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Spin-oscillation dynamics beyond the single-mode approximation for a harmonically trapped spin-1 Bose-Einstein condensate[1] JIANWEN JIE, QINGZE GUAN, SHAN ZHONG, ARNE SCHWETTMANN, DOERTE BLUME, Univ of Oklahoma — Compared to single-component Bose-Einstein condensates, spinor Bose-Einstein condensates display much richer dynamics. In addition to density oscillations, spinor Bose-Einstein condensates exhibit intriguing spin dynamics that is associated with population transfer between different hyperfine components. This work analyzes the validity of the widely employed single-mode approximation when describing the spin dynamics in response to a quench of the system Hamiltonian. The single-mode approximation assumes that the different hyperfine states all share the same time-independent spatial mode, i.e., the field operator for each of the hyperfine states is expanded in terms of one and the same spatial basis state. This implies that the resulting spin Hamiltonian only depends on the spin interaction strength and not on the density interaction strength. Taking the spinor sodium Bose-Einstein condensate in the $f = 1$ hyperfine manifold as an example, it is found that the single-mode approximation misses, in some parameter regimes, intricate details of the spin and spatial dynamics. Our results have implications for a variety of published and planned experimental studies.

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