Quantum-Induced DNA Mutations: A Literature Review

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Abstract

Quantum biology investigates quantum phenomena in biological processes. This review study addresses the central dogma of molecular biology, emphasizing genetic code and codons, while identifying sources of errors such as tautomeric forms and DNA polymerase translation errors.

DNA mutations, particularly point mutations, are examined through the concept of quantum mechanics, where DNA can be viewed as a noisy channel due to the formation of tautomeric forms caused by proton tunneling. The presence of degenerate codons, which map to the same amino acid, introduces superposition effects. The genetic quantum channel is modeled as a codon-codon channel, described using open quantum system (OQS) theory and quantum mechanical perturbation theory, to calculate transition probabilities from the initial codon.

This review presents the current state of research in modeling the tautomeric form through an asymmetric double well potential, the application of the Lindblad equation, and the modeling of environments using harmonic oscillators, phase damping, amplitude damping, phase-flip, and depolarizing channels. The study underscores the significance of quantum simulations in understanding the quantum effects on DNA mutations, ultimately contributing to the robustness of biological systems against such errors.

Keywords: Open quantum systems, double well potential, Lindblad equation, harmonic oscillators phase damping, amplitude damping, phase-flip, depolarizing channels, central dogma of molecule biology, DNA mutations