Exponential methods for solving hyperbolic problems with application to kinetic equations

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Résumé

In this talk, we consider the application of exponential integrators to purely hyperbolic problems. Exponential methods are attractive in a range of kinetic problems as they remove the CFL condition induced by the linear part of the system, which in practice is often the most stringent stability constraint. In previous work these schemes have been found to perform very well for drift-kinetic problems. However, despite their computational efficiency, it was observed that in some situations commonly used exponential integrators, such as the Cox–Matthews scheme, behaves rather erratically in terms of the maximal allowed time step size. In this work our goal is to study the stability of exponential integrators for purely hyperbolic problems. We do this by peforming an analysis of the linearized problem. This analysis shows that classic exponential integrators demonstrate severe defficiency in terms of their stability. Based on this analysis we propose to use Lawson methods, which can be shown not to suffer from the same deficiency. We confirm these results by performing numerical simulations for both the Vlasov–Poisson equations and a drift-kinetic simulation of the ion temperature gradient instability.

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