



Congratulations to New ICFO PhD Graduate

Dr David Moreno Mencia graduated with a thesis entitled *The Application of Broadband Ultrafast Spectroscopy to Reveal Structural, Magnetic and Electronic Dynamics in Quantum Materials*

November 22, 2021

We congratulate Dr David Moreno Mencia who defended his thesis today in ICFO's auditorium with online participations due to social distancing to contain the Coronavirus pandemic.

Dr Moreno Mencia obtained his MSc degree in Photonics from the joint Photonics program of the UAB, UB, UPC and ICFO. He joined the Ultrafast Optical Dynamics of Solids research group led by Prof Dr Simon Elliot Wall to carry out his PhD studies on the characterization of a femtosecond mid-IR light pulse for time-resolved optical spectroscopy. Dr Moreno Mencia thesis entitled *The Application of Broadband Ultrafast Spectroscopy to Reveal Structural, Magnetic and Electronic Dynamics in Quantum Materials* was supervised by Prof Dr S

mon Elliot Wall.

ABSTRACT:

In the last decades, quantum materials have received much attention in the field of condensed matter physics due, in part, to their exotic properties. These are difficult to understand as they result from multiple physical interactions with similar strength, such as charge, spin, orbitals and phonon degrees of freedom.

To study and control these interactions, the use of light has emerged as a powerful tool. For example, thanks to recent advantages on X-ray sources it has been possible to improve our understanding of how the atomic structure of quantum materials changes upon photo-excitation. However, these experiments are difficult and there are only a few facilities in the world to perform them. In contrast to X-ray sources, table-top ultrafast laser systems allow us to measure in a systematic manner by performing optical pump-probe spectroscopy. The versatility of this approach enables the simultaneous monitoring of the different degrees of freedom that dictate the properties of quantum materials. In this thesis, we use pump-probe broadband spectroscopy in the visible region to study the structural, electronic and magnetic dynamics with unprecedented detail in two key quantum materials such as $\text{Sr}_3\text{Ir}_2\text{O}_7$ and V_2O_3 . In $\text{Sr}_3\text{Ir}_2\text{O}_7$, a compound that undergoes a magnetic phase transition, firstly we study how photo-excitation affects to the reflectivity at a wide range of energies. This provides us information about the electronic and structural properties of this compound. Secondly, we show how to control magnetic order by photo-excitation and demonstrate that light can non-thermally suppress the magnetic long-range order in this material.

In V_2O_3 we characterize its insulator to metal and structural phase transitions. In the metallic state, we show that a key phonon mode is very sensitive to sample inhomogeneity. When taking this into account, we find no evidence for non-thermal lattice dynamics in contrast to existing literature. Furthermore, we show that the light induced transition from the insulator to metallic phase proceeds along a highly damped and incoherent pathway, where vibrational coherence is not observed.

Thesis Committee:

Prof Dr Paul van Loosdrecht, Cologne University

Prof Dr Dmitri K. Efetov, ICFO

Prof Dr Michael Gensch, Institute of Optics and Atomic Physics