A Michelson controlled-not gate with a single-lens astigmatic mode converter

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Abstract: We propose and demonstrate experimentally a single lens design for an astigmatic mode converter that transforms the transverse mode of paraxial optical beams. As an application, we implement a controlled-not gate based on a Michelson interferometer in which the photon polarization is the control bit and the first order transverse mode is the target. As a further application, we also build a transverse mode parity sorter which can be useful for quantum information processing as a measurement device for the transverse mode qubit.

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![Diagram of the experimental setup](image)

**Experimental results**

- $|H, v\rangle$ $\rightarrow$ **CNOT** $\rightarrow$ $|V, v\rangle$
- $|V, v\rangle$ $\rightarrow$ **CNOT** $\rightarrow$ $|V, v\rangle$
- $|H, v\rangle$ $\rightarrow$ **CNOT** $\rightarrow$ $|H, v\rangle$
- $|H, v\rangle$ $\rightarrow$ **CNOT** $\rightarrow$ $|H, v\rangle$