Effect of coupling strength heterogeneity on stochastic resonance in small-world networks of coupled neurons

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We investigate the impact of coupling strength heterogeneity on stochastic resonance (SR) in small-world networks of coupled FitzHugh–Nagumo model neurons. Heterogeneity is introduced by drawing coupling strengths from a Gaussian distribution. The SR response is analyzed under both zero and finite time delays, and in the presence of either common Gaussian noise (shared across all neurons) or independent Gaussian noise (distinct for each neuron). In the absence of time delay, SR remains robust against coupling heterogeneity. However, even a small time delay fundamentally alters this behavior, making SR highly sensitive to heterogeneity. Under delayed conditions, SR is weak at low levels of diversity but becomes significantly enhanced as heterogeneity increases. These findings highlight a nontrivial interplay between coupling diversity, temporal delays, and noise structure in shaping stochastic resonance in neuronal networks.

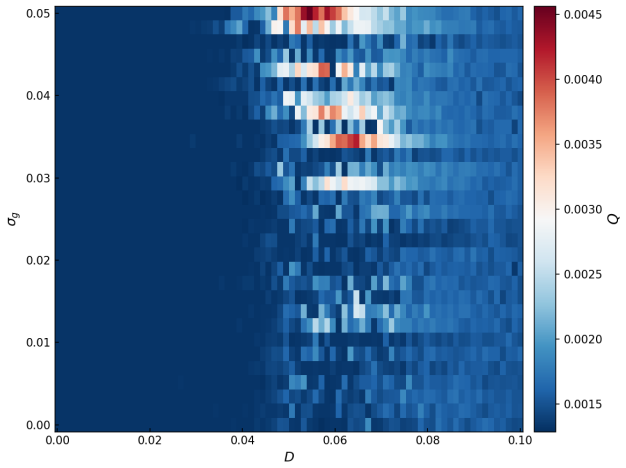

Figure 1: SR response Q vs. noise amplitude D for varying coupling strength diversity σ_g, under fully independent Gaussian noise, for time delay $\tau = 31$ time steps.