Imaging stars with quantum error correction

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The development of high-resolution, large-baseline optical interferometers would revolutionize astronomical imaging [1]. However, classical techniques are hindered by physical limitations including loss, noise, and the fact that the received light is generally quantum in nature. We show how to overcome these issues using quantum communication techniques. We present a general framework for using quantum error correction codes for protecting and imaging starlight received at distant telescope sites [2].

In our scheme, the quantum state of light is coherently captured into a non-radiative atomic state via Stimulated Raman Adiabatic Passage [3], which is then imprinted into a quantum error correction code. The code protects the signal during subsequent potentially noisy operations necessary to extract the image parameters. We show that even a small quantum error correction code can offer significant protection against noise. For large codes, we find noise thresholds below which the information can be preserved. Our scheme represents an application for near-term quantum devices that can increase imaging resolution beyond what is feasible using classical techniques.

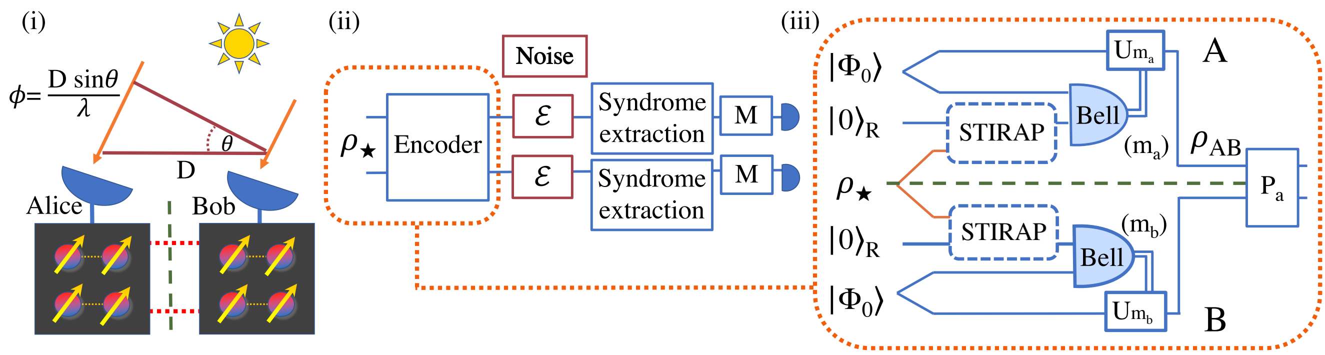

Figure 1: **Overview of our protocol [2].** (i) Light at wavelength λ is collected at two sites, Alice and Bob. (ii) A general framework for the process encoding, error correction, and measuring the signal. The starlight $\rho_\star$ is input into an encoder, which outputs a logical state of a quantum code. (iii) A more detailed schematic that shows how to encode the starlight into a logical state. The green dashed line denotes spatial separation between Alice and Bob. $\mathrm{U_m}$ are Pauli corrections depending on the outcome of local Bell measurements.

[1] E. T. Khabiboullineet al., *Phys. Rev. Lett. 123*, 070504 (2019).

[2] Z Huang, GK Brennen, Y Ouyang, arXiv:2204.06044 (2022).

[3] N. V. Vitanov et al., *Rev. Mod. Phys.* 89, 015006 (2017).