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Quantum Interferometry with Microwave-Dressed Spinor Bose-Einstein Condensates in the Regime of Long Evolution Times

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— We recently achieved all-optical generation of Na spinor Bose-Einstein condensates (BEC) in our crossed far-off resonant trap at 1064 nm. Using our BEC, we experimentally investigate atom interferometry based on spin-exchange collisions in the regime of long evolution times where the Bogoliubov and truncated Wigner approximations break down, and compare the results with our numerical simulations. Spin-exchange collisions in the F= 1 spinor Bose-Einstein condensate can be precisely controlled by microwave dressing, and generate pairs of entangled atoms with magnetic quantum numbers \( m_F = +1 \) and \( m_F = -1 \) from pairs of \( m_F = 0 \) atoms. Spin squeezing created by the collisions can reduce the noise in an atom interferometer below the shot noise limit. For long evolution times, \( t \gg h/c \), where \( c \) is the spin-dependent interaction energy, \( c \approx h \cdot 30 \text{ Hz} \), there are large numbers of atoms with \( m_F = +1 \) or \( m_F = -1 \) in the arms of the interferometer, allowing for easier detection via Stern-Gerlach time-of-flight absorption imaging.

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