Mathematics > Dynamical Systems

The Poincare map of randomly perturbed periodic motion

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A system of autonomous differential equations with a stable limit cycle and perturbed by small white noise is analyzed in this work. In the vicinity of the limit cycle of the unperturbed deterministic system, we define, construct, and analyze the Poincare map of the randomly perturbed periodic motion. We show that the time of the first exit from a small neighborhood of the fixed point of the map, which corresponds to the unperturbed periodic orbit, is well approximated by the geometric distribution. The parameter of the geometric distribution tends zero together with the noise intensity. Therefore, our result can be interpreted as an estimate of stability of periodic motion to random perturbations.
In addition, we show that the geometric distribution of the first exit times translates into statistical properties of solutions of important differential equation models in applications. To this end, we demonstrate three examples from mathematical neuroscience featuring complex oscillatory patterns characterized by the geometric distribution. We show that in each of these models the statistical properties of emerging oscillations are fully explained by the general properties of randomly perturbed periodic motions identified in this paper.

Subjects: **Dynamical Systems (math.DS)**; Probability (math.PR); Adaptation and Self-Organizing Systems (nlin.AO); Neurons and Cognition (q-bio.NC)

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