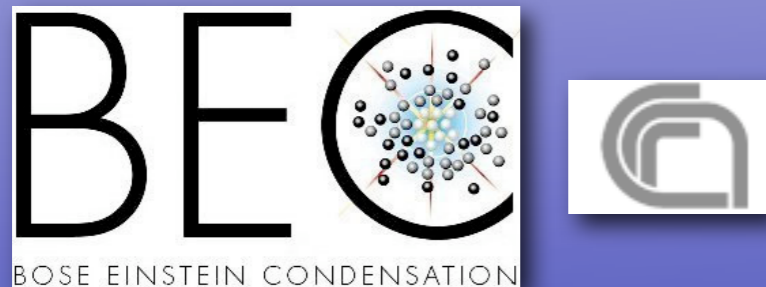


# Trapped Bose-Einstein Condensates: Superfluidity, Entanglement, and Interferometry

**Francesco Piazza**



CNR - Istituto Nazionale di Ottica  
Center on Bose-Einstein Condensation  
Trento, Italy

**Supervisor:** Dr. Augusto Smerzi

## **Collaborations:**

- Toronto Ultra-Cold Atoms Lab  
J. H. Thywissen's group

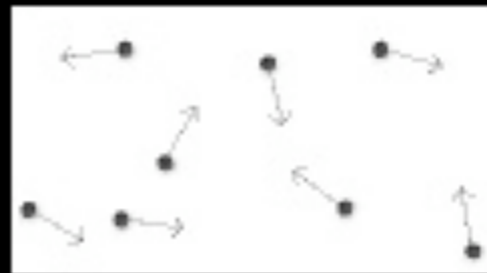


- Los Alamos National Laboratory  
L.A. Collins (Theoretical Division)



# Ultracold Gas of Bosonic Atoms

## Macroscopic Wave Function



High  
Temperature



Low  
Temperature



Bose-Einstein  
Condensation



Zero  
Temperature:  
Pure Bose  
condensate

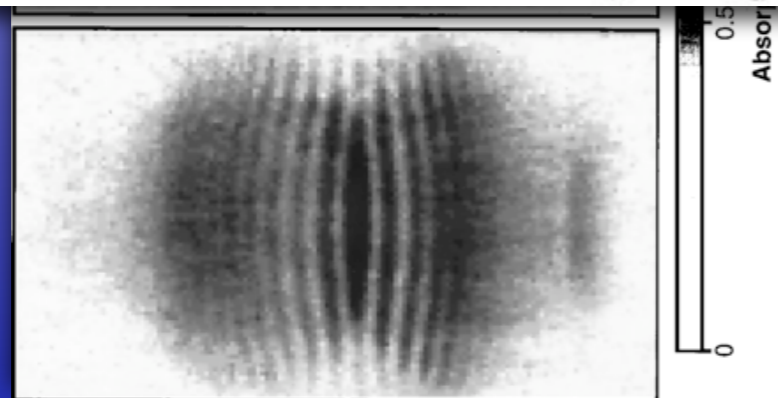
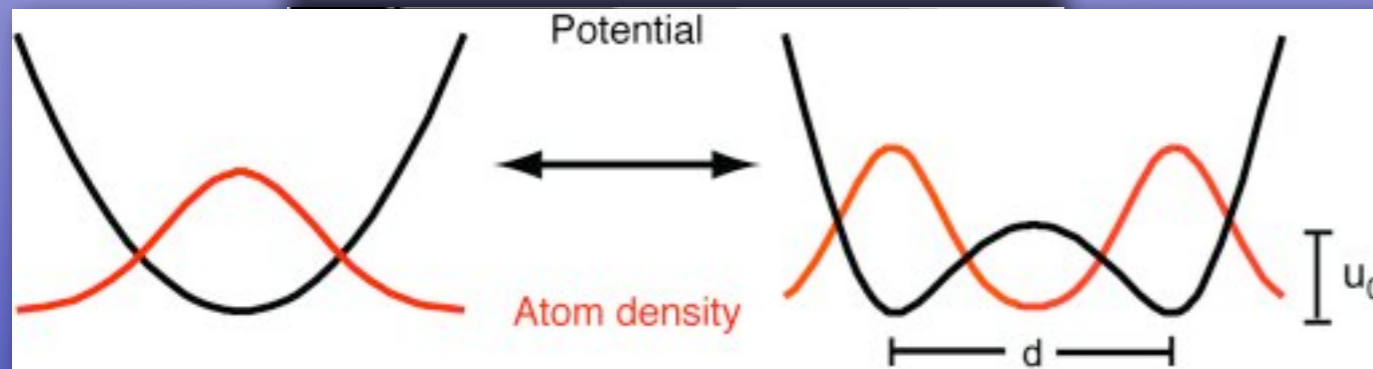
# Ultracold Gas of Bosonic Atoms

**Macroscopic Wave Function**

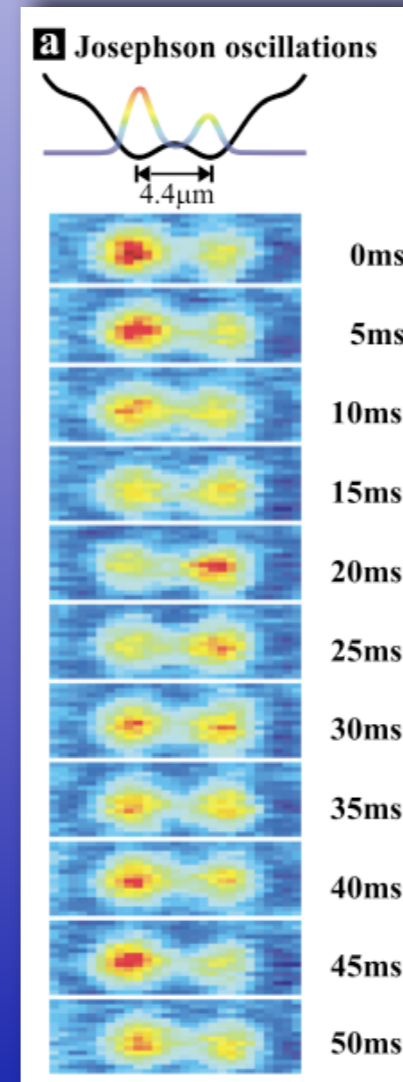
**Bright  
Coherent Source**

**Macroscopic Phase**

**Two-slit  
interference**



**MIT (1997)**



**Flow without  
a drive**

**Heidelberg (2005)**

# Ultracold Gas of Bosonic Atoms

**Macroscopic Wave Function**

**Bright  
Coherent Source**

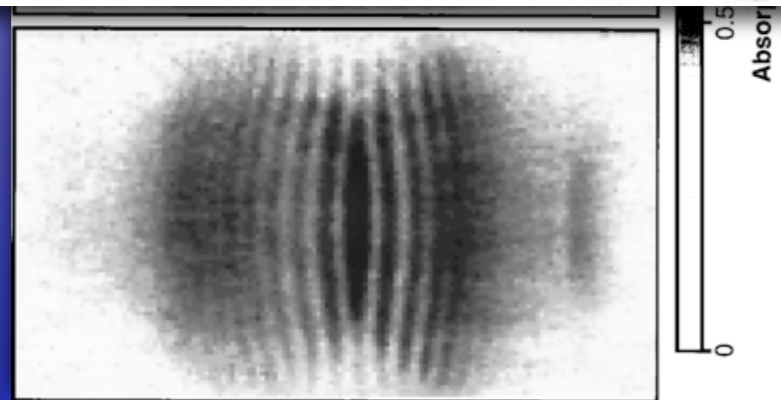
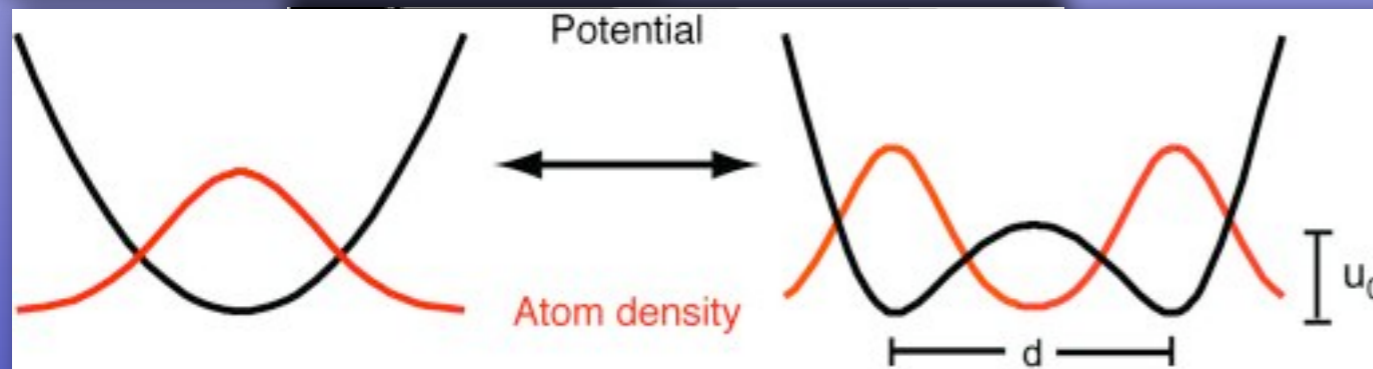
**Macroscopic Phase**

**Quantum  
Interferometry**

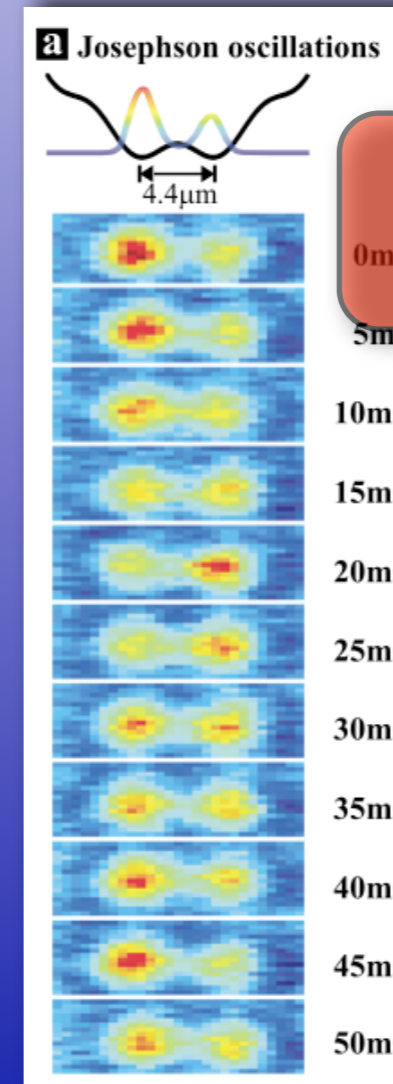
**Two-slit  
interference**

**Superfluidity**

**Flow without  
a drive**

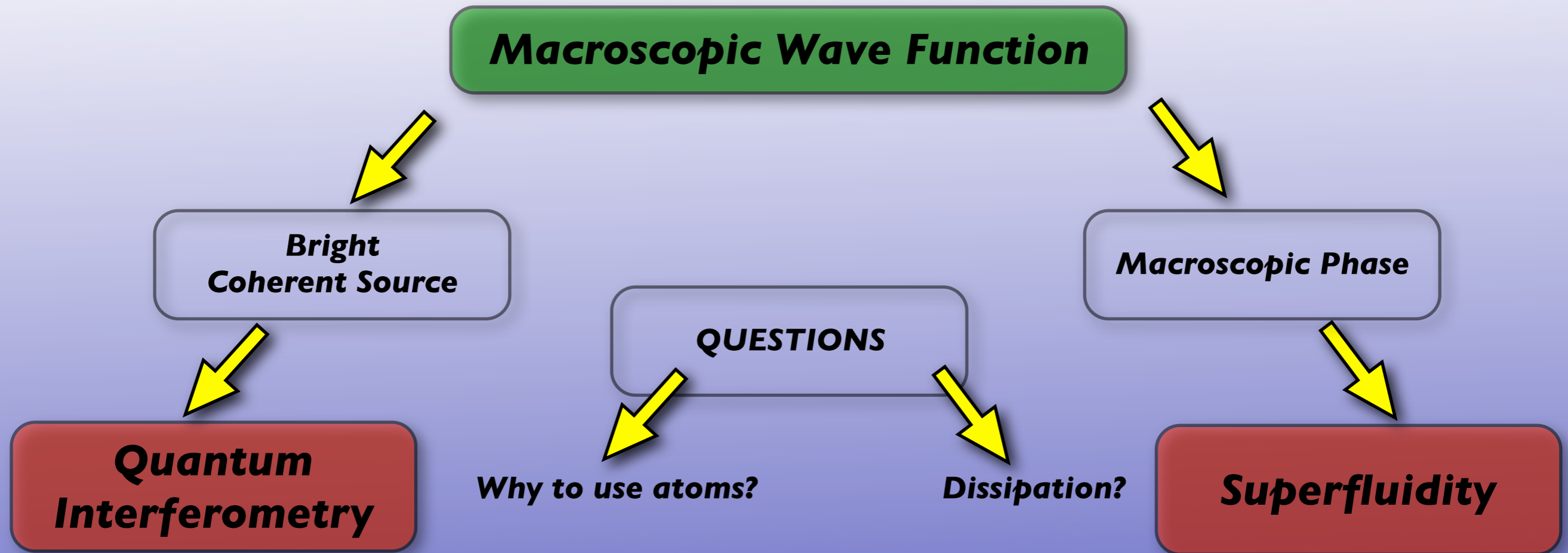


**MIT (1997)**



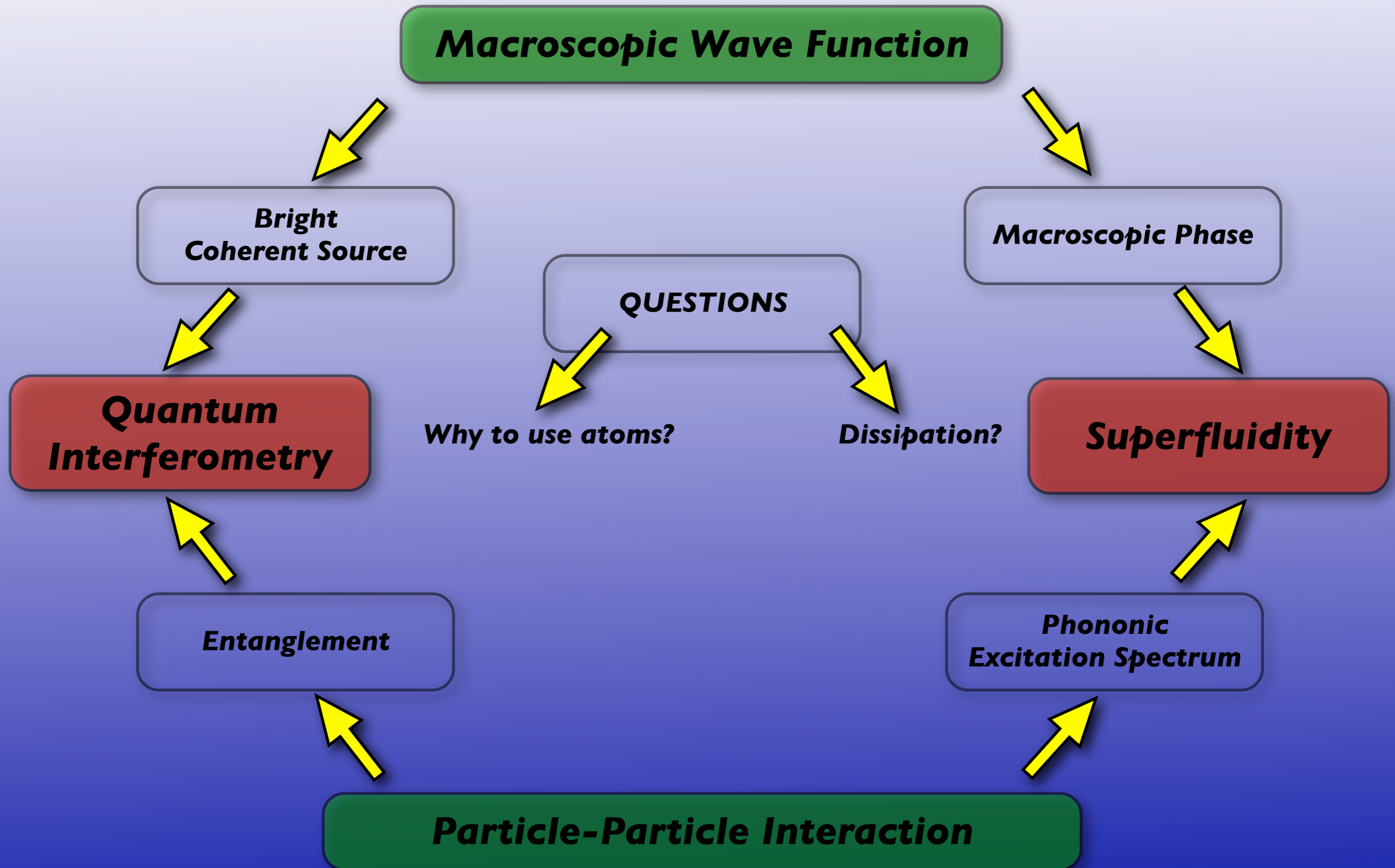
**Heidelberg (2005)**

# Ultracold Gas of Bosonic Atoms





# Ultracold Gas of Bosonic Atoms



# Projects

- **Superfluidity**

- Dissipation Dynamics

- F. P., L.A. Collins, and A. Smerzi, Phys. Rev.A 80, 021601(R) (2009)

- Critical Velocities

- G. Watanabe, F. Dalfovo, F. P., L. P. Pitaevskii, and S. Stringari, Phys. Rev.A 80, 053602 (2009)

- Josephson Physics

- F. P., and A. Smerzi, arXiv:0912.3209

- **Quantum Interferometry**

- Double Well Rabi Interferometer

- J.A. Chwedenczuk, L. Pezzè, F. P., and A. Smerzi, [arXiv:0909.0705](https://arxiv.org/abs/0909.0705)

- **Entanglement Production & Detection**

- Quantum Superpositions in Periodic Potentials

- F. P., L. Pezzè, and A. Smerzi, Phys. Rev.A 78, 051601(R) (2008),  
Research Highlights, Nature Physics 4, 903 (2008)