

Towards a Probabilistic Foundation of Relativistic Quantum Theory: The One-Body Born Rule in Curved Spacetime

In this talk I present a novel approach to the foundations of relativistic quantum theory, which is based on generalizing the quantum-mechanical Born rule for determining particle position probabilities to curved spacetime. A principal motivator for this research has been to overcome internal mathematical problems of quantum field theory (QFT), which axiomatic approaches to QFT have shown to be not only of mathematical but also of conceptual nature. The approach presented here is probabilistic by construction, can accommodate a wide array of dynamical models, does not rely on the symmetries of Minkowski spacetime, and respects the general principle of relativity.

The first step of this research program was to consider the one-body case under the assumption of smoothness of the mathematical quantities involved. This is what I focus on in the presentation. It turns out that the one-body case may be identified as a special case of the theory of the general-relativistic continuity equation. In our work we employed prior contributions by C. Eckart and J. Ehlers to overcome overly restrictive assumptions of related approaches in the literature. As in the non-relativistic analog theory, there are two distinct formulations of the theory, namely the Lagrangian and the Eulerian picture, respectively. Our main contribution to the mathematical physics literature is the development of the Lagrangian picture in this general-relativistic setting. The Lagrangian picture serves as a blueprint for the generalization to the many body case and the case that the number of bodies is not a constant.

This work was carried out at Texas Tech University as part of my dissertation, which I completed under the guidance of my supervisor Bill Poirier.