Tunable Spin-Orbit coupling: spectroscopy and cyclic coupling

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Here we look at soc-ed bose gas with modulation. Technique generalizes the proposal of (Karina) and opens the door to generating cyclic couplings between $m_f = +1$ and $m_f = +1$ we propose a new method of probing the energy-momentum dispersion of a spin-orbit coupled quantum gas

Empezar con porque nos interesa soc (tal tez hacer enfasis en edge states, topological stuff, hofstadter). Describir el Hamiltoniano para un sistema de spin uno. Aadir la modulacin y explicar que modulacin es equivalente a tres frequencias (citar spin one paper) espectralmente como en ciertos lmites puedes tener acoplamiento cclico. Por que quiero medir directamente las bandas? Mencionar que hay otras tecnicas como spin injection, pero que esta tecnica ofrece la ventaja de que no necesitas hardware adicional o "reservoir states" que solo ciertos elementos tienen. Motivar eso. De ah voy a Fourier spectroscopy, funciona para un sistema conocido. Hamiltoniano modulato, comparar el gap de Molmer-Sorensen (acoplamiento entre -1 y +1) con la transicin de dos fotones. Pensar en Mariposas de Hofstater, fin.

A. Modulated/tripple frequency coupling

B. Spectroscopy

The time evolution of the system is given by the time dependent Schrödinger equation.

$$i\hbar\frac{d|Psi\rangle}{dt} = \hat{H}|\Psi\rangle \tag{1}$$

Under the presence of a Raman field,

$$|m_f\rangle \xrightarrow{t} \sum_n c_n e^{-iE_n t/\hbar}|\psi_n\rangle|\langle m_{f'}|m_f(t)\rangle|^2 = |\sum_{n,k} c_{nk} e^{-iE_n t/\hbar}\langle\psi_k|\psi_n\rangle|^2 \tag{2}$$

$$\tag{3}$$

I. METHODS

A. Fourier Spectroscopy

The Fourier Spectroscopy technique takes advantage of the time evolution of a bare atomic state after a dressing field is suddenly turned. The initial state becomes a superposition of dressed states and it undergoes Rabi oscillations in time. The spectral components of these oscillations contain information about the energies of the dressed states.

Aqu algo sobre el caso particular de las energias SOC.

The measurement can be simplified by noticing that a non-moving atom cloud in the laboratory reference frame dressed by a field with non-zero detuning is equivalent to a moving cloud with a resonant field in a suitable moving reference frame. As can also be seen in the Hamiltonian (citarlo aqui) the detuning term δ/Er and the momentum term $4k/k_R$ have the same effect in the energy differences.

For the case of our spin-orbit coupled BECs, the bare state The system is let to evolve for a finite time T and afterwards the field is snapped off. A Stern-Gerlach pulse applied at our 21 ms time of flight (TOF) allows us to project the state of the condensate back into the bare m_f basis.

For the experimental sequence we start

II. RESULTS

III. DISCUSSION

IV. CONCLUSION