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Optical depth and its relation to warm ensemble based quantum memories and communication rates

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The realization of long-distance quantum communication will depend critically on quantum repeater nodes that incorporate robust and scalable quantum memories. To be practical, these memories must meet specific operational requirements. One promising candidate for such devices is the atomic warm vapor system, operating under the regime of electromagnetically induced transparency (EIT). These systems offer ease of implementation and demand minimal experimental infrastructure. A central figure of merit in the performance of atomic quantum memories is the optical depth, which directly influences the efficiency of light-matter interactions. In this work, we simulate and experimentally measure the optical depth performance of an EIT-based quantum memory utilizing a warm atomic vapor cell. We further convert these optical depth and efficiency metrics into projected entanglement distribution rates. Our study assesses the viability of these memory systems within optical quantum repeater architectures, which are vital for establishing robust quantum communication across long distances.

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