微分方程数值解与计算物理专题研讨会

会 议 日 程

时间：2021 年 5 月 9 日（周日） 线上会议（腾讯会议号：116 609 209）	
08:30-09:00 主持：王廷春	Analysis of structure-Preserving Methods for Several Time-dependent PDEs 李东方　华中科技大学
09:00-09:30 主持：廖洪林	Numerical methods for charged-particle dynamics in a strong magnetic field 王斌　西安交通大学
09:30-10:00 主持：李春	Complete monotonicity-preserving numerical methods for time fractional ODEs 王冬岭　西北大学
10:00-10:10	**茶　歇**
时间：2021 年 5 月 9 日（周日） 线下会议（地点：藕舫楼 818 室）	
10:10-10:40 主持：王曰朋	二阶非均匀BDF格式对步长变化的鲁棒性 廖洪林　南京航空航天大学
10:40-11:10 主持：龚跃政	High-precision theory and calculations of few-body systems in Hylleraas coordinates: highlights and discussions from an interdisciplinary research viewpoint 李春　南京大学
11:10-11:40 主持：刘长迎	Some efficient energy-preserving algorithms based on the partitioned averaged vector field method 蔡文君　南京师范大学
11:40-12:10 主持：蔡文君	Supplementary variable method (SVM) for thermodynamically consistent partial differential equations 龚跃政　南京航空航天大学
12:10-12:40 主持：卢长娜	Linear high-order energy-preserving schemes for the nonlinear Schrödinger equation with wave operator using the scalar auxiliary variable (SAV) approach 李鑫　合肥工业大学
午餐后离会	

Analysis of structure-Preserving Methods for Several Time-dependent PDEs

李东方　华中科技大学

报告摘要： We use the scalar auxiliary variable (SAV) reformulation to construct structure- preserving methods for several PDEs. The proposed time discretization can be of arbitrarily high order. We also discuss efficient linearization of the methods and their conservation properties.

Numerical methods for charged-particle dynamics in a strong magnetic field

王斌　西安交通大学

报告摘要： In this talk, we consider numerical methods for the charged-particle dynamics (CPD) under a strong magnetic field. We first propose a modification of the standard Boris algorithm for the CPD in a strong magnetic field with maximal ordering. With an appropriate choice of filters, second-order error bounds are obtained by the modulated Fourier expansions of the exact and the numerical solutions. Then some splitting methods including energy/volume-preserving splitting are proposed. A uniform and optimal error bound is derived by using two different techniques for two different scalings of the CPD.

Complete monotonicity-preserving numerical methods for time fractional ODEs

王冬岭　西北大学

报告摘要： The time fractional ODEs are equivalent to convolutional Volterra integral equations with completely monotone kernels. We introduce the concept of complete monotonicity-preserving (CM-preserving) numerical methods for fractional ODEs, in which the discrete convolutional kernels inherit the CM property as the continuous equations. We prove that CM-preserving schemes are at least $A(\pi/2)$ stable and can preserve the monotonicity of solutions to scalar nonlinear autonomous fractional ODEs. Significantly, by improving a result of Li and Liu (Quart. Appl. Math., 76(1):189-198, 2018), we show that the L1 scheme is CM-preserving. The good signs of the coefficients for such class of schemes ensure the discrete fractional comparison principles, and allow us to establish the convergence in a unified framework when

applied to time fractional sub-diffusion equations and fractional ODEs. The main tools in the analysis are a characterization of convolution inverses for completely monotone sequences and a characterization of completely monotone sequences using Pick functions due to Liu and Pego (Trans. Amer. Math. Soc. 368(12): 8499-8518, 2016). The results for fractional ODEs are extended to CM-preserving numerical methods for Volterra integral equations with general completely monotone kernels. Numerical examples are presented to illustrate the main theoretical results.

二阶非均匀 BDF 格式对步长变化的鲁棒性

廖洪林　南京航空航天大学

报告摘要：我们把变步长 BDF 公式看成一类非局部卷积逼近，借助于一个新的离散分析工具---离散正交卷积核，建立了二阶 BDF 格式的 L2 模稳定性和收敛性。新的稳定性结果合理地模拟了连续问题的稳定不等式，新的误差估计几乎不依赖步长比参数，这充分表明 BDF2 格式对步长变化具有很强的鲁棒性。我们也将新分析方法应用到若干非线性相场模型，得到了一些新的理论结果；当然，新技术也带来了不少问题和困难。

High-precision theory and calculations of few-body systems in Hylleraas coordinates: highlights and discussions from an interdisciplinary research viewpoint

李春　南京大学

报告摘要：It is well known that, high-precision theory and calculations of few-body atomic and molecular systems, are remarkably important in modern physics including problems related to the art of measurement, natural and practical units, especially determining fundamental physical constants and testing limit of validity of fundamental theory from a comparison with experiment. We will briefly introduce and discuss, the Rayleigh-Ritz variational method with nonlinear optimization for solving the nonrelativistic cases in Hylleraas coordinates, and the Rayleigh-Schrödinger perturbation method for relativistic and quantum electrodynamic (QED) corrections, with an emphasis from an interdisciplinary viewpoint. Interdisciplinary research occurs naturally but not automatically, it needs integrating expertise from various knowledge domains and elaborate collaborations among researchers from different disciplines as well.

Some efficient energy-preserving algorithms based on the partitioned averaged vector field method

蔡文君　南京师范大学

报告摘要： In this talk we will first introduce the standard averaged vector field method for general Hamiltonian system and then the partition strategy to construct more efficient energy-preserving algorithms for coupled Hamiltonian systems. Further combing the exponential integrator, our method can not only keep the energy preserved but also be suitable for solving highly oscillatory problems. Some numerical tests are made to illustrate the efficiency and conservation of the proposed methods.

Supplementary variable method (SVM) for thermodynamically consistent partial differential equations

龚跃政　南京航空航天大学

报告摘要： In this talk, we present a new paradigm for developing structure-preserving algorithms for thermodynamically consistent partial differential equation (TCPDE) system, called the supplementary variable method (SVM). We add a proper number of supplementary variables to the TCPDE system coupled with its energy equation and other deduced equations through perturbations to arrive at a consistent, well-determined, solvable and structurally stable system. The extended system not only reduces to the TCPDE system at specific values of the supplementary variables, but also allows one to retain consistency and solvability after a consistent numerical approximation. Among virtually infinite many possibilities to add the supplementary variables, we present two that maintain thermodynamical consistency in the extended system before and after the approximation. The new schemes are compared with the energy stable SAV scheme and the fully implicit Crank-Nicolson scheme. The numerical results favor the new schemes in the overall performance.

Linear high-order energy-preserving schemes for the nonlinear Schrödinger equation with wave operator using the scalar auxiliary variable (SAV) approach

李鑫　合肥工业大学

报告摘要： In this talk, we present two classes of linear high-order conservative

numerical schemes for the nonlinear Schrödinger equation with wave operator. Based on the method of order reduction in time and the SAV technique, we transform the original model into an equivalent system, where the energy is modified as a quadratic form. To construct linear high-order conservative schemes, we first adopt the extrapolation strategy to derive a linearized PDE system, which approximates the transformed model with high precision and inherits the modified energy conservation law. Then we apply the symplectic Runge-Kutta method in time to arrive at a class of linear high-order energy-preserving schemes. In order to complement the new linear schemes, the prediction-correction strategy is employed to design another class of energy-preserving algorithms. We provide ample numerical results to confirm the convergence, accuracy and conservation property of the proposed schemes.