A "generic" mechanism for synchronous chaos in neuronal networks ?

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Electrophysiological and anatomical data indicate that many regions of the cerebral cortex are functionally organized. For instance, in primary visual cortex, where neurons display selective responses to the orientation of elongated stimuli, cells with similar preferred orientations tend to interact more than those with different preferred orientations. These patterns of connectivity can influence the intrinsic local cortical dynamics as it has been shown in the framework of the classical "ring model" used in modeling feature selectivity in cortex.

My talk focuses on the dynamics of networks consisting of an excitatory and an inhibitory population of neurons with a ring architecture. I will briefly review the spatio-temporal patterns that arise when interactions are instantaneous, as in the classical ring model. Then I will show that the presence of delays, due for instance, to the kinetics of spike generation, finite-velocity propagation of action potentials, synaptic dynamics and dendritic integration, gives rise to a wealth of new bifurcations leading to a very rich phase diagram. In particular the network display synchronous chaotic activity in a broad region of its phase diagram. This chaotic regime requires interactions dominated by inhibition at short range and by excitation at long range. We find it both in networks of spiking neurons and in population rate models. Numerical integration of the mean field equations show that in population rate models the chaotic regime emerges via period doubling. Simulations suggest that sub-harmonic cascades also occur in networks of spiking neurons.

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