Nontrivial effects of noise in excitable electronic circuits

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We present experimental results on noise-induced synchronization, stochastic resonance, coherence resonance and frequency matching using two non-identical weakly coupled electronic models of a neuron. Electronic neurons are always non-identical due to the value dispersion of the electronic components, and they are unavoidably coupled when using a common noise source. Our circuit can be tuned to self-oscillate so as to produce (i) single spikes at non-regular inter-spike intervals, or (ii) spikes that are interspersed with two- and three-spike bursts. The phase portrait shows a stable limit cycle and a saddle point, originating thus a stable and an unstable manifold, both necessary to get noise-induced phase synchronization according with previous theoretical models. By applying to two such "neurons" a common noise of increasing intensities, their initially very different instantaneous frequencies tend to match and the system's behavior to become periodic. We show that this effect is noise-mediated, rather than due to the weak coupling. The measured activation times become equal in both oscillators for a definite noise intensity, and the same occurs for excursion times. Experimental evidences support the hypothesis that the mechanisms of coherence resonance are operating.

The plot of the phase differences between the spike sequences in both circuits as function of time for different noise intensities shows plateaus with different durations, indicating phase synchronization induced by the common noise. Nevertheless, complete synchronization has not been observed.

Our experimental results are relevant for real neurons, since our circuit shares the same bifurcation scenarios, and the underlying mechanism—namely conductivity change—is the same. These experiments may thus help understand how neurons transmit, encode and process information.