

RAMAN COOLING QUASIMOMENTUM IN AN OPTICAL LATTICE

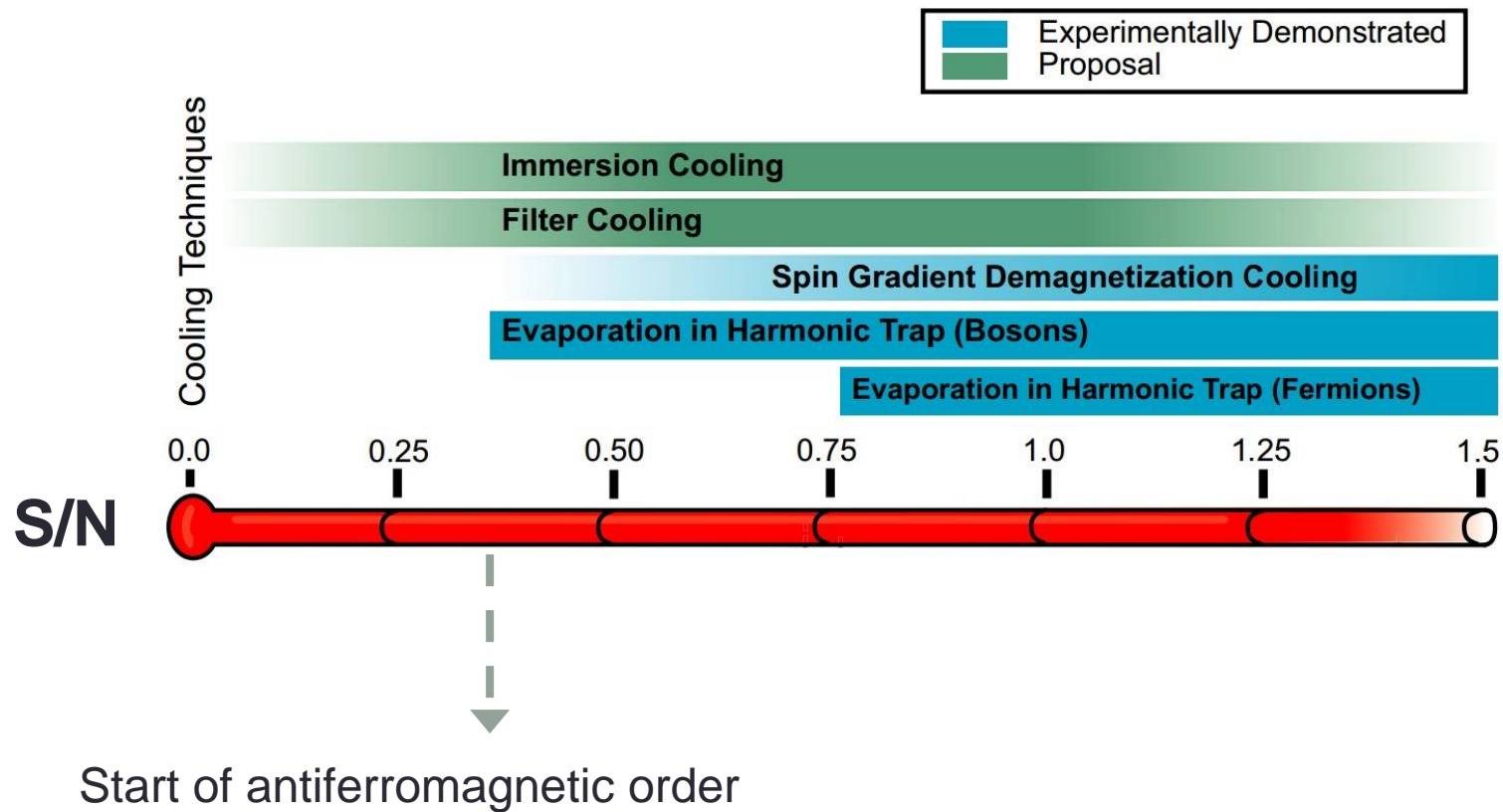
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DAMOP 2014

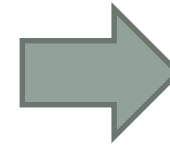
Why a Colder Gas?

- Benchmarks for the half-filled Femi Hubbard Model



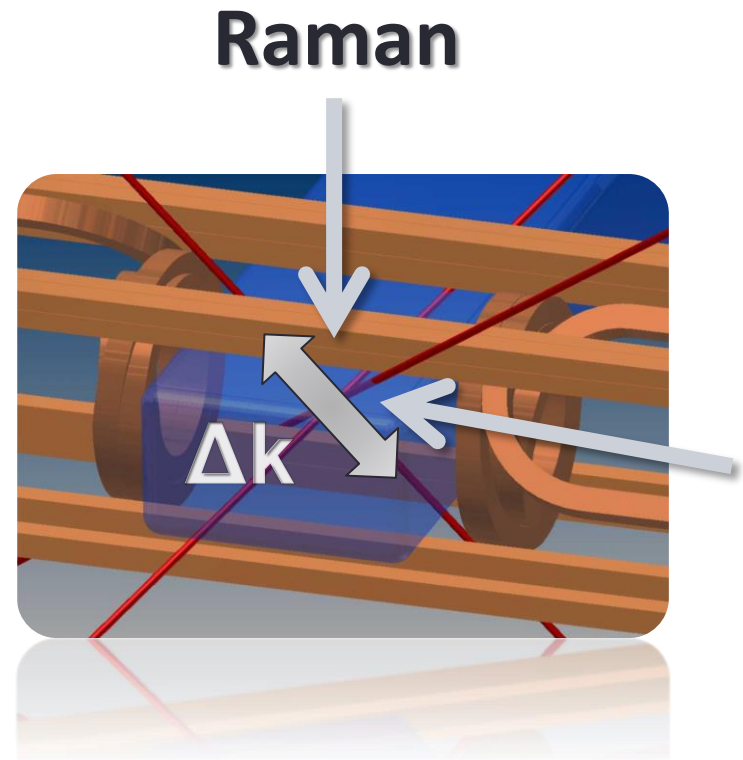
Raman Cooling Quasimomentum

Proof-of-principle demo with bosons



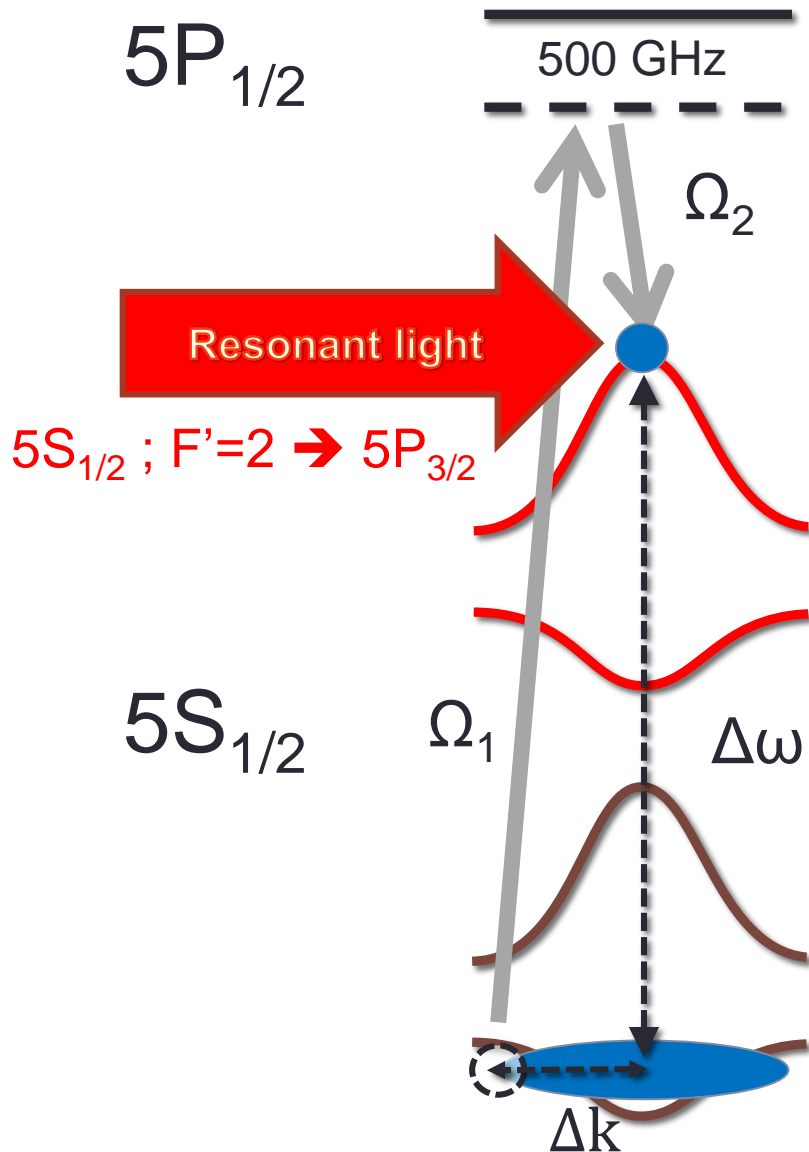
1D cooling
in a 3D gas

- ^{87}Rb
- Cubic spin-*independent* lattice
- SF regime



Cooling Cycle

^{87}Rb



1. One cycle

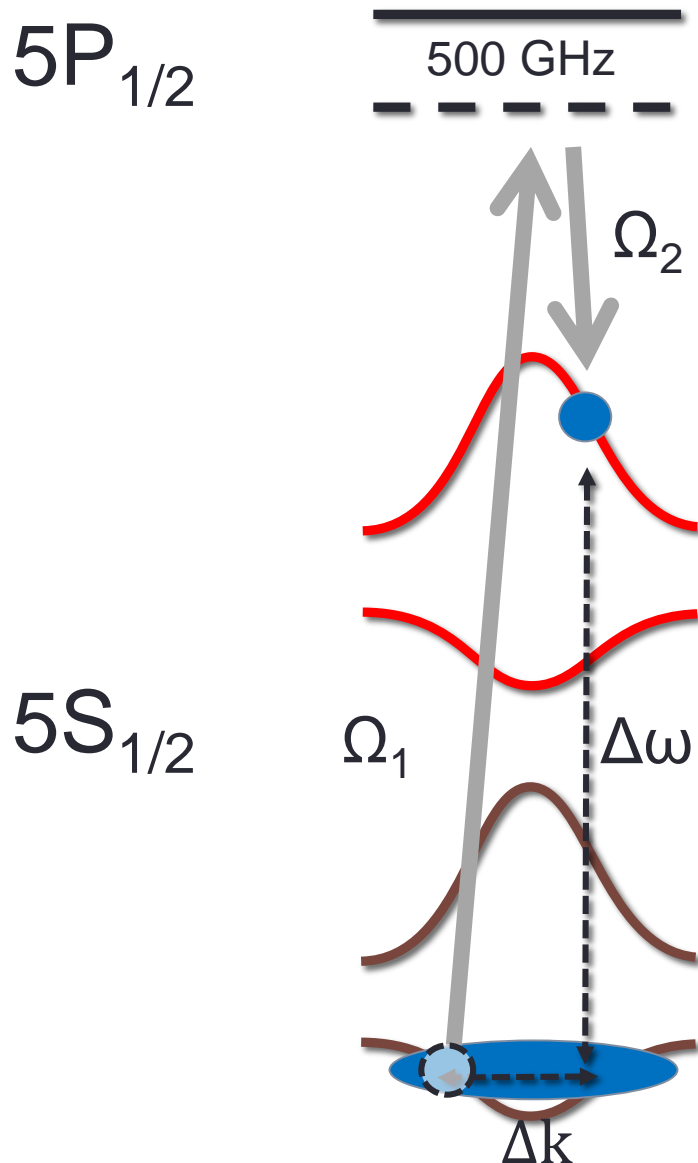
- Select atoms with high quasimomentum
- Excitation to $F'=2$
- Resonant light
- Let the gas relax

$|2, 0\rangle$

$|F, m_F\rangle = |1, 0\rangle$

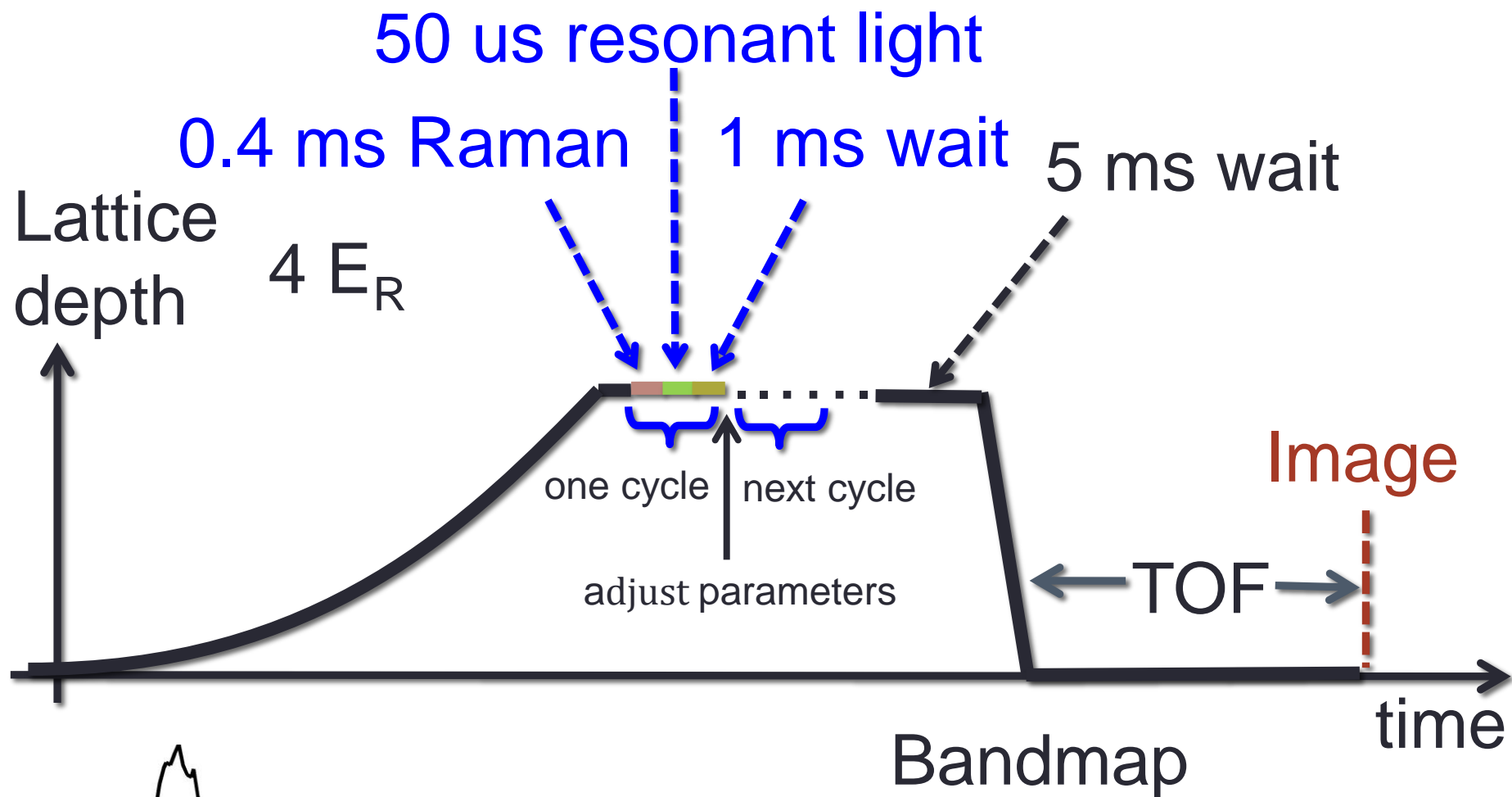
Cooling Cycle

^{87}Rb

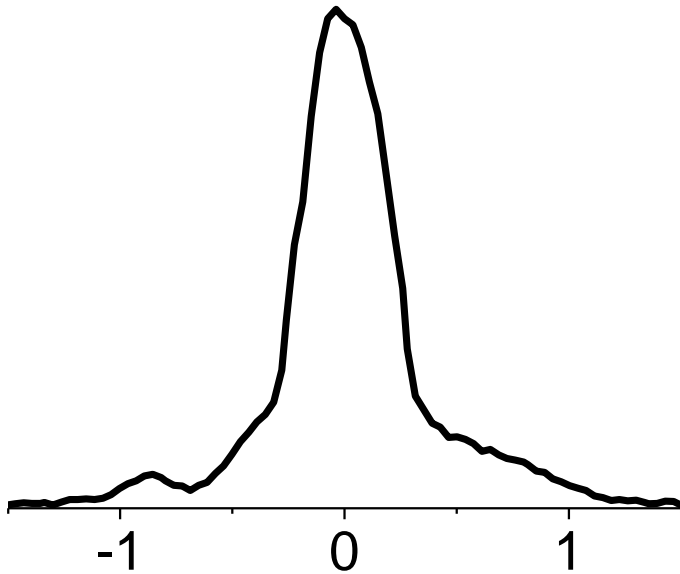
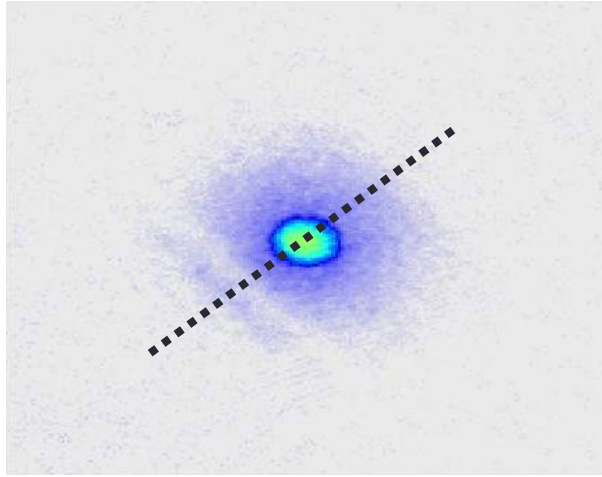


1. One cycle:
 - Select atoms with high quasimomentum
 - Excitation to $F'=2$
 - Resonant light
 - Let the gas relax
2. Adjust $\Delta\omega$, Ω_1 , Ω_2
3. Next cycle

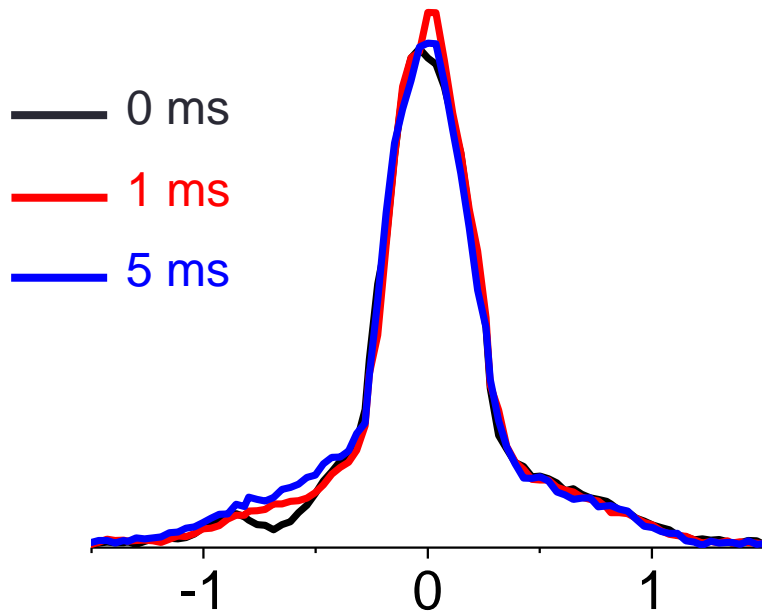
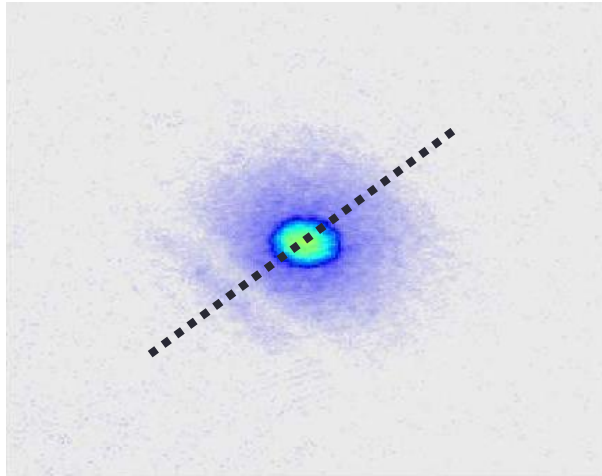
Experimental Sequence



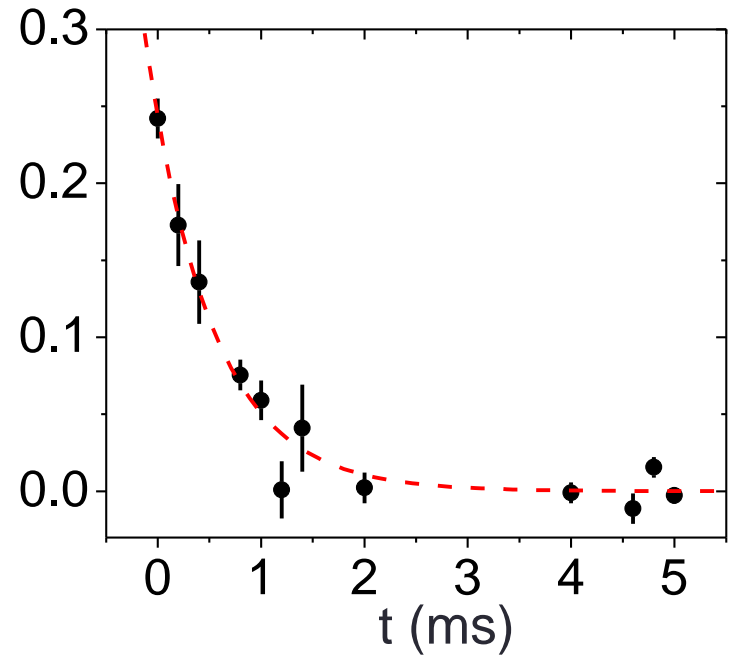
Mid-Cooling cycle: Quasimomentum Relaxation



Mid-Cooling cycle: Quasimomentum Relaxation



Center of momentum vs time



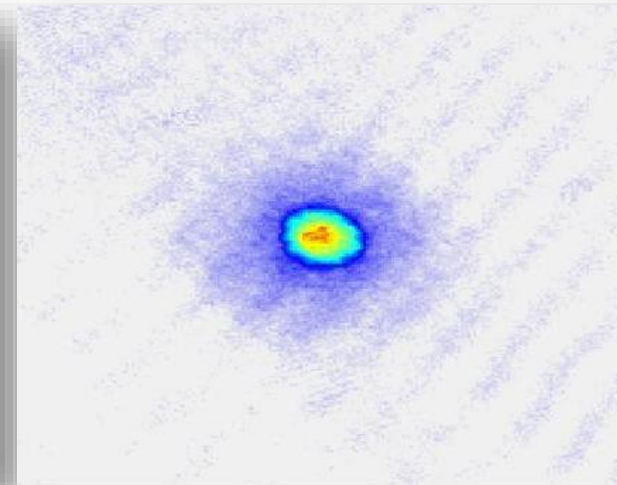
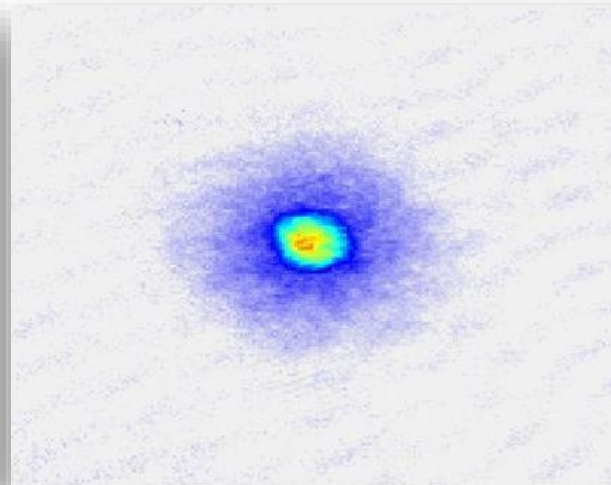
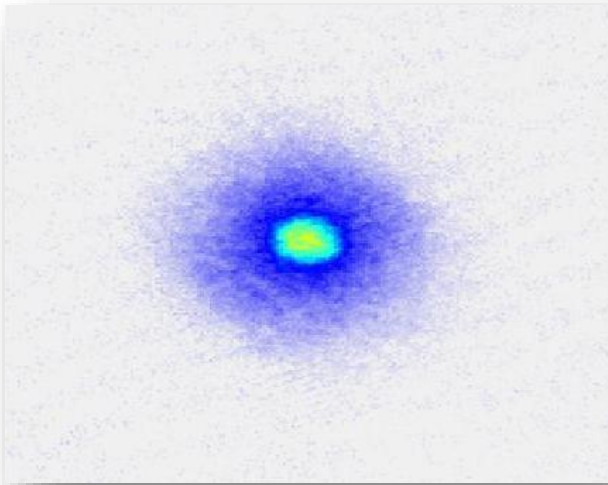
$$\tau = (0.6 \pm 0.1) \text{ ms}$$

$$h/U \sim 1 \text{ ms}$$

Full Cooling Cycle

1 cycle

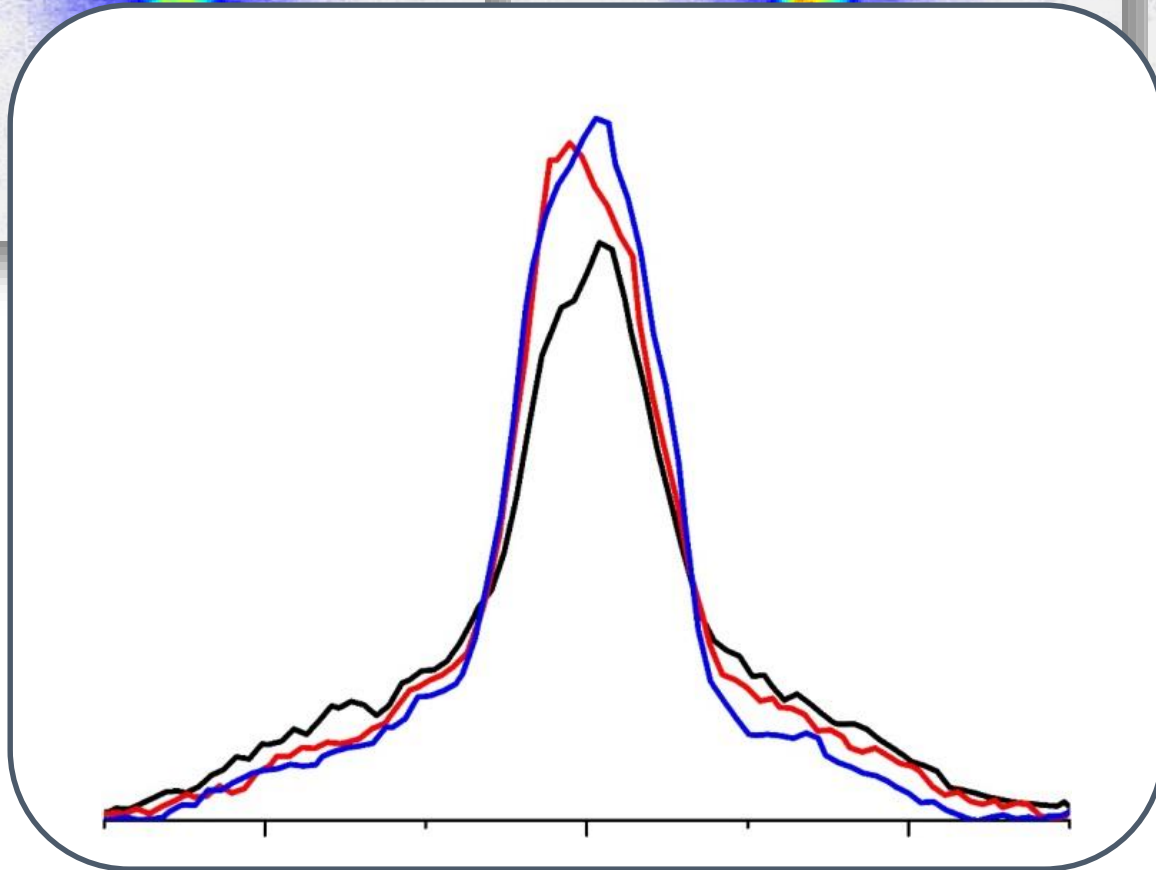
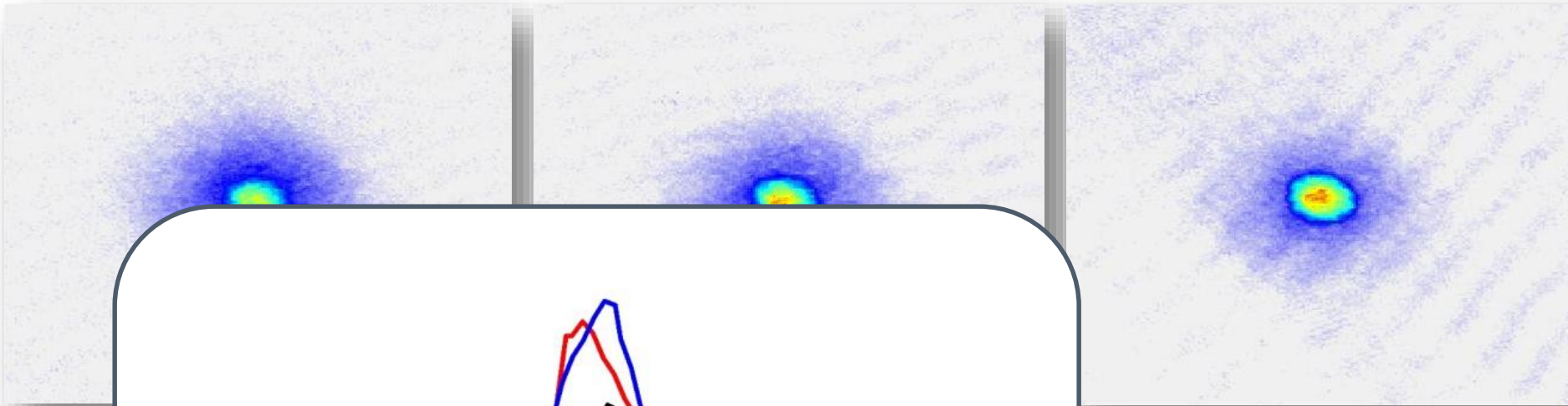
2 cycles



Full Cooling Cycle

1 cycle

2 cycles

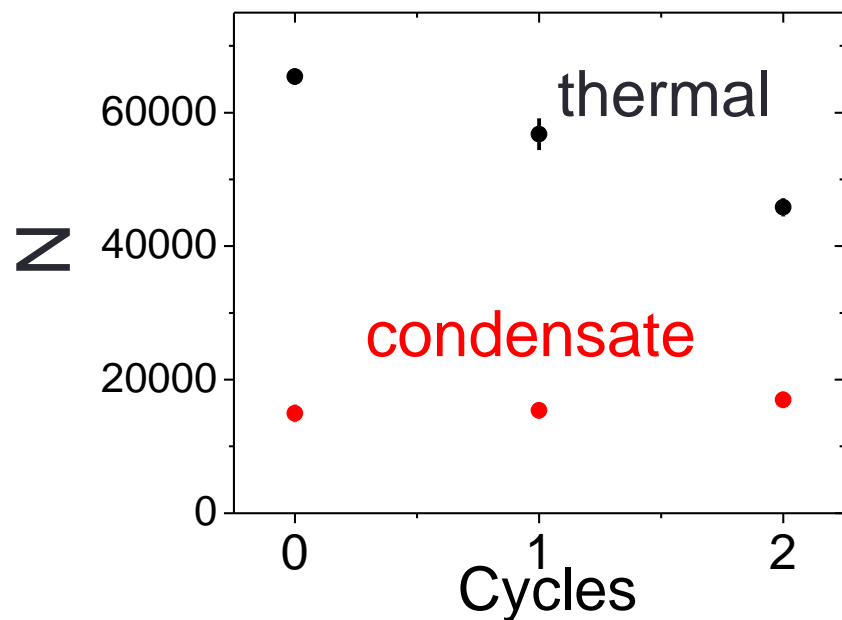


1 cycle

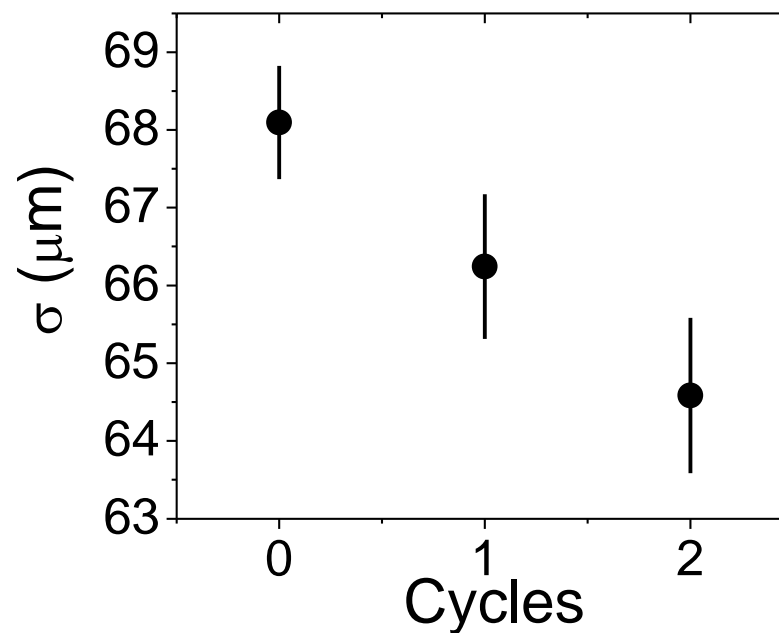
2 cycles

Cooling Results

Atom number

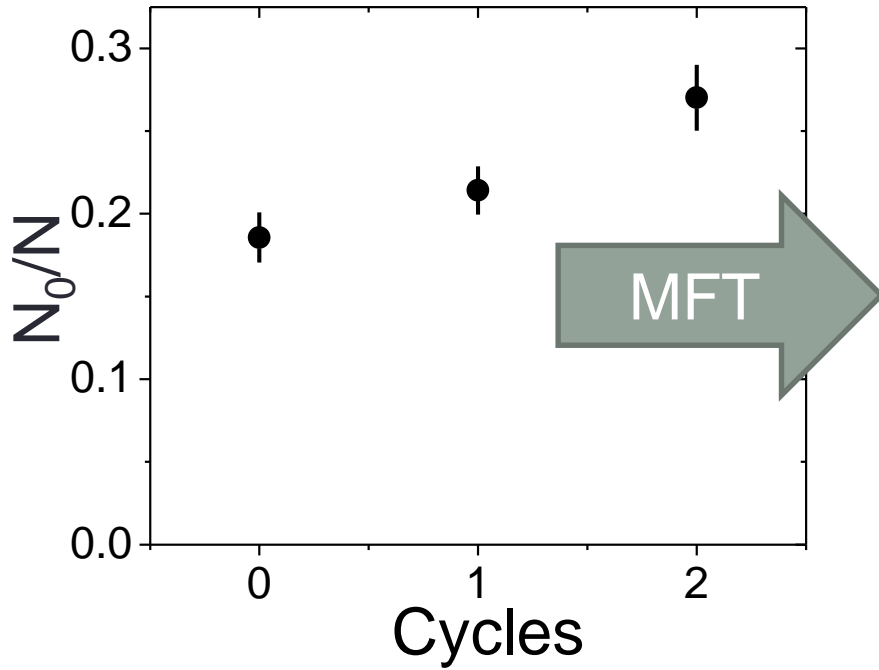


Thermal width

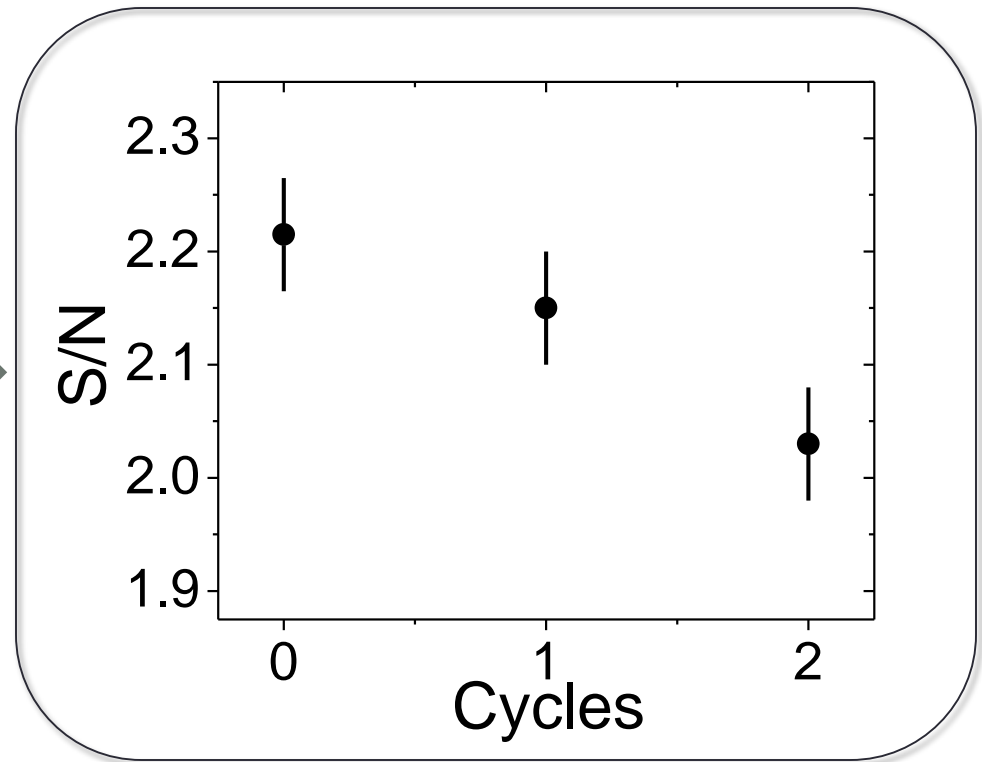


Cooling Results

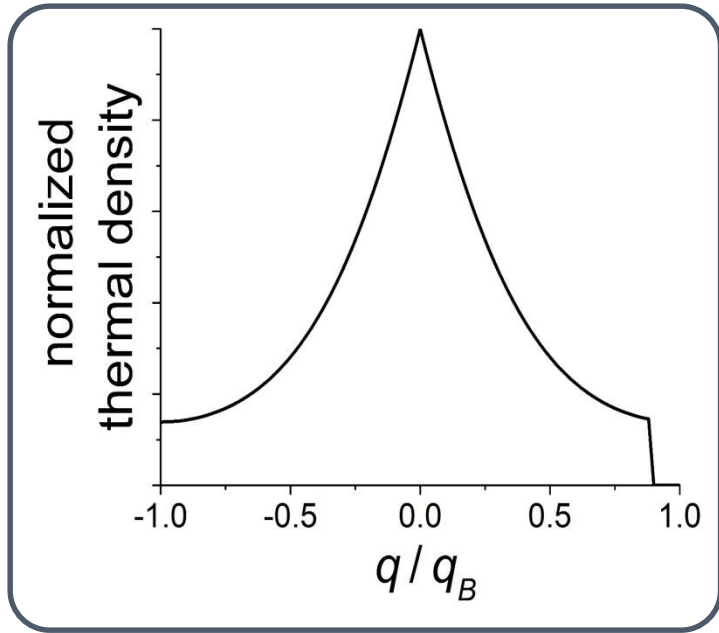
Condensate fraction



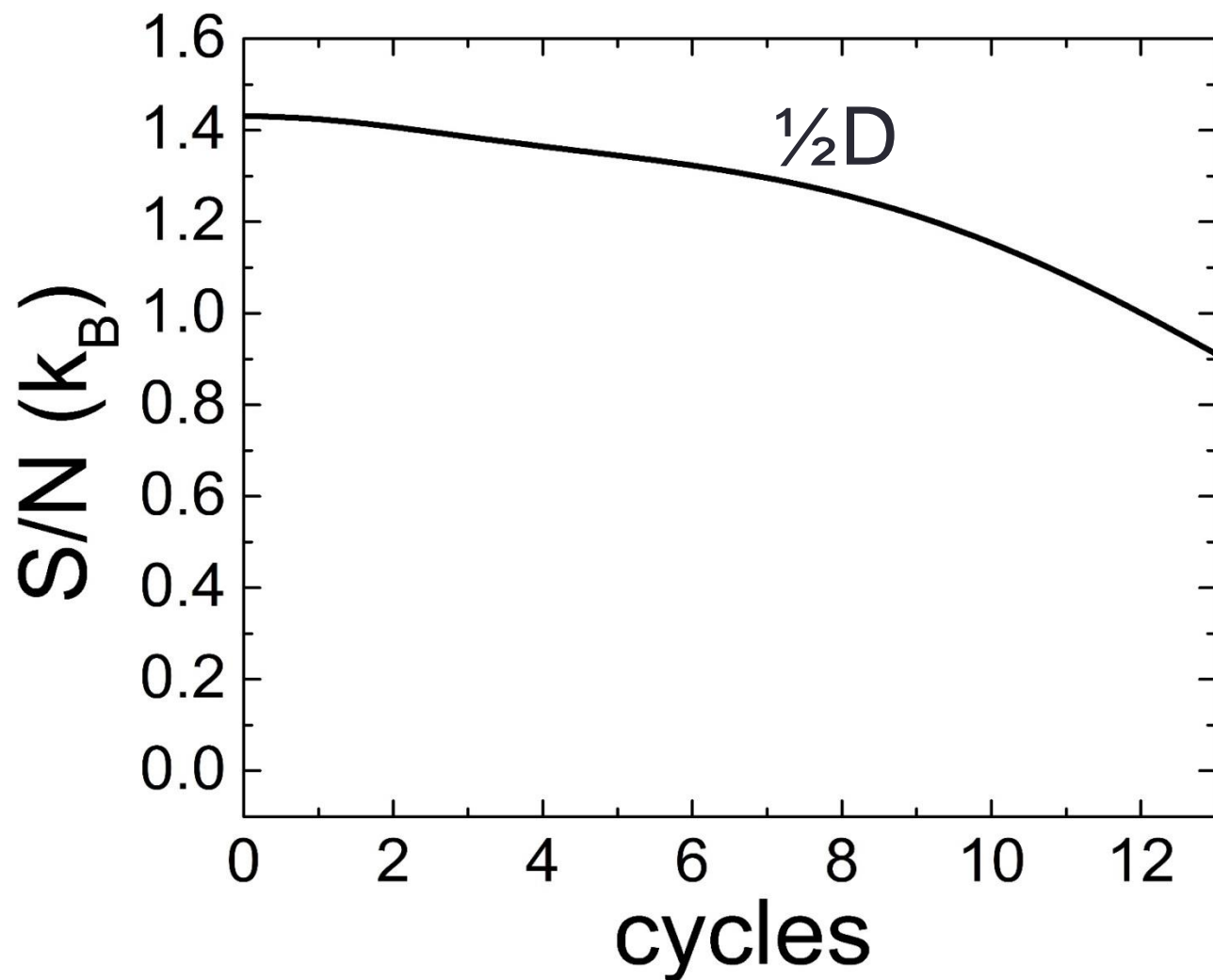
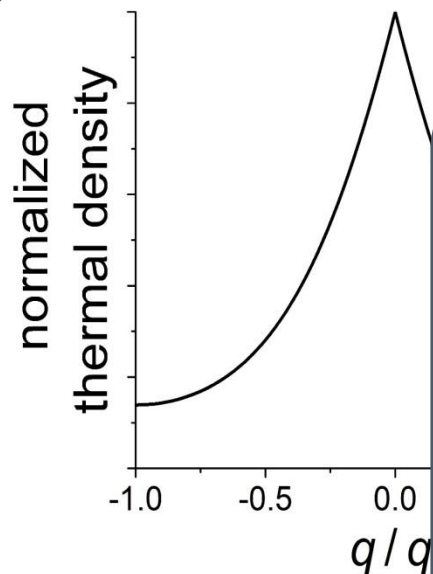
Entropy per particle



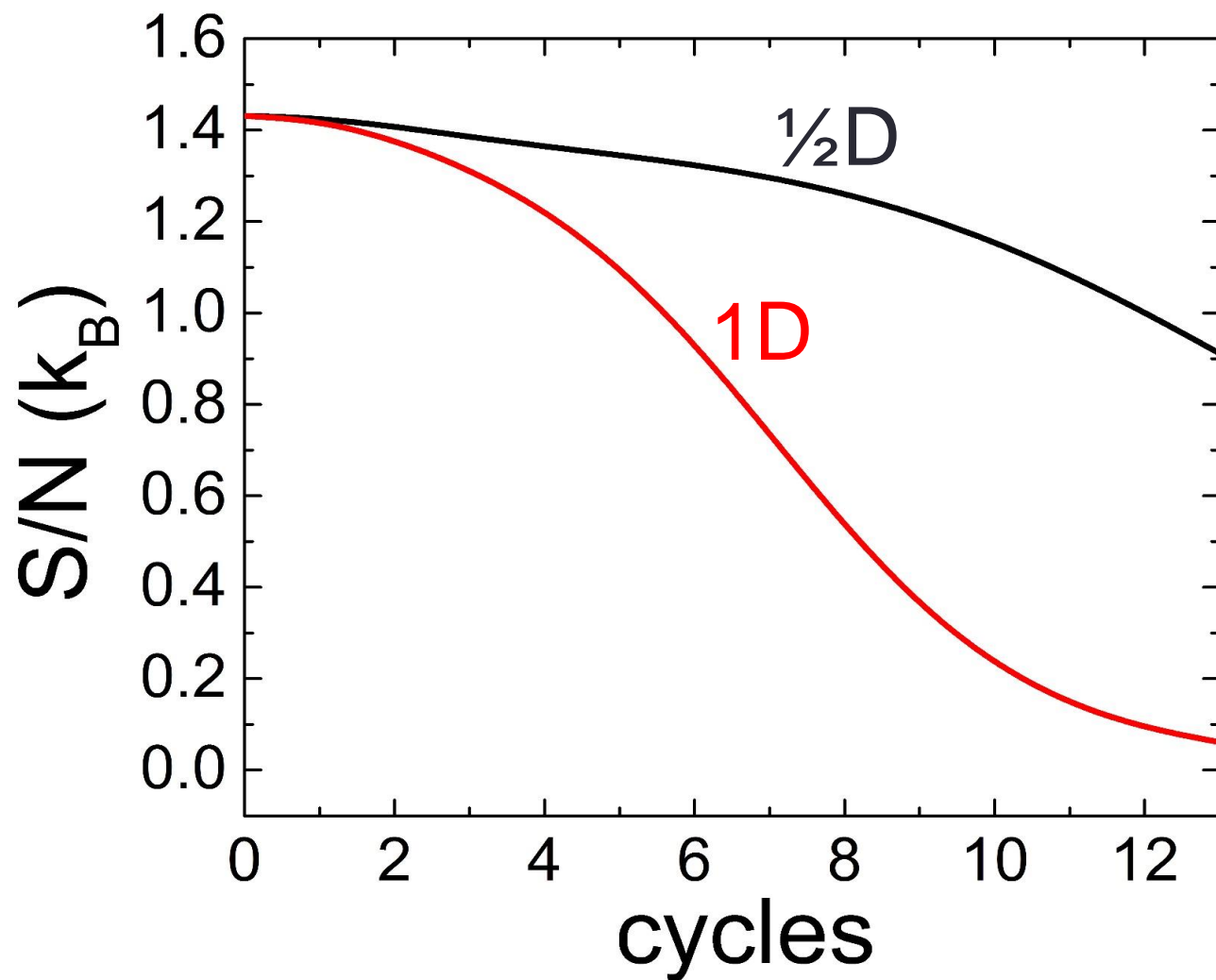
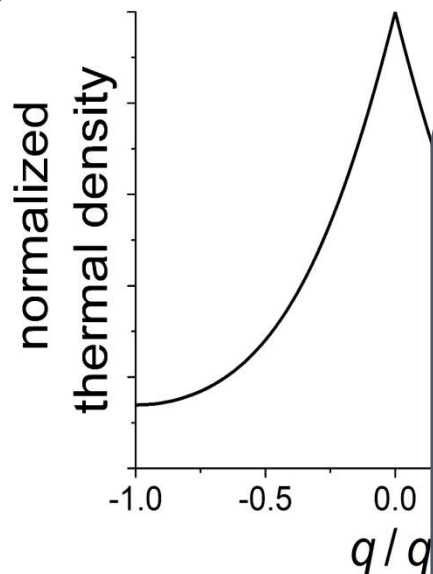
Semiclassical Model



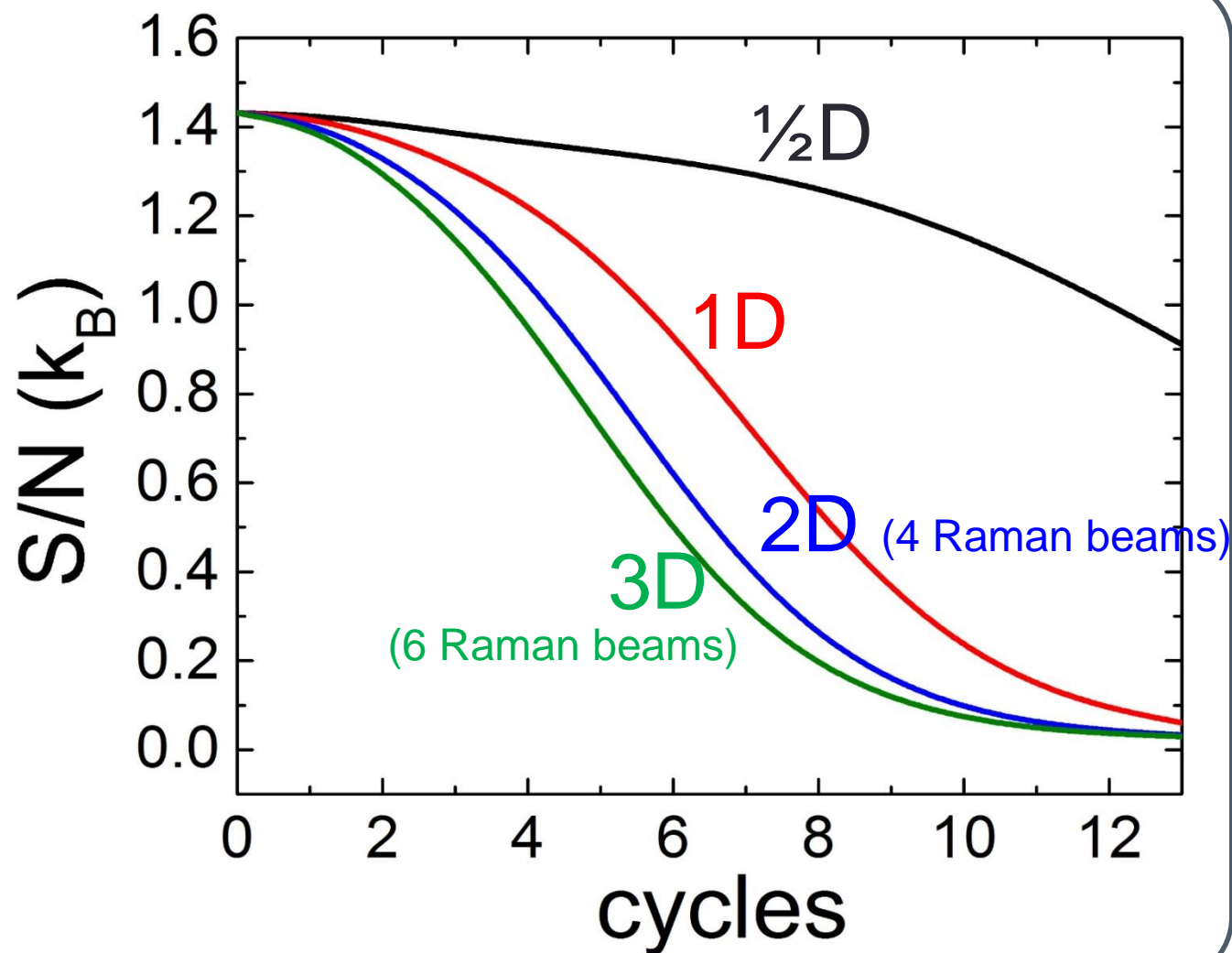
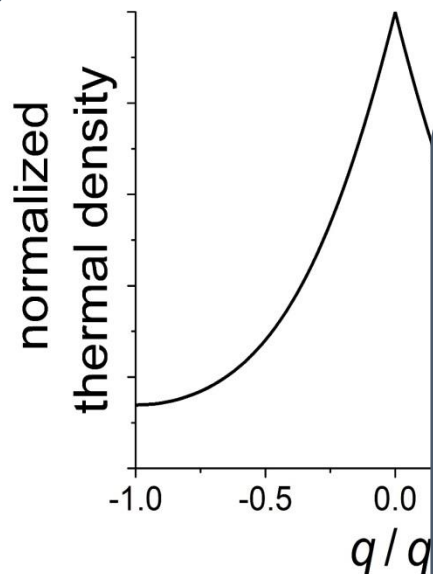
Semiclassical Model



Semiclassical Model



Semiclassical Model



Summary

- Method for any species, boson and fermion
- It should work well with more Raman beams

- Caveats
 - Rabi profile
 - Finite momentum in ground state

Try with fermion!