MINISTERIO
DE ECONOMÍA
Y COMPETITIVIDAD

ICMAB
INSTITUT DE CIÈNCIA DE MATERIALS DE BARCELONA
EXCELENCIA SEVERO OCHOA
CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

EXPRESSION OF INTEREST FOR DOCTORAL PROGRAMME COFUND DOC-FAM

PROJECT TITLE / JOB POSITION TITLE:

Learning from neuromorphic vision systems using time causality of optical stimuli

JOB POSITION DESCRIPTION:
(max. 2.000 characters – including spaces)
Include all the relevant information about the position, role and responsibilities required within the project/group

As described in the Research Project, the candidate will follow his/her PhD Thesis in the field of neuromorphic engineering. To achieve this objective, he/she will have access to all required laboratories, all located within ICMAB premises. In particular, he/she will access our advanced optical laboratory, which include optical spectroscopy and high-resolution imaging tools. The candidate will follow an intensive training, so as to ensure a solid understanding of the techniques. The student will be acquainted with state-of-the art techniques that allow real-space imaging with diffraction limitation [see our References below]. This is relevant for the full characterization of synaptic-like devices excited by short optical stimuli. Artificial neuron networks will be defined so that electric transport can be done with in-situ excitation of the small synapses by optical stimuli controlled to timescales down the microsecond. The candidate will be responsible with defining the required devices in the clean room facilities using optical and electron-beam lithography to define small optical devices with length scales from around 100 nm up to around 100 microns. The candidate will also take advantage of Python-based algorithms to model neural networks, especially regarding the possibilities of learning from visual scenes and the applying artificial neuromorphic vision to build cognitive maps akin to those that enable space navigation in the brain.

The supervisor of the project will provide all the necessary means for the successful candidate to attend schools and relevant international scientific meetings and workshops.

USEFUL REFERENCES:
[1] O. Vlasin et al., Scientific Reports 5 15800 (2015); [2] Casals et a., Phys. Rev. Lett. 117, 026401 (2016). [3] Casals et a., Phys. Rev. Lett. 120, 217601 (2018).

RESEARCH PROJECT / RESEARCH GROUP DESCRIPTION:
(max. 2.000 characters – including spaces)

Over the recent years, we have investigated the properties of quantum wells (QWs) at the $LaAlO_3/SrTiO_3$ interface, including 2D superconductivity, Rashba spin-orbit fields and lattice vibrational modes [1-3]. More recently we uncovered persistent photoconductance (PPC), whereby the system changes its conductance in a plastic way, retaining memory from its past history, as in the case of memristors, but using light instead of electric pulses. Our most astounding discovery (yet unpublished [4]) is that light pulses can be used to replicate spike timing-dependent plasticity (STDP). STDP was proposed to emulate time causality of electro-chemical signals in biological neurons: pre-synaptic neurons spiking after post-synaptic neurons are "anti-causal" and learning is weakened; pre-synaptic neurons spiking before post-synaptic neurons are causal, reinforcing learning. STDP enables unsupervised learning, without need of labelling training data.

Our discovery is particularly relevant, as it extends the STDP concept beyond electrical stimuli to the realm optical stimuli, opening up whole new perspectives on neuromorphic engineering and in artificial vision. More specifically, our project aims at generating neuronal spikes in our physical system –e.g., using, among other approaches, RC differentiators, where R and C are defined in the QWs–. The candidate will be trained in Python-based algorithms that will help to understand how artificial networks can be designed to learn from visual inputs, with the ultimate objective of building a first design that may learn from simple visual patterns. The student will be supervised by Dr. Gervasi Herranz, whose activity can be reached through the Researcher ID: G-2770-2014

[1] Pesquera et al., Physical Review Letters 2014.
[2] Herranz et al., Nature Communications 2015.
[3] Gazquez et al., Physical Review Letters 2017.
[4] Y. Chen et al., to be submitted soon.

ACADEMIC BACKGROUND / SKILLS:
(max. 1.000 characters – including spaces)
Include all the relevant information about the expected academic requirements and skills required for the position

Candidates should be fluent in English, both spoken and written, with a strong background in solid state physics and optics. Programming and mathematical skills will be particularly appreciated. A curious, enquiring spirit and enthusiasm for Science are more than welcome.

GROUP LEADER:

Title: Dr.
Full name: Gervasi Herranz
Email: gherranz@icmab.cat
Research project / Research Group website: http://departments.icmab.es/mulfox/

RELATED LINKS TO THE POSITION (optional)
URL: https://gervasi-herranz.blog

Title link: