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Quadrupole Raman transitions driven by optical vortex beams in ultracold atomic clouds JOSEPH D. MURPHREE, MAITREYI JAYASEELAN, ZEKAI CHEN, ELISHA HABER, NICHOLAS P. BIGELOW, University of Rochester — Recent experiments in trapped ions demonstrate that a circularly polarized Laguerre–Gaussian (LG) beam carrying orbital angular momentum (OAM) transfers both components of its angular momentum—polarization and OAM—to the valence electron of the ion via a quadrupole transition. This displays a richer interaction between the angular momenta of the atom and the field compared to dipole transitions, where the polarization couples solely to the electron's angular momentum and the OAM couples to the atom's center of mass motion. It also promises the ability to control electronic transitions by manipulating the spatial distributions of the intensity and phase of the applied field. Two-photon Raman processes composed of two such quadrupole transitions will also display these novel features, and can be configured to coherently transfer the electron between states in the ground state manifold, allowing quadrupole transitions to be explored in low energy quantum systems. We examine the effects of these quadrupole Raman transitions driven by LG beams on an ultracold atomic cloud. We discuss the experimental parameters necessary for realizing the transitions in the lab, considering specifically the $5\,^2\mathrm{S}_{1/2} \rightarrow 4\,^2\mathrm{D}_{1/2}$ transition in rubidium-87.

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