

SPECTRAL AND HIGH-ORDER METHODS FOR RELATIVISTIC QUANTUM MECHANICS

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ABSTRACT

Relativistic quantum mechanical models form an important class of dispersive partial differential equations, with applications ranging from quantum physics to materials science and high-field phenomena. Their numerical simulation presents substantial challenges, including highly oscillatory dynamics, multiscale regimes, spinor coupling, long-time accuracy, and the preservation of intrinsic mathematical structures. This mini-symposium brings together computational and applied mathematicians and computational physicists working on spectral and high-order numerical methods for relativistic quantum models. The focus will be on accurate and efficient discretizations, robust time integration strategies, and rigorous numerical analysis for Dirac-type, Klein-Gordon-type and relativistic Schroedinger-type as well as their related coupled systems. Particular emphasis will be placed on how structure-preserving spectral and high-order methods can improve resolution, stability, and efficiency across different physical regimes.

SPEAKERS

1. Emmanuel Lorin (Carleton University): Time-dependent Dirac equation with physics-informed neural networks: computation and properties.
2. Alexander Ostermann (University of Innsbruck): On the convergence of split exponential integrators for semilinear parabolic problems.

3. Yulong Xing (The Ohio State University): Energy conserving discontinuous Galerkin method with scalar auxiliary variable technique for the nonlinear Dirac equation.
4. Liang-You Peng (Peking University): Solving the time-dependent Klein-Gordon and square-root Klein-Gordon equations with Krylov-subspace methods.
5. François Golse (Ecole polytechnique): On the approximation of the von Neumann equation in the semi-classical limit.
6. Yue Feng (Xi'an Jiaotong University): Improved uniform error bounds on time-splitting Fourier pseudospectral method for long-time dynamics of the Schrödinger-Poisson equation.
7. Bin Wang (Xi'an Jiaotong University): A uniformly accurate exponential wave integrator method for the nonlinear Klein-Gordon equation with highly oscillatory potential.
8. Caoyi Liu (National University of Singapore): A uniformly accurate multiscale time integrator for the nonlinear Klein-Gordon equation in the nonrelativistic regime via simplified transmission conditions.
9. Chushan Wang (University of Chicago): Optimal error bounds on the exponential integrator for dispersive equations with highly concentrated potential.
10. Yan Wang (Central China Normal University): Numerical methods for the nonlinear Dirac equation in the massless nonrelativistic regime.
11. Jia Yin (Fudan University): High-order compact methods for the Dirac equation.
12. He Wang (Fudan University): Time-splitting methods for the Dirac equation in the semiclassical regime.