PhD course:

# "Photophysics of organic and perovskite materials and devices"

# SYLLABUS

## 1 Lecturers' information

**Name and Surname**: Alberto Privitera

*Affiliation: Department of Industrial Engineering, University of Florence*

e-mail: alberto.privitera@unifi.it

**Name and Surname**: Marcello Righetto

*Affiliation: Department of Condensed Matter Physics, Clarendon Laboratory, University of Oxford*

e-mail: marcello.righetto@physics.ox.ac.uk

Proposed by: Alberto Privitera

## 2 Title of the course

Photophysics of organic and perovskite materials and devices

## 3 Course program

The fields of organic and perovskite electronics have seen a burgeoning growth over the last 20 years. At the same time, our scientific understanding of those photophysical processes underlying optimum device performance has significantly improved. Our improved comprehension has ultimately allowed disclosing new intriguing mechanisms that will revolutionise technological applications of organic and perovskite semiconductors and as a result our day-to-day lives.

This course gives an overview of our present-day knowledge of the physics behind organic and perovskite-based devices and the future perspectives for these technologies. A comprehensive review of the elementary excitations processes and dynamics will be provided together with molecular approaches to control them. Specific attention will be focused on the unique role of species with unpaired spins which have recently demonstrated tremendous potential to revolutionise the field of organic and perovskite electronics.

## 4 Course content detailed per lesson of two hours (possibly with dates and room real and virtual)

Lesson 1 – Review of solar cell principles. Next-generation photovoltaic technologies. Introduction to chemistry and physics of organic solar cells.

Lesson 2 – Elementary excitations and spin processes in organic devices (e.g. polarons, singlet/triplet excitons, and charge transfer states). Spin managing: future perspectives for organic optoelectronics.

Lesson 3 – Introduction to the chemistry and physics of metal halide perovskites, from octahedral building blocks to high-performance semiconductors.

Lesson 4 – Excited state dynamics beyond highly-efficient perovskite solar cells (e.g. excitonic interactions, large polarons, bimolecular recombination). Spin-orbit coupling and spin-polarized charge carriers in perovskites.

## 5 Suggested reading

- The Physics of Solar Cells by Jenny Nelson
- Organic Solar Cells: Theory, Experiment, and Device Simulation by Wolfgang Tress
- The Physics of Solar Cells: Perovskites, Organics, and Photovoltaic Fundamentals by Juan Bisquert
- Halide Perovskites: Photovoltaics, Light Emitting Devices, and Beyond by Tze Chien Sum

## 6 Learning Objectives

- General understanding of the basic principles of next-generation photovoltaics.
- Comprehension of the main photophysical and spin processes in organic and perovskite-based materials.

## 7 Knowledge and Skills to be acquired

- Understanding how molecular and material engineering can be used to control device photophysics and performance.
- Understanding how to apply the fundamental concepts of organic and perovskite photophysics to other (opto)electronic technologies, such as light-emitting diodes, sensors, spintronics, and quantum information.

## 8 Prerequisites

Suggested but not needed:

Physical chemistry or spectroscopic methodologies, Solid-state physics or chemistry

## 9 Teaching Methods

☐ MODE 1 - Pre-recorded lessons uploaded on the moodle platform (a meeting must be organized with PhD students in order to clarify eventual doubts)

☑ MODE 2 (preferred) - Lessons delivered in-person and in remote with simultaneous recording by the WEBEX platform

## 10 Further information

## 11 Type of Assessment

The final evaluations will have to be validated maximum 1 month after the end of the course.

Critical review and discussion of a scientific paper focusing on topics covered in the course.

## 12 Period

End of April, beginning of May.