
**Title :** Multi-armed bandit problem
**Abstract:**
In this very brief talk I will present a problem known as 'multi-armed bandit problem'. With this, I will talk about optimal control in a simple quantum communication scenario, and explain how machine learning can help to achieve it in challenging situations.

**Name:** David López-Núñez
**Co-Authors:** Rafael Luque Merino, Marco Pfirmann, Martin Weide, Sergio Valenzuela, Pol Forn-Díaz
**Title :** Dynamic control of superconducting qubits

**Abstract:**
Many problems considered as unsolvable in today's computers could be solved in a universal fault-tolerant quantum computer. Optimization algorithms are one of the main areas in which a quantum computer could have an enormous effect, as well as so diverse fields as quantum chemistry or criptography. Among all the different physical implementations of such a device, superconducting circuits (SC) are one of the leading platforms. One of the main advantages of SC is the great design tunability and variability of the devices, thanks to the fact that they are manufactured with a well-know technology. Circuit Quantum Electrodynamics (cQED) describes the interaction between these circuits and the cavity or resonator with which they interact, which can be modeled as an atom in a cavity. This interaction provokes a state-dependent shift on the cavity resonance, allowing us to measure the state of the qubit by probing the cavity. Here we will present how to make a dynamic control of the qubit through the application of microwave pulses. This control is fundamental for applying quantum gates in quantum algorithms.

**Name:** Esteban Martínez-Vargas
**Co-Authors:** Ramon Muñoz-Tapia
**Title :** Certified answers for ordered quantum discrimination problems
**Abstract:**
Quantum discrimination is a fundamental task in quantum information science. This task consists in estimating which of several quantum hypothesis has been given to us. The simplest and most studied case is when we have just two hypothesis. The case of multiple hypothesis (more than two), despite being very important remains being a challenge. We found that if a set of multiple quantum hypothesis have a special structure, novel discrimination techniques can be implemented. We obtain an efficient semidefinite program and also find a general lower bound valid for any error distance that only requires the knowledge of an optimal minimum-error scheme. We apply our results to the cases of quantum change point and quantum state anomaly detection.

**Name:** Andreu Riera-Campeny
**Co-Authors:** ---
**Title :** An Introduction to Open Quantum Systems
**Abstract:**
The laws of quantum mechanics are known to govern any system that is perfectly isolated from its environment. However, this is not the usual situation in nature: physical systems talk to each other. A natural question is whether exists a description of a –quantum—system that interacts with the environment. The answer is positive and is given by the theory of open quantum systems. This talk aims at giving a brief self-contained introduction to this field.

## Session 4: Optics and Electromagnetism

**Name:** Albert Van Eeckhout
**Co-Authors:** Angel Lizana, Juan Campos
**Title :** Polarimetric methods for biomedical applications.

**Abstract:**
Complete characterization of biological samples is of interest in different industrial and research fields, as for instance, in biomedical applications, for the recognition of organic structures or for the early detection of some diseases. During the last decades, polarimetric methods are experiencing an increase of attention in the study of biomedical tissues, and they are nowadays used in such framework to both provide qualitative (polarimetric imaging) and quantitative (data processing) information of the studied samples. In this context, my PhD thesis is focussed in two main research lines: (1) the development of mathematical metrics useful to describe the physical properties of

polarizing samples; and (2) the use of such metrics in the context of biomedical applications. To this aim, we use the Mueller matrix formalism as an ideal framework to work with polarizing samples. Under this formalism, 4x4 Mueller matrices can be understood as the polarimetric transfer function of samples, and fully describes the polarimetric light-matter interactions. The polarization modifications produced by a sample on an incident light beam can be originated by a number of complex internal processes, but can be roughly understood as the result of the combination of three pure polarimetric features of the sample: its diattenuation, its retardance and its depolarization. However, in general, these characteristics are mixed in the different coefficients of the Mueller matrix of the sample. One of my research topics has dealt with the search of mathematical metrics, based on the synthetization of the information encoded in the Mueller matrix, to reveal important information of samples both from a qualitative or quantitative point of view. In particular, we mainly focussed in the study of the depolarization content of samples, as we have found that this channel is especially significant to reveal information of biological samples. Another main research line of my PhD deals with the application of the developed metrics in biomedical applications. In such field, we have found how depolarizing information revealed biological structures that were hidden in regular intensity images and thus they are highly useful to characterize organic structures with a non-invasive method. This could be useful for tissues auto-recognition in clinical processes, or for some diseases early diagnosis. Last but not least, the potential of the developed techniques to be applied in biological applications has been tested not only in the context of animal samples, but also in vegetal samples, where we have obtained promising results.

**Name:** Jordi Alcalà Barrat
**Co-Authors:** Alejandro Fernández, Cornelia Pop, Anna Palau, Narcís Mestres,Susagna Ricard,Teresa Puig, Xavier Obradors.
**Title :** Vortex Pinning, Dynamics and Resistive Switching of Nanostructured YBCO Thin Films and Nanocomposites
**Abstract:**
Resistive-switching devices have become a leading candidate to mimic key characteristics of biological components in a neural network, while providing clear advantages in energy and scalability [2,3]. The resistive switching effect consists of a non-volatile reversible switch between different resistance states, induced by an electric field [4]. Strongly correlated metal oxides showing metal-Mott insulating transitions (MIT) appear as particularly interesting materials for future neuromorphic device architectures, with large resistance variations, that may be induced with small carrier concentration modulations, driven by an electric field [5].
The ability to continuously tune the electrical resistance, as well as to obtain high nonlinearly behaviour, positions them uniquely as an effective way to mimic neurons and synapses on a device level [6]. Moreover, a key advantage of using Mott insulators to mimic neuromorphic devices is the possibility to induce both non-volatile and volatile functionalities in the same material. Synaptic plasticity needs to be non-volatile whereas neuron spikes may be volatile. In this project we aim to explore the potential of strongly correlated metallic perovskite films, showing a tuneable metallic-insulator phase transition (MIT), to artificially mimic the behaviour of the two basing blocks of neuromorphic systems (neurons and synapses), using the design flexibility provided by the material itself.
Superconducting magnetic systems are the ultimate enabling technology for fusion device, based on magnetic confinement concept. The most advanced fusion reactors exploit superconducting magnets based on LTS that may be cooled at liquid helium temperature. However, in perspective of sustainable commercial fusion reactors, the possibility to use HTS (with operation temperatures > 4.2 K) offer clear technological advances with higher efficiency in cooling and reduction in the reactor complexity. High temperature $YBa_2Cu_3O_{7-d}$ (YBCO) coated conductors offer a realistic vision for high

field (B > 13–20 T), low temperature (T < 50K) conditions of fusion devices. In general pinning performance of YBCO films have been optimized for applications in liquid nitrogen temperature (65-77K) at intermediate fields (0-5T) and up to date, relatively poorly knowledge exists on their performance at low temperatures.