



復旦大學
FUDAN UNIVERSITY

Applied Math Ph.D. Seminar

Time-Splitting Methods for the Dirac Equation in the Semiclassical Regime

Speaker: He Wang (Fudan University)

Time: 2026-03-05, 16:10 to 17:00

Location: Rm 1801, Guanghai East Tower

Advisor: Jia Yin (Fudan University)

Abstract: Currently, several finite difference methods are used to solve the Dirac equation in the semiclassical regime. However, finite difference methods have certain limitations in terms of accuracy and stability. The CNFD method, often employed to enhance stability, usually requires solving large linear systems, leading to significant computational costs. In this work, we conduct a rigorous analysis of the numerical error for the time-splitting methods applied to the Dirac equation in the semiclassical region. The dimensionless parameter $\epsilon \in (0, 1]$, representing the reduced Planck constant, causes the solution field to exhibit rapid oscillations with characteristic wavelengths of order $O(\epsilon)$. We demonstrate that both S_1 and S_2 schemes preserve total mass conservation in a discrete sense. Furthermore, we establish error estimates for the time-splitting methods, clearly describing how the approximation error varies with time resolution τ , spatial discretization step h , and the parameter ϵ . We also derive error bounds for physical observables, and through numerical experiments, we validate the reliability of the error estimates.