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**ICFO**  
The Institute  
of Photonic  
Sciences



Erasmus+



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Initiative d'excellence  
Aix-Marseille



## **Master in Photonics – “PHOTONICS BCN” ERASMUS+ “EUROPHOTONICS”**

### **MASTER THESIS PROPOSAL**

**Dates: April - September 2020**

**Laboratory : ICFO-QOT**

**Institution: Institut de Ciències Fotoniques**

**City, Country : Casteldefels, Spain**

**Title of the master thesis: Frontiers of Machine Learning, Quantum Simulations and Many Body Physics**

**Name of the master thesis supervisor: Maciej Lewenstein**

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Phone number : 626723233

Mail address : Carrer de Veciana 19, 08023 Barcelona

**Keywords : machine learning (ML), quantum simulations, many body physics**

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

The MSc student will join one of the running research projects in the ICFO-QOT. The concrete choice will depend on the current efforts in the group (that change adjusting to scientific needs), student's preferences and preparation, availability of supervisor/co-supervisor and resources for a specific theme. At this stage ICFO-QOT can absorb two (maximally three) MSc students in this area. QOT-ICFO studies and develops:

- 1) Quantum-applied ML/AI; we apply conventional ML/AI methods to help improve QIP tasks, especially in the context of quantum phases and phenomena recognition, designing, improving, and controlling quantum experiments;
- 2) Quantum-enhanced ML/AI, i.e. designing and applying quantum and quantum-inspired algorithms for (classical/conventional) ML problems. This includes the merging and superposing theory of tensor networks and neural networks, the design of hybrid quantum-classical algorithms for optimization problems of ML, etc. We work also on a fully classical statistical physics approach to optimize ML optimization problems providing a benchmark and challenge for the quantum ML.
- 3) We work on the design, implementations and quantum advantages of quantum neural networks, with a focus on ultracold atoms and ions, in the spirit of "old quantum perceptron" from 1994, but enriched by novel technologies and possibilities of quantum experimental physics.



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**Additional information :**

\* Required skills: Good level of theoretical physics, numerical methods and computer skills, good knowledge of mathematical methods of physics and statistics.

\* Miscellaneous :