SCHOOL OF NATURAL SCIENCES
APPLIED MATHEMATICS SEMINAR 291

Efficient Exponential Time Integration for Stiff PDEs: Construction and Applications

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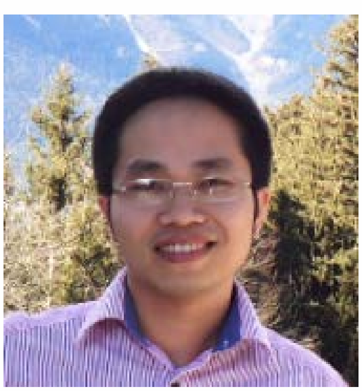
ABSTRACT

Discretizing time-dependent PDEs in space often yields a large system of stiff ODEs. For solving such problems numerically, explicit methods usually lack stability and are required to use tiny time steps. Thus standard implicit methods (e.g., Radau-IIA, DIRK, BDF, IMEX) are commonly used but are usually costly as they require the solution of large linear systems at every step. With the developments of numerical linear algebra, it turns out that exponential integrators can overcome these shortcomings. This time integration technique has received a lot of interests and it has been shown that the integrators are highly competitive: they are fully explicit and thus do not require the solution of large linear systems in each step. Moreover, they offer very high accuracy and do not suffer from the stability restriction imposed by the CFL condition inherent in the explicit methods.

In this talk, first I will briefly present the basic idea behind exponential integrators, namely exponential Runge-Kutta/Rosenbrock methods. Then I will focus on designing customized such exponential methods for the purpose of efficiency improvement. In particular, I will show that one can construct parallel exponential Rosenbrock methods which can be implemented on a multi-processor system or parallel computers. For problems with very stiff nonlinearities, the implicit-explicit exponential methods have been constructed. They can be used with any preconditioners and thus offer significant computational savings compared to the widely used IMEX integrators. Finally, I will demonstrate the efficiency of the new integrators in solving a number of two-dimensional PDEs (such as advection-diffusion-reaction equations and Schnakenberg systems), as well as their applications in visual computing e.g. computational modeling of elastodynamic systems.

This talk is based on the research works that have been carried out during my appointment at the UCM since fall 2014.

BIO:



Dr. Luan is currently a Visiting Assistant Professor at the School of Natural Sciences, University of California, Merced. Prior to this appointment, he was a PhD fellowship at the Department of Mathematics, University of Innsbruck, where he received a Ph.D. in Applied Mathematics in 2014. His research interests lie in the area of applied mathematics, primarily in numerical analysis, ordinary and partial differential equations, and scientific computing. He is also interested in mesh-free methods, structure preserving numerical integration, and scattered data approximation/ interpolation problems.