A simple parameter can switch between different weak-noise-induced phenomena in a simple neuron model

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Can real biological neurons having similar physiological features and synaptic inputs encode very different information [1]? Mathematically speaking, the answer is yes. Here, we show theoretically and numerically that two very different weak-noise-induced phenomena: self-induced stochastic resonance (SISR) [2] and inverse stochastic resonance (ISR)[3], can be related by a simple parameter switch in one of the simplest mathematical neuron models, the FitzHugh-Nagumo (FHN) neuron model [4]. We consider a FHN model with a unique fixed point perturbed by weak synaptic noise. Depending on the stability of this fixed point and whether it is located to either the left or right of the fold point of the critical manifold, SISR or ISR, may emerge. Furthermore, we show that SISR is more robust to parametric perturbations than ISR, and the coherent spike train generated by SISR is more robust than that generated deterministically. ISR also depends on the location of initial conditions and on the time-scale separation parameter of the model equation.

References

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