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A quantum low-energy gravity model free from causality violation problems

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Wave-function collapse following a measurement process is a longstanding controversial issue of quantum physics. It introduces an element of strong non-linearity and irreversibility in an otherwise unitary and reversible dynamics. Several proposals of modification of Quantum Mechanics have been put forward in the past few decades in order to solve such a dichotomy. Among them, some approaches considered the possible role of gravity in the wave-function collapse as a result of the incompatibility of general relativity and unitary time evolution of Quantum Mechanics. In this contribution we present a nonunitary model of Newtonian Gravity (NNG) [1-3], which shows several appealing features: while reproducing at a macroscopic level the ordinary Newtonian interaction, it presents a mass threshold for gravitational localization. In particular, it provides a mechanism for the evolution of macroscopic coherent superpositions of states into ensembles of pure states.
In particular, we explicitly show how a one-parameter generalization of our NNG model is free from any causality-violation problem for any finite value of parameter [4]. The basic idea is to look at the single particle Newton-Schroedinger equation as the mean-field approximation of an equation of N identical copies of the particle, interacting via usual gravitational interaction, when N goes to infinity. The general N-copy model is a fully consistent quantum theory, in which superluminal communications are automatically avoided. This feature is shown to be a consequence of the intrinsic mechanism of spontaneous state reduction, built in in our NNG model and completely suppressed in the Newton-Schroedinger limit. We discuss in detail a specific (ideal) EPR-like experiment involving the superposition of two distinct Center of Mass position states of a massive body and show that the absence of causality violations leads to the appearance of unusual communications among Everett branches of the wave function. Our results agree with previous findings by Polchinski [5], obtained for a general class of nonlinear models characterized by nonlinear observables which depend only on the density matrix.

References

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Summary

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