数学与系统科学研究院

计算数学所学术报告

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报告题目：

Recent developments on approximations of fractional Caputo's derivative

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报告时间： **2018 年 4 月 13 日（周五）**

下午 16:00--17:00

报告地点： 数学院科技综合楼

Z311 报告厅

报告摘要：

Time-fractional linear and nonlinear parabolic equations involving the fractional Caputo derivative are important models in modeling complex systems such as glassy and distorted materials. In developing

numerical methods especially for fractional partial differential equations, the Caputo's derivative introduces some new difficulties, such as initial singularity, kernel singularity and historical memory. In this talk, we report the well-known L1 formula on general nonuniform time grids for solving fractional linear and nonlinear reaction- subdiffusion equations. By introducing a discrete convolution kernel of Riemann-Liouville fractional integral, we establish a discrete fractional Gronwall-type inequality, which is a generalization of classical Gronwall inequality for local time derivative and is useful in stability and convergence analysis of numerical schemes. To simplify the consistence analysis of nonuniform L1 formula, we bound the local truncation error by a discrete convolution form with the L1 coefficients, and consider a global convolution error with the discrete Riemann- Liouville integral kernel. This novel technique avoids the detailed evaluations of discrete convolution kernels and provides a simple way to analyze the approximate error of L1 formula. For the fractional linear reaction-subdiffusion

equation, a new L^2-norm error estimate reflecting the regularity of solution is obtained for simple discrete schemes on nonuniform time meshes. To accelerate the time-integration, a fast L1 formula on nonuniform meshes is constructed by splitting the Caputo derivative into a local part and a history part, and applying the sum-of-exponentials technique to approximate the singular kernel over the history interval. We construct a two-level fast linearized algorithm for two-dimensional time-fractional semilinear reaction-subdiffusion equation. The resulting scheme is computationally efficient in long-time simulations since it requires only $O(M\log N)$ storage and $O(MN\log N)$ computational cost with M grid points in space. Unconditionally maximum norm error estimate reflecting the regularity of solution is established by applying discrete H^2 energy method, discrete fractional Gronwall-type inequality and global consistence error analysis. Numerical tests are provided to confirm the sharpness of error analysis.

欢迎大家参加！