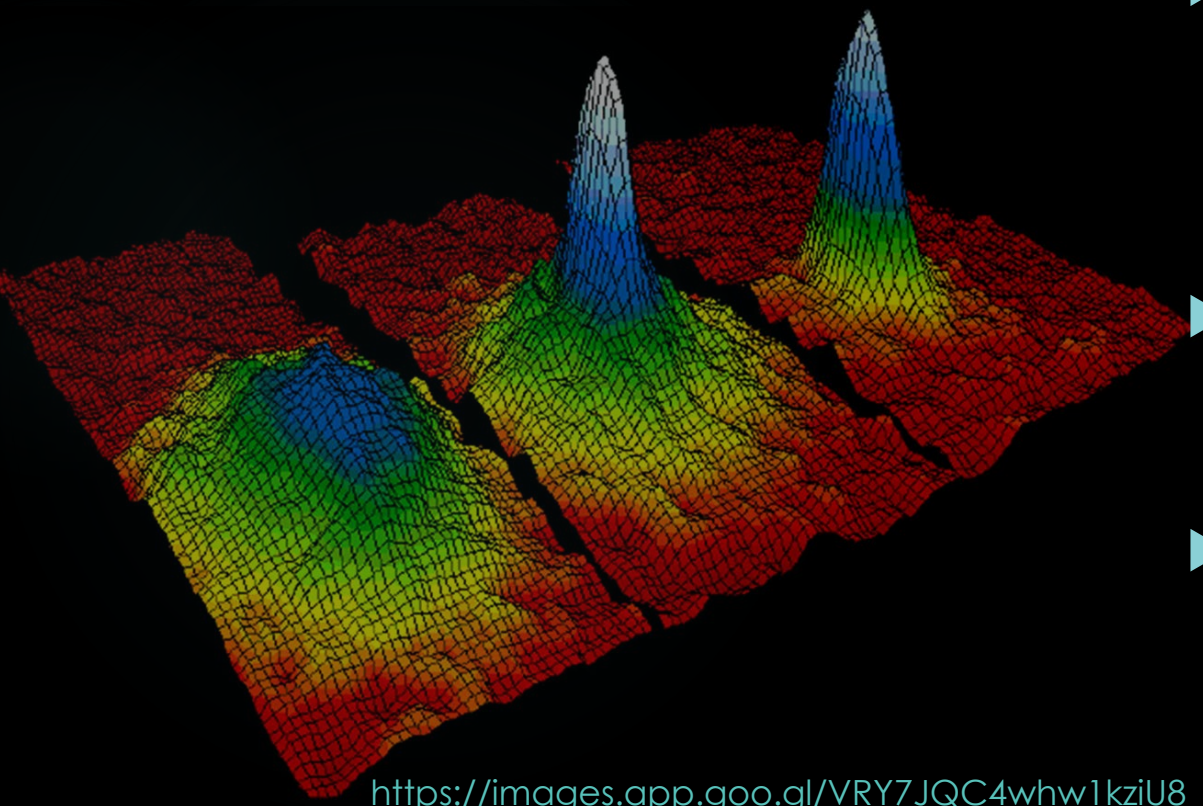
# Saturated Absorption Spectroscopy of $^{87}Rb$: Towards Achieving Bose-Einstein Condensates

JESSICA CLARK

# Bose-Einstein Condensates (BECs)



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- Bosons – Pauli Exclusion Principle doesn't apply
  - $^{87}$Rb atom
  - Atom can share the same set of quantum numbers with other atoms in the condensate
- Extremely low temperatures (~100s nK)
  - Low energy
  - The bosons occupy the ground state
  - Wavelength becomes longer
- Wavelengths overlap each other – lose their identity – function as one quantum system
- BEC is a quantum-statistical phase transition

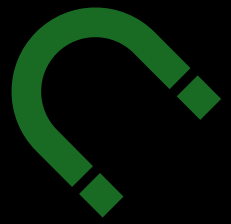
# Why It's Important

- Observe quantum behavior at a macroscopic level
  - Large number of particles occupy same quantum state, displaying wave-like properties
- Quantum simulations
  - Quantum many-body systems
- Quantum computing and information processing
- Analogue black holes
- Similarities to superfluidity and superconductivity

# Experimental Techniques for BEC

## Laser cooling

Slows atoms using laser light



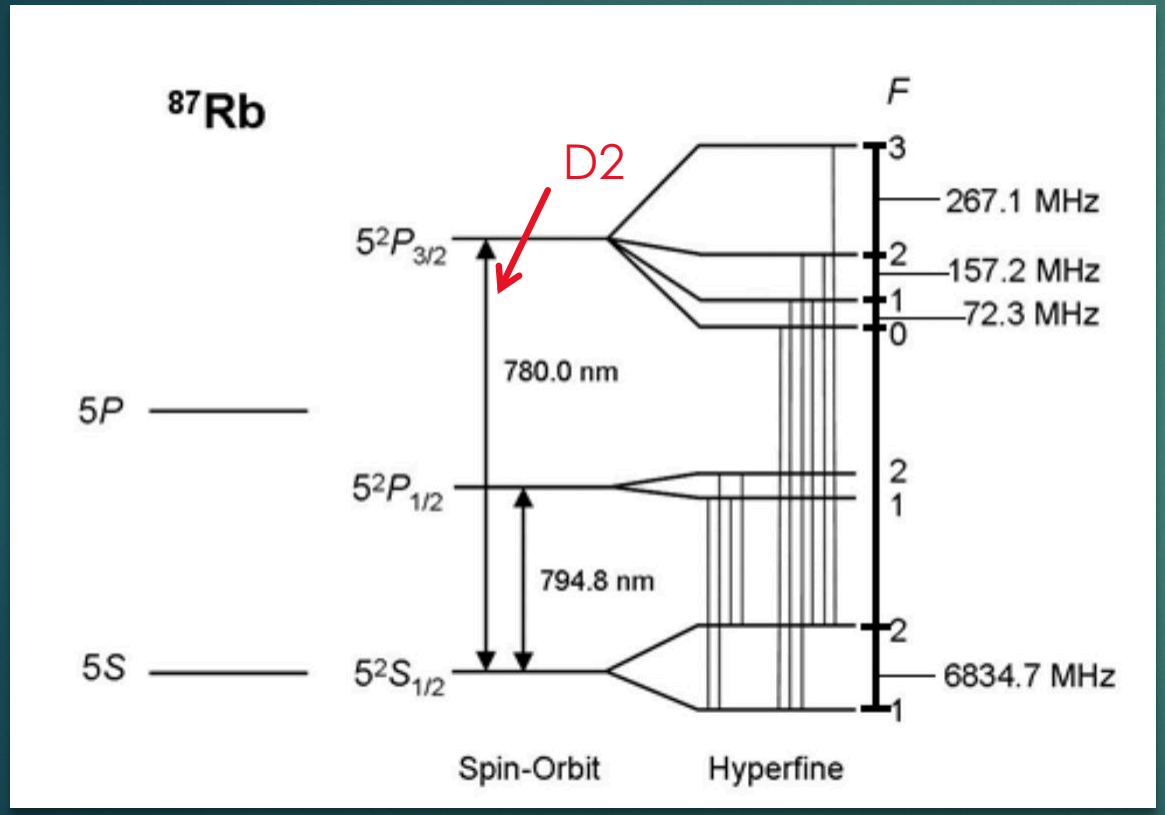
## Magnetic Trapping

Uses magnetic fields to confine atoms

## Evaporative Cooling

Selective removal of hot atoms

# My Role: Saturated Absorption Spectroscopy




- Stabilizes laser frequency to a specific atomic transition (D2)
- Process:
  - Shoot laser through vapor cell of $^{87}Rb$
  - Atoms absorb photons corresponding to transition frequency
  - Problem: Doppler broadening
- Prerequisite for laser cooling

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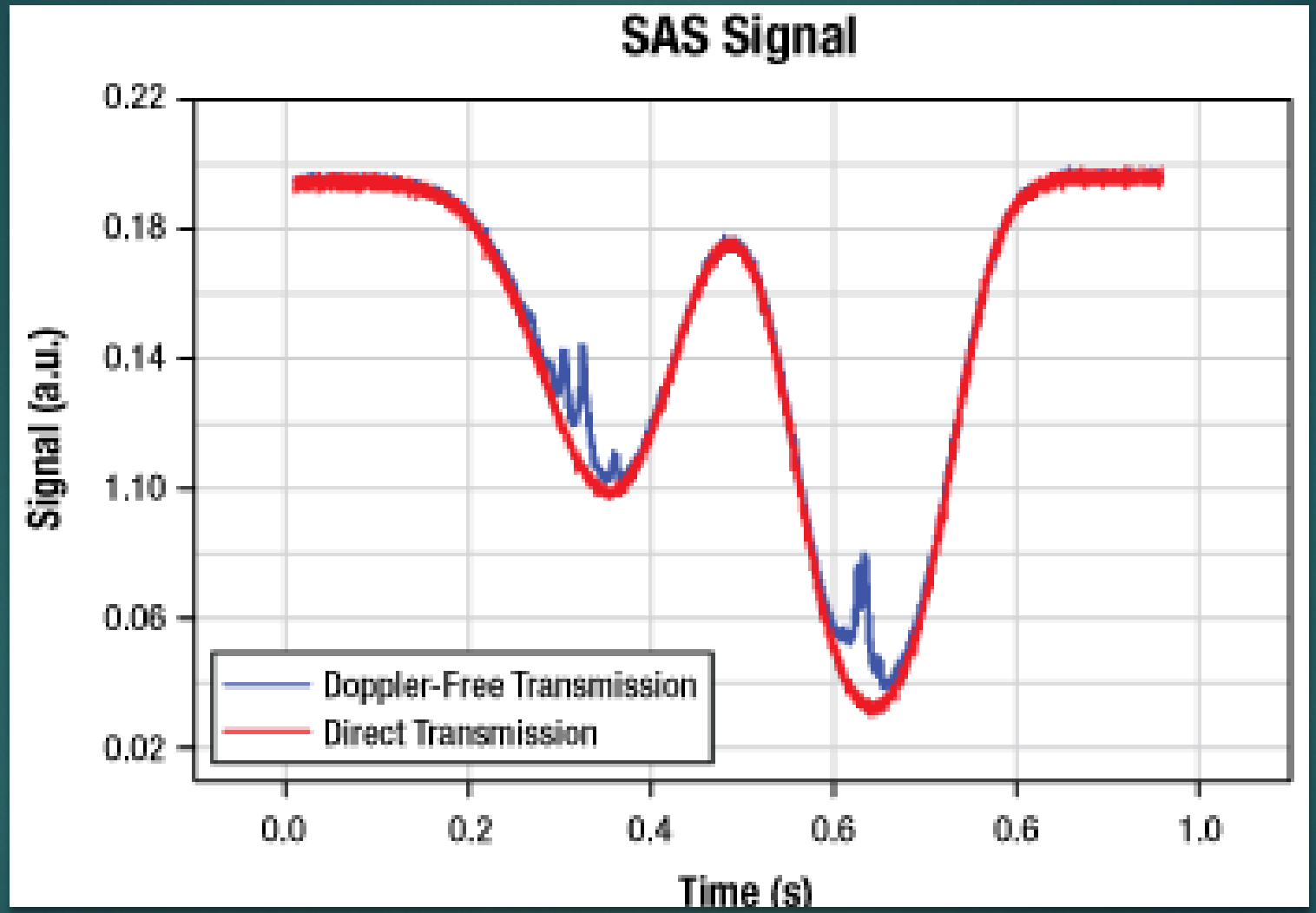


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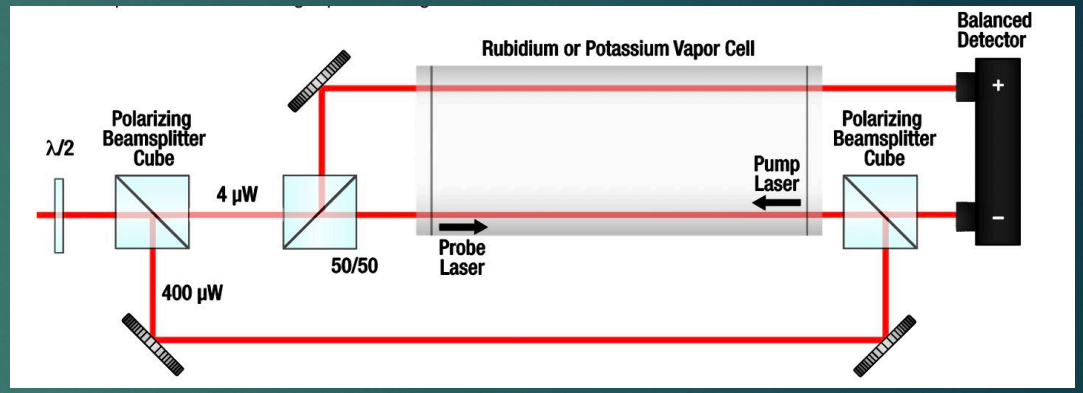
# How It Works

- Problem: Doppler Broadening
  - Range of frequencies due to Doppler shifts, not just resonant frequency
  - Fine and hyper-fine structures not observable
- Solution: Saturated absorption spectroscopy
  - Pump and probe beam: pass through $^{87}Rb$ cell in opposite directions
  - Stationary atoms in resonance with both beams
  - Pump beam "saturates" the atoms that are in resonance with it
  - Probe beam then can't be absorbed by the saturated atoms, causing sharp dip in the absorption spectrum at resonance frequency

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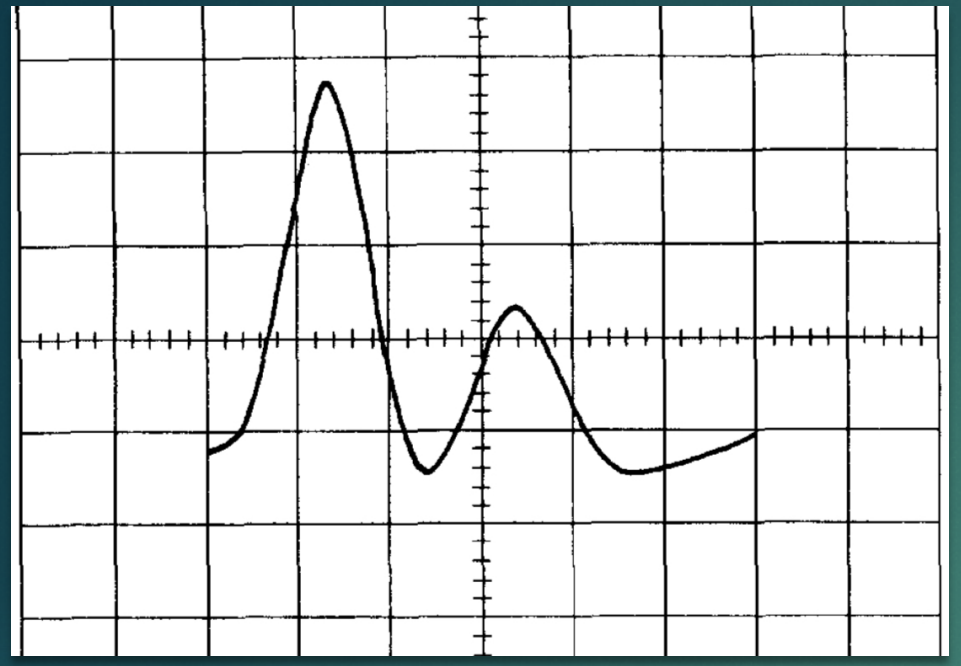

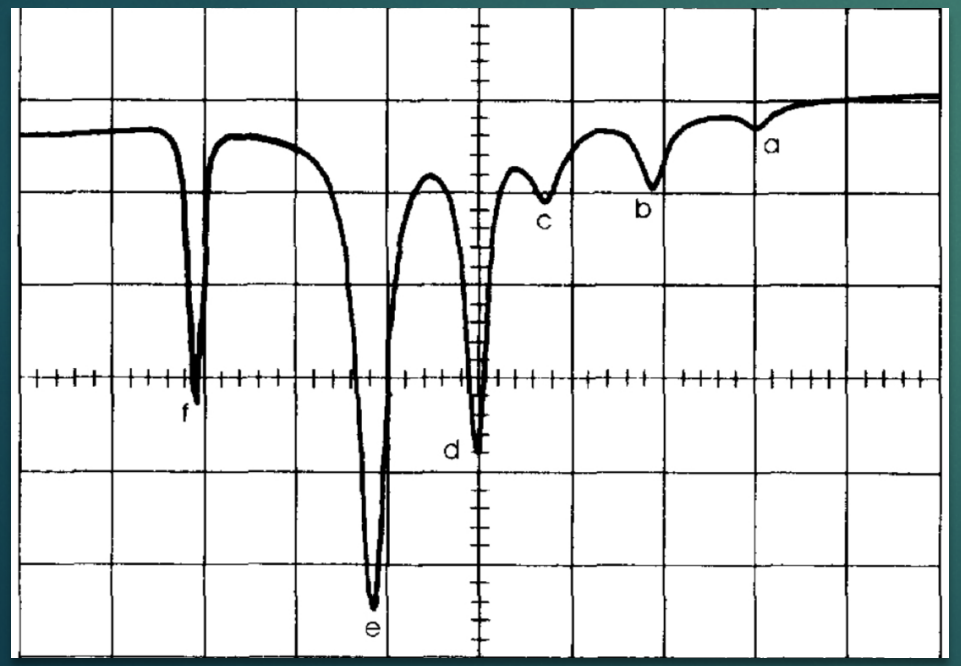


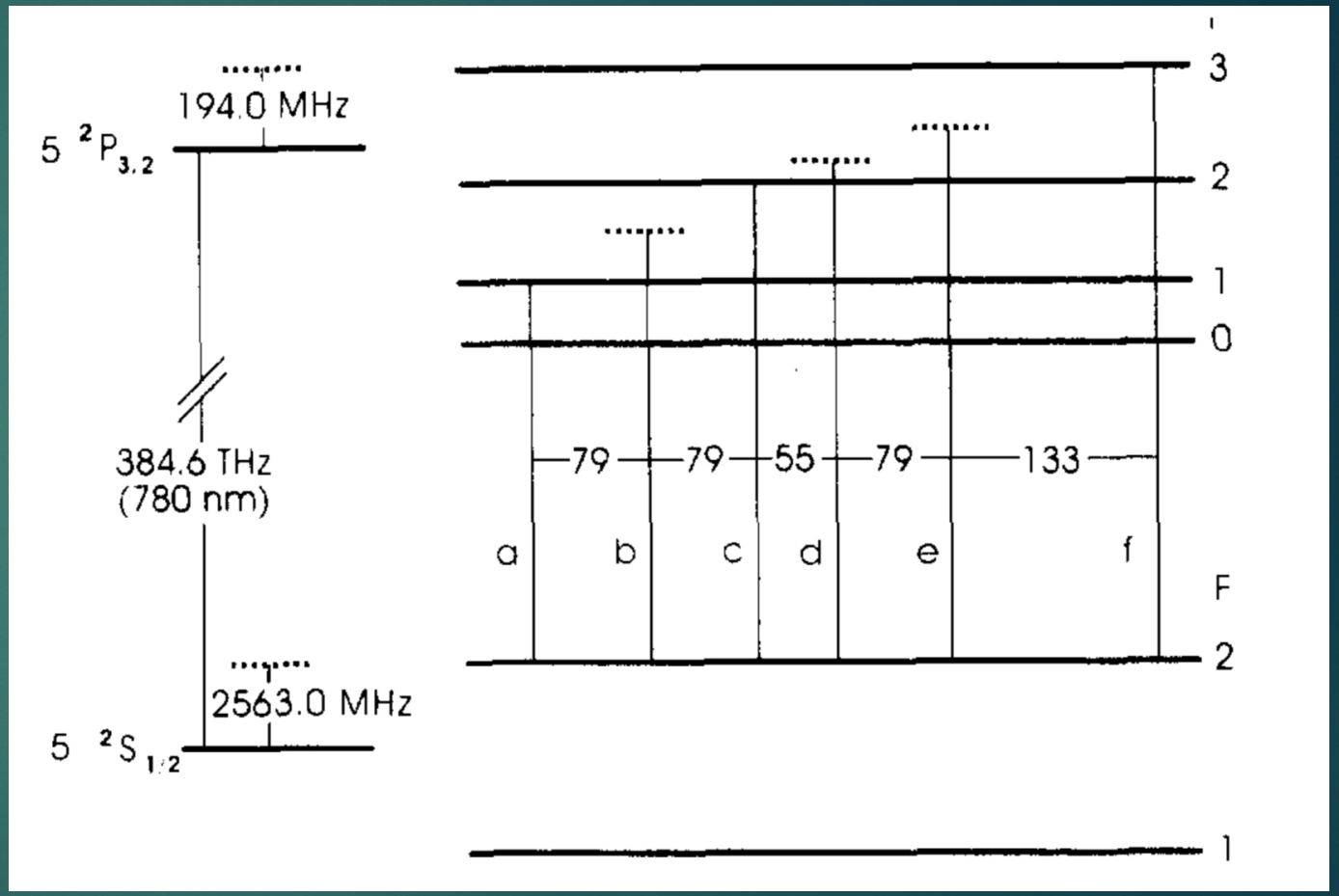


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# Questions?