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A Raman phase gate for ^{87}Rb Bose–Einstein Condensates JOSEPH D. MURPHREE, MAITREYI JAYASEELAN, JUSTIN T. SCHULTZ, NICHOLAS P. BIGELOW, University of Rochester — Bose–Einstein condensates (BECs) are of interest for use in quantum information and quantum computing due to their macroscopic dimensions and long coherence lifetimes. This requires the realization of quantum gates in BECs, and phase gates are an important first step. We use a coherent Raman process to implement a phase gate on a ^{87}Rb BEC. This process is capable of effecting a spatially varying, arbitrary rotation on the Bloch sphere in the pseudo-spin-$\frac{1}{2}$ space created from two spin sublevels. We first use a set of Raman pulses to create a full-Bloch BEC, a spin texture on the cloud which includes every state on the Bloch sphere. A second set of Raman pulses introduces a phase shift between the spin components, applying a phase gate to every possible superposition of states simultaneously. The amount and spatial uniformity of the added phase is then measured using atom-optic polarimetry. Using structured or singular Raman beams with this technique could enable the study of quantum gates with Laguerre–Gaussian basis states.

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