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A Monte Carlo Approach to the Worldline Formalism in Curved Space

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Numerical Worldline (WL) Monte Carlo (MC) techniques for particle path integrals in flat spacetimes have been deeply developed in order to extract physical information from QFT systems. It is however possible to extend such procedures to the case of (Euclidean) curved spaces, where the proper-time discretization of a bosonic worldline point-particle is treated similarly to a time-slicing regularization for the associated quantum path integral. In particular, it induces a well-known counterterm in the theory which, together with curvature effects arising directly from the curved metric tensor, plays the role of an additional potential. To test the setup, the numerical evaluation of the heat kernel of a free scalar point-particle on a 4-hyperboloid is presented; such system was already studied analytically, and the expressions of the associated effective potential and of the metric tensor were provided in closed form. The curved space problem was turned into a flat space one, allowing for a direct comparison between WLMC techniques in curved (the test) and in flat (the check) space.

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