Papers 2023

Alejandro Perez, Salvatore Ribisi and Sami Viollet *Universe, 9(2):75, 2023* : arXiv:2301.03951

Modelling quantum particles falling into a black hole: the deep interior limit

Authors: Alejandro Perez, Salvatore Ribisi, Sami Viollet

Abstract: In this paper we construct a solvable toy model of the quantum dynamics of the interior of a spherical black hole with falling spherical scalar field excitations. We first argue about how some aspects of the quantum gravity dynamics of realistic black holes emitting Hawking radiation can be modelled using Kantowski-Sachs solutions with a massless scalar field when one focuses on the deep interior region $r \ll M$ (including the singularity). Further, we show that in the $r \ll M$ regime, and in suitable variables, the KS model becomes exactly solvable at both the classical and quantum levels. The quantum dynamics inspired by loop quantum gravity is revisited. We propose a natural polymer-quantization where the area a of the orbits of the rotation group is quantized. The polymer (or loop) dynamics is closely related with the Schroedinger dynamics away from the singularity with a form of continuum limit naturally emerging from the polymer treatment. The Dirac observable associated to the mass is quantized and shown to have an infinite degeneracy associated to the so-called ε-sectors. Suitable continuum superpositions of these are well defined distributions in the fundamental Hilbert space and satisfy the continuum Schroedinger dynamics. △ Less

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Alejandro Perez and Sami Viollet: arXiv:2307.10254

Discreteness Unravels the Black Hole Information Puzzle: Insights from a Quantum Gravity Toy Model

Authors: Alejandro Perez, Sami Viollet

Abstract: The black hole information puzzle can be resolved if two conditions are met. Firstly, if the information of what falls inside a black hole remains encoded in degrees of freedom that persist after the black hole completely evaporates. These degrees of freedom should be capable of purifying the information. Secondly, if these purifying degrees of freedom do not significantly contribute to the system's energy, as the macroscopic mass of the initial black hole has been radiated away as Hawking radiation to infinity. The presence of microscopic degrees of freedom at the Planck scale provides a natural mechanism for achieving these two conditions without running into the problem of the large pair-creation probabilities of standard remnant scenarios. In the context of Hawking radiation, the first condition implies that correlations between the {\em in} and {\em out} Hawking partner particles need to be transferred to correlations between the {\em microscopic degrees of freedom} and the {\em out} partners in the radiation. This transfer occurs dynamically when the {\em in} partners reach the singularity inside the black hole, entering the UV regime of quantum gravity where the interaction with the microscopic degrees of freedom becomes strong. The second condition suggests that the conventional notion of the vacuum's uniqueness in quantum field theory should fail when considering the full quantum gravity degrees of freedom. In this paper, we demonstrate both key aspects of this mechanism using a solvable toy model of a quantum black hole inspired by loop quantum gravity. △ Less

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Johannes Münch, Alejandro Perez, Simone Speziale and Sami Viollet arXiv:2212.06708

3. arXiv:2212.06708 [pdf, other] gr-qc hep-th doi 10.1088/1361-6382/accccd

Generic features of a polymer quantum black hole

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Abstract: Non-singular black holes models can be described by modified classical equations motivated by loop quantum gravity. We investigate what happens when the sine function typically used in the modification is replaced by an arbitrary bounded function, a generalization meant to study the effect of ambiguities such as the choice of representation of the holonomy. A number of features can be determined without committing to a specific choice of functions. We find generic singularity resolution. The presence and number of horizons is determined by global features of the function regularizing the angular components of the connection, and the presence and number of bounces by global features of the function regularizing the time component. The trapping or anti-trapping nature of regions inside horizons depends on the relative location with respect to eventual bounces. We use these results to comment on some of the ambiguities of polymer black hole models. △ Less

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