

Leapfrog Chebyshev methods

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In this talk we consider variants of the leapfrog method for second order differential equations. In numerous situations the strict CFL condition of the standard leapfrog method is the main bottleneck that thwarts its performance. Based on Chebyshev polynomials new methods have been constructed that exhibit a much weaker CFL condition than the leapfrog method.

We will analyze the stability and the long-time behavior of leapfrog-Chebyshev methods in two-step formulation. This analysis indicates that one should modify the schemes proposed in the literature in two ways to improve their qualitative behavior.

For linear problems, we propose to use special starting values required for a two-step method instead of the standard choice obtained from Taylor approximation. For semilinear problems, we propose to introduce a stabilization parameter as it has been done for Runge-Kutta-Chebyshev methods before. For the stabilized methods we prove that they guarantee stability for a large class of problems.

While these results hold for quite general polynomials, we show that the polynomials used in the stabilized leapfrog Chebyshev methods satisfy all the necessary conditions. In fact, all constants in the error analysis can be given explicitly.

The talk concludes with numerical examples illustrating our theoretical findings.

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