Optimal Control of Two-Qubit Rydberg Atom Logic Gates

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We present a theoretical study on the optimal control of two-qubit logic gates implemented with neutral atoms excited to Rydberg states. Our approach is based on a detailed error model that incorporates the principal physical processes underlying gate performance, with particular attention to incoherent losses such as spontaneous emission and technical imperfections. We develop a framework that combines this model with Pontryagin's Maximum Principle to derive control strategies that maximize gate fidelity while minimizing loss-induced errors. The optimization landscape is further shaped by constraints from realistic experimental parameters. Preliminary numerical results demonstrate the effectiveness of the method, especially in reducing leakage and enhancing gate robustness. Our findings provide both a deeper theoretical understanding of Rydberg-based quantum logic and practical guidance for future experimental implementations.

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