Cold Atom Experiment (II) [Jin]

- Map out phase diagram:
  - Parameters: $T/T_F$ and $a$
  - $T_F$ is the Fermi temperature

- Alternative measurements
  - Vortices
  - Thermodynamics (circumvent "projection onto molecular state" trick)

  For molecular, $k$ smear out as tightly bound molecule
  $\Rightarrow$ high momentum in constituents

- Photoemission Spectroscopy:
  - Used to measure $\Delta$, where it is defined so that $2\Delta = \text{energy needed to break a pair}$

- RF Spectroscopy: History (measuring binding energy)
  - Use a third state & measure difference is peak transfer
• Making the measurement near crossovers

- Issues with measurement
  ▶ Non-homogenous trap depth $\rightarrow$ non-homogenous gas density
  ▶ Final state effect
    - Can be circumvented by taking transition to another spin state that is weakly interacting.

• Momentum-resolved RF Spectroscopy ($\sim$ ARPES)
  ▶ Require weak final-state effect and require long mean-free path ($\geq$ cloud size)
  ▶ The "spin flipped" particle is distinguished by rise in spin state.
  ▶ The dispersion of the single particle state obtained by energy conservation

- Weakly interacting gas:
\( T/T_c \lesssim 0.1 \)

- Issue: As interaction is tuned up, the gas in known to contract. Thus \( E_f \neq E_0 \).

- Additional use of momentum-resolved RF spectroscopy, e.g., p-wave pairing.

- P-wave pairing

  - Examples: \(^3\)He

  - New features: anisotropic gap, multiple superfluid phases, narrow resonance

  - Resonance:

  - Experiment done on spin-polarized gas.

  - Now resonance (quasi-bound) state can be seen:

  - Molecule lifetime \( \sim 1.2s \) (\( \sim 1 \) collision)

  - Quasi-bound state shows \( \sim E^{-3/2} \) dependence in lifetime, as expected.