UNIVERSITÄT LEIPZIG

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Physics Colloquium

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A Transfer Operator Approach to Relativistic Quantum Wavefunctions

Koopman operator theory is in widespread use in applications, from analysis and control of fluid fluid flows to modeling of electric power grid dynamics and soft robotics. However, the original intent of Koopman and von Neumann was to put classical and quantum mechanics on the same footing by introducing an operator formalism into classical mechanics. Here we pursue their path the opposite way and examine what the Koopman (and more generally, transfer) operators can say about quantum mechanical evolution. We introduce a transfer-operator based wavefunction formalism and obtain an evolution equation for the wavefunction of 0-spin and spin 1/2 particles. The equation features a non-hermitian term associated with the local divergence of trajectories that can be generated e.g. by gravitational effects. In the special relativity limit the scalar wavefunction of Dirac spinors satisfies the new equation. In the non-relativistic case we obtain the Schrödinger equation in the limit when trajectories have small deviations from inertial motions. However, when changes in trajectory curvature are not small, classical effects arise, and when divergence of trajectories is present, non-hermitian effects arise.

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