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The Institute  
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Erasmus+

## Master in Photonics – “PHOTONICS BCN” Master ERASMUS Mundus “EuroPhotonics”

### MASTER THESIS PROPOSAL

**Dates: April 2021 - September 2022**

**Laboratory:** Quantum Optics Theory/Ultrafast Dynamics Quantum Solids

**Institution:** ICFO – The Institute of Photonic Sciences

**City, Country:** Castelldefels, Spain

**Title of the master thesis:** “The most non-linear optics: Phase change materials”

**Name of the master thesis supervisor and co-supervisor:** Dr. Allan Johnson and Prof. Maciej Lewenstein

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**Keywords:** Nonlinear optics, ultrafast, femtosecond, quantum materials, phase change materials, pulse characterization, FROG

#### **Summary of the subject (maximum 1 page):**

Strong laser pulses can induce non-linear optical responses in materials, which underpin the operation of almost all modern photonic systems. The most common description of optical non-linearities is in terms of a power series expansion in the field strength, leading to the concept of second-order, third-order, etc. nonlinear responses. Very strong pulses cause this picture to breakdown [1], leading to non-perturbative non-linear optics, for example exponential field dependences [2,3].

In this project you will explore the ultimate limit of optical non-linearity, the *discontinuous* response of phase change materials. Photo-induced phase transitions can exhibit an abrupt change in optical properties at the critical fluence which initiates the phase transition [3], but their unique non-linear optical properties are barely explored. Here we will use ultrafast pulse characterization techniques to measure the optical response of a phase change material on the driving laser pulse for the first time. We will build up a description of the discontinuous response, which could lead to an entirely new class of non-linear optical materials with applications in optical modulators, couplers, laser cavities and beyond.

[1] R.W. Boyd, Non-linear Optics (8<sup>th</sup> ed)

[3] Lewenstein *et al.*, Phys. Rev. A. (1994)

[2] Popmintchev *et al.*, Science (2012)

[4] Perez-Salinas *et al.*, arXiv:[2103.09502](https://arxiv.org/abs/2103.09502) (2021)

#### **Additional information (if needed):**

\* Required skills: Nonlinear optics, ultrafast optics

\* Miscellaneous: Python experience a plus