MS11: Accurate and efficient time integration methods for unsteady PDEs II

Further Study of Back and Forth Error Compensation and Correction Method for Advection and Hamilton-Jacobi Equations

Yingjie Liu, *Georgia Institute of Technology*

We further study the properties of the back and forth error compensation and correction (BFECC) method for advection equations such as those related to the level set method and for solving Hamilton-Jacobi equations on unstructured meshes. In particular, we develop a new limiting strategy. This new technique is very simple to implement even for unstructured meshes and is able to eliminate artifacts induced by jump discontinuities in derivatives of the solution as well as by jump discontinuities in the solution itself (even if the solution has large gradients in the vicinities of a jump). Typically, a formal second order method method for solving a time dependent Hamilton-Jacobi equation requires quadratic interpolation in space. A BFECC method on the other hand only requires linear interpolation in each step, thus is local and easy to implement even for unstructured meshes. Joint with Lili Hu and Yao Li.

A High Order Time Splitting Method Based on Integral Deferred Correction for Semi-Lagrangian Vlasov Simulations

Wei Guo, *Michigan State University*

The dimensional splitting semi-Lagrangian methods with different reconstruction/interpolation strategies have been applied to kinetic simulations in various settings. However, the temporal error is dominated by the splitting error. In order to have numerical algorithms that are high order in both space and time, we propose to use the integral deferred correction (IDC) framework to reduce the splitting error. The proposed algorithm is applied to the Vlasov-Poisson system, the guiding center model, and incompressible flows.

Long-Time Numerical Integration of the Generalized Nonlinear Schródinger Equation with Time Steps Exceeding the Instability Threshold

Taras Lakoba, *University of Vermont*

In applications focusing on obtaining statistics of solutions, relatively low accuracy (0.1use larger time steps to reduce simulation time, but larger steps may cause numerical instability (NI). We consider two methods of suppressing NI. One method works for equations with bounded/localized ”potential” and consists of simply applying absorbing boundary conditions. The alternative is to use a leap-frog-type exponential time differencing method instead of the split-step method.

Compact Implicit Integration Factor Method for a Class of High Order Differential Equations

Xinfeng Liu, *University of South Carolina*

When developing efficient numerical methods for solving parabolic types of equations, severe temporal stability constraints on the time step are often required due to the high-order spatial derivatives and/or stiff reactions. The implicit integration factor (IIF) method, which treats spatial derivative terms explicitly and reaction terms implicitly, can provide excellent stability properties in time with nice accuracy. One major challenge for the IIF is the storage and calculation of the dense exponentials of the sparse discretization matrices resulted from the linear differential operators. The compact representation of the IIF (cIIF) can overcome this shortcoming and greatly save computational cost and storage. In this talk, by treating the discretization matrices in diagonalized forms, we will present an efficient cIIF method for solving a family of semilinear fourth-order parabolic equations, in which the bi-Laplace operator is explicitly handled and the computational cost and storage remain the same as to the classic cIIF for second-order problems. In particular, the proposed method can deal with not only stiff nonlinear reaction terms but also various types of homogeneous or inhomogeneous boundary conditions.