Introduction

The Need 4 Speed

- Faster tunneling rates with lighter atoms:
  \[ t \approx \frac{4}{\sqrt{\sqrt{E_0} \frac{V_0}{E_0}}} \exp \left( -\frac{\sqrt{V_0}}{E_0} \right) \]
  where the recoil energy is \( E_0 = \frac{\hbar^2}{2m} \)
- Higher \( T_c \) for magnetically ordered states
- Suitable to study spin dynamics within experimentally relevant timescales

Possible Experiments

Quantum Simulation

- Realization of 2-component Spin Hamiltonians
- Anisotropic Heisenberg Model (XXZ model)

\[ H = \sum_{i,j} \left( \lambda x a_i^\dagger s_i^x a_j s_j^x + \lambda z a_i^\dagger s_i^z a_j s_j^z \right) - B_z \sum a_i^\dagger a_i + h.c. \]

- Study its magnetic phase transitions

Spin Dynamics

- Spin transport by superexchange interactions in a two-component system

Experimental Setup

Experimental Model

- Two-components Hamiltonian realized by \(^7\text{Li}\) atoms in two hyperfine states placed in an optical lattice
- Experimental ‘knobs’: what we can vary:
  - Energy ratio \( t/U \) by optical lattice depth
  - On-site interaction energy \( U \) by external magnetic field
  - Spin separation by a magnetic field gradient
  - Scattering length by a Feshbach resonance
  - Temperature

Laser Table

Machine Table

- Oven, Differential Pumping, Zeeman Slower and Main Chamber
- The machine in real space
- Spectroscopy

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