Quantum Optics Group led by **Prof. Maciej Lewenstein** start a new, third in the row European Research Council Advanced Grant, entitled NOQIA. The abstract of the project is attached below. This is a very interdisciplinary project connecting different areas: atto-science, quantum simulators, topological effects in physics and quantum machine learning and quantum neural networks.

The project will run 5 years starting from 1st July 2019. There will be:

- Three openings for postdocs. The applications should be submitted through our Jobs Opening site https://jobs.icfo.eu/, although I encourage you to contact Prof. Maciej Lewenstein personally via email (maciej.lewenstein@icfo.eu). The deadline is 30/06/2019, although we will keep openings until the positions are filled. The requirements include excellent knowledge of theoretical physics, analytic and numerical methods, with focus on attoscience, quantum simulators with various platforms (ultracold atoms, ions, superconducting qubits, circuit QED etc.), classical and quantum machine learning and neural networks, and topological effects in condensed matter, high energy and AMO physics.
- Three openings for PhD students. The applications should be submitted through our Jobs Opening site https://jobs.icfo.eu/, through the standard ICFO procedure. The candidates should explain in the letter of interest their preference for NOQIA. They are encouraged, obviously, to apply for co-funded or even funded PhD stipends that are usually available in ICFO PhD calls. Along the year, there are two “big” and two “small” calls with corresponding deadlines.

NOvel Quantum simulators – connectIng Areas

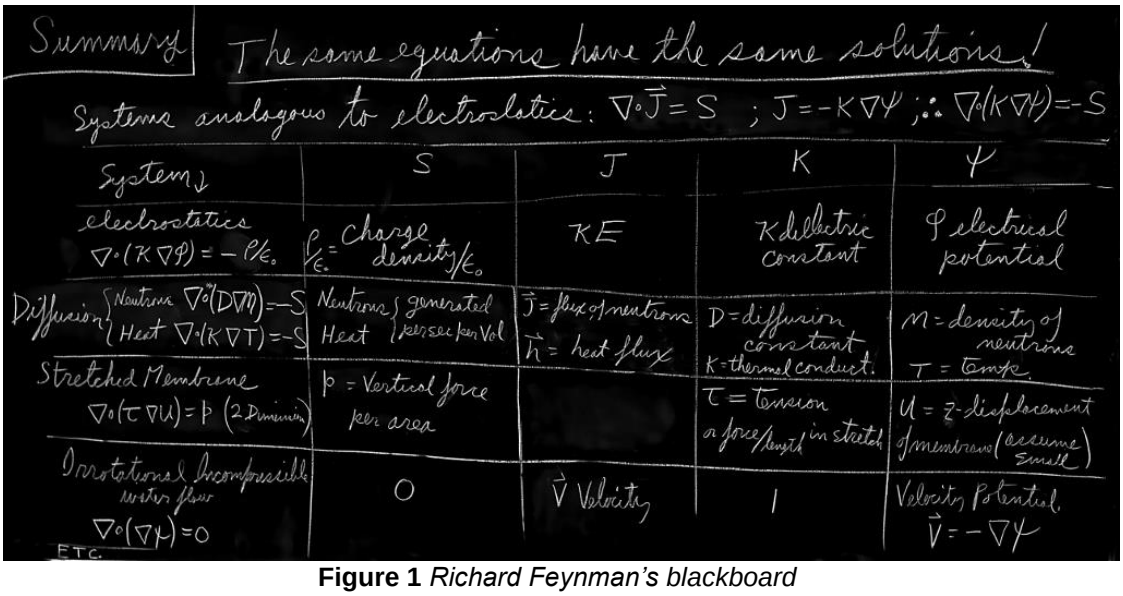

Figure 1 *Richard Feynman’s blackboard*

Quantum simulators (**QS**) are experimental systems that allow mimic complex, hard to simulate models of condensed matter, high energy physics and beyond. One realizes QS with various

platforms: from ultracold atoms and ions to Josephson junctions/superconducting qubits. They constitute the important pillar of quantum technologies (**QT**), and promise future interdisciplinary applications and solutions in chemistry, material science and optimization problems. Over the last decade, QS were particularly successful in mimicking topological effects in physics (**TEP**) and in developing accurate quantum validation and certification (**QVC**) methods. NOQIA is a theory project, aimed at introducing the established field of **QS+TEP+VC** into two novel areas: physics of ultrafast phenomena and attoscience (**AS**), on one side, and quantum machine learning (**ML**) and neural networks (**NN**) on the other. This will open up new horizons and opportunities for research both in AS and in ML/NN. For instance, in AS we will address the question if intense laser physics may serve as a tool to detect topological effects in solid state and strongly correlated systems (including graphene, twisted bilayer systems etc.). We will study response of matter to laser pulses carrying topological signatures, to determine if they can induce topological effects in targets. We will design/analyse QS using trapped atoms to simulate, understand and detect topological phenomena in the AS. We will also pay special attention to studies of decay processes with multiple fragments, such as multi-electron ionization or molecule dissociation, and their QS analogues – here the understanding of few- and many body quantum correlations is another challenge. On the ML/NN side, we will apply classical ML to analyse, design and control QS for topological systems, in order to better understand and optimize them. Conversely, we will transfer to ML the many-body techniques, such as tensor networks, to analyse and possibly improve performance of classical machine learning. We will design and analyse quantum neural network devices that will employ topology in order to achieve robust quantum memory or robust quantum information processing. We will design/study attractor neural networks with topological stationary states, or feed-forward networks with topological Floquet and time-crystal states. Both in AS and ML/NN, NOQIA will rely on quantum validation and certification protocols and techniques.

Recently, because of fascinating challenges and open questions, there has been a growing interest at the interface of QS, TEP and both AS and ML. The PI, with his uniquely broad and crucial experience, will lead NOQIA towards the novel, breakthrough interdisciplinary discoveries in all of these areas.