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Talk 2:

Noise-induced order in collective neural populations

In this talk we will examine the effect of neuronal and tissue-wide excitability on the regularity of the collective oscillations exhibited by cortical neuronal networks in different behavioral situations. We first discuss the narrow-band rhythmic activity between 30 and 90Hz, known as gamma oscillations, exhibited by primary cortical areas upon sensory stimulation. We show that, when embedded in a balanced network, type-I excitable neurons entrained to the collective rhythm show a discontinuity in their firing-rates between a slow and a fast spiking mode. This jump in the spiking frequencies is characteristic to type II neurons, but is not present in the frequency-current curve (f-I curve) of isolated type I neurons. Therefore, this rate bimodality arises as an emerging network property in type I population models, which allows two encoding mechanisms, for input rate variations and LFP phase, to coexist within the network.

In the second part of the talk we will examine the effect of tissue excitability on the regularity of the UP/DOWN oscillations exhibited by cortical networks under conditions of slow-wave sleep and anaesthesia. Experimental results show that the periodicity of these oscillations is highest for an intermediate excitability level, as controlled by the extracellular potassium concentration applied to the tissue. A mathematical model, based on a partially structured network of conductance-based neurons, allows us to relate the excitability level to the amount of background synaptic noise affecting the network. Under this interpretation, we can interpret the enhanced regularity observed experimentally as an instance of stochastic coherence, typical of nonlinear systems subject to noise. In contrast with traditional examples of stochastic coherence, here the phenomenon is an emerging property of the network.