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Covariant nonperturbative pointer variables for quantum fields

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Abstract

We propose a formalism for describing covariant, non-perturbative detector models in quantum field theory. We do so by describing the dynamics of a pointer-variable, which is given by a simple harmonic oscillator, coupled with a free quantum field over a possibly curved spacetime. Our core objective is to understand the dynamics of the detector's pointer variable in terms of covariant equations of motion leading to local observables. To achieve this, we derive and renormalize an integro-differential equation that governs the pointer variable's dynamics, introducing phenomeno-logical parameters such as a dispersion coefficient and a Lamb-shift parameter. Our formal solution, expressed in terms of Green's functions, allows for the covariant, and causal analysis of induced observables. Our analysis departs from previous results in the Literature in that the covariance and locality of the interaction remain under control, making it suitable for investigations of measurements in general globally hyperbolic spacetimes.

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