"Neurophysics: a new physics frontier to understand the structure of the brain and its function."

Joaquin Torres (Universidad de Granada)

Abstract:

After more than a century of intense multidisciplinary research in neuroscience, very innovative and highly ambitious research initiatives have started in recent years (such as the Human Brain Project, the BRAIN Initiative, etc.), which pursue the challenge of understand in depth the fundamental mechanisms governing the behavior of the brain. These initiatives seek not only to explain emerging high-level brain phenomena such as memory, learning, decision-making, processing of spatio-temporal information, and ultimately the very nature of consciousness, but also understanding why neurological disorders occur and exploring what would be the best strategies to cure them. In this talk, I will focus on describing the aspects in which physics and mathematics can play a fundamental role in understanding some of these high level brain functions. I will describe, in particular, how many of them emerge as a consequence of having a very large number of excitable elements -- that is the neurons communicating each other by complex mechanisms through the synapses --, the existence of the nonlinearities in the dynamics that determine the behavior of neuron and synapses, and the structure of the neural network of the brain itself. I will expose also how physics can explain the appearance of new phenomenology in biologically motivated neural networks models that has not been described so far and which could also appear in experiments in actual neural systems.