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Stability analysis of first order S-ROCK methods for stochastic differential equations with delays in the deterministic part

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Abstract

In previous works we have presented the study of S-ROCK (stochastic Runge–Kutta–Chebyshev) methods applied to either stochastic differential equations with delay in the noise [1], or to delay differential equations with no stochastic terms [2]. For both cases the ways to study the stability, namely mean-square stability and P-stability respectively, are well established and it is possible to construct difference equations expressing the new value in terms of several previous values. However, in the general case we didn't manage to get such expression for the equation with both stochastic and delayed deterministic terms. Still, when the interpolation between the time-mesh points is made linearly and the stochastic term is considered in a way it is done in S-ROCK methods, it is possible to almost get such expression and to construct the stability regions for S-ROCK methods with linear interpolation which generalize both previously considered cases. We also find "optimal" damping factors for the generalized case.

References

[1] Y. Komori, A.S. Eremin, K. Burrage. Stability analysis of numerical methods using a linear test SDE with delay and non-delay in a diffusion term // AIP Conf. Proc. **2293**, 100005 (2021)
[2] A.S. Eremin, T.S. Zubakhina. Real-valued stability analysis of Runge–Kutta–Chebyshev methods for delay differential equations // AIP Conf. Proc. **2425**, 090006 (2022)

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