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Phase reduction is an important tool for studying coupled and driven oscillators.

The question of how to generalize phase reduction to stochastic oscillators remains actively debated. In this work, we propose a method to derive a self-contained stochastic phase equation of the form

\$\diff \phi = a(\phi)\diff t + \sqrt{2D(\phi)}\,\diff W(t)\$ that is valid not only for noise-perturbed limit cycles, but also for noise-induced oscillations. We show that our reduction captures the asymptotic statistics of qualitatively different stochastic oscillators, and use it to infer their phase-response properties.

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