Hamiltonian Formalism for the Rarita–Schwinger System

Bence Juhász, László Árpád Gergely
University of Szeged, Szeged, Hungary

We extend our previous investigation of the canonical description of Dirac and Schrödinger systems for the massive Rarita–Schwinger system, the vector-valued spinor theory describing spin-3/2 fields. We simplify the Lagrangian and Hamiltonian descriptions by introducing a modified time derivative. We discuss both the simplest and the Hermitian Lagrangians, which differ by a total divergence. Through highly intuitive methods, we identify two new Hamiltonians, both of them correctly reproducing all aspects of the dynamics.

In the more systematic approach of the Dirac–Bergmann framework, we analyze the massive Rarita–Schwinger system, finding that it exhibits a more complex constraint structure, which requires a careful analysis. We introduce a properly factor ordered Poisson bracket adapted to the spinorial structure. The time evolution of the constraints reproduces the Rarita–Schwinger equations, while also fixing all generalized velocities. The 6 second class constraints require the introduction of a sound Dirac bracket, equally adapted to the spinorial structure. The 2 first class constraints represent auxiliary degrees of freedom, which do not generate gauge transformations. Thus, the massive Rarita–Schwinger system provides a physically relevant counterexample to the Dirac conjecture.

Finally, we identify reduced phase space coordinates in which the Dirac bracket reduces to a Poisson bracket, and we formulate a quantization rule based on this structure. These results provide a consistent Hamiltonian and quantization framework for the massive Rarita–Schwinger system.