Universidade de São Paulo
Instituto de Física de São Carlos

Semana Integrada do Instituto de Física de São Carlos

13ª edição

Livro de Resumos

São Carlos
2023

Ficha catalográfica elaborada pelo Serviço de Informação do IFSC

Semana Integrada do Instituto de Física de São Carlos
(13: 21-25 ago.: 2023: São Carlos, SP.)
Livro de resumos da XIII Semana Integrada do Instituto de Física de São Carlos – Universidade de São Paulo / Organizado por Adonai Hilário da Silva [et al.]. São Carlos: IFSC, 2023.
358p.

Texto em português.
1.Física. I. Silva, Adonai Hilário da, org. II. Título.

ISSN: 2965-7679

PG132

Bounding the effective Zeno dynamics on amplitude damping beyond the Zeno limit

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Developing protocols for preserving information in quantum systems is a fundamental pursuit in realizing practical quantum computation. In this regard, the Quantum Zeno Effect has emerged as a widely utilized technique to safeguard classical information stored in quantum systems. (1) However, existing results pertaining to this method often assume operations performed infinitely quickly on the system of interest, which only serves as an approximation to real-world scenarios, where the temporal resolution of any experimental apparatus is inherently finite. (2) In this study, we go beyond this conventional assumption and derive the effective Zeno dynamics for any time interval between operations. Our analysis considers a qubit undergoing thermalization, as described by a generalized amplitude damping channel, while the operations performed consist of projections onto an orthonormal basis that may or may not coincide with the pointer basis to which the system is thermalizing. By obtaining the probability of successfully storing a bit of information after a given time, we investigate the performance of the protocol in two important scenarios: the limit of many interventions, with a first-order correction to the Zeno limit, and the limit of very few interventions. In doing so, we provide valuable insights into the protocol's performance by establishing bounds on its efficacy. These findings enhance our understanding of the practical applicability of the Quantum Zeno Effect in preserving classical information stored in quantum systems, allowing for better design and optimization of quantum information processing protocols.

Palavras-chave: Quantum computation. Quantum information. Quantum Zeno effect.

Agência de fomento: FAPESP (2022/00993-9)

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