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Improved linear response for stochastically driven systems

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The recently developed short-time linear response algorithm, which predicts the average response of a nonlinear chaotic system with forcing and dissipation to small external perturbation, generally yields high precision of the response prediction, although suffers from numerical instability for long response times due to positive Lyapunov exponents. However, in the case of stochastically driven dynamics, one typically resorts to the classical fluctuation-dissipation formula, which has the drawback of explicitly requiring the probability density of the statistical state together with its derivative for computation, which might not be available with sufficient precision in the case of complex dynamics (usually a Gaussian approximation is used). Here we adapt the short-time linear response formula for stochastically driven dynamics, and observe that, for short and moderate response times before numerical instability develops, it is generally superior to the classical formula with Gaussian approximation for both the additive and multiplicative stochastic forcing. Additionally, a suitable blending with classical formula for longer response times eliminates numerical instability and provides an improved response prediction even for long response times.