UNIVERSITY OF CAMBRIDGE

# Multi-particle theory of superconductivity

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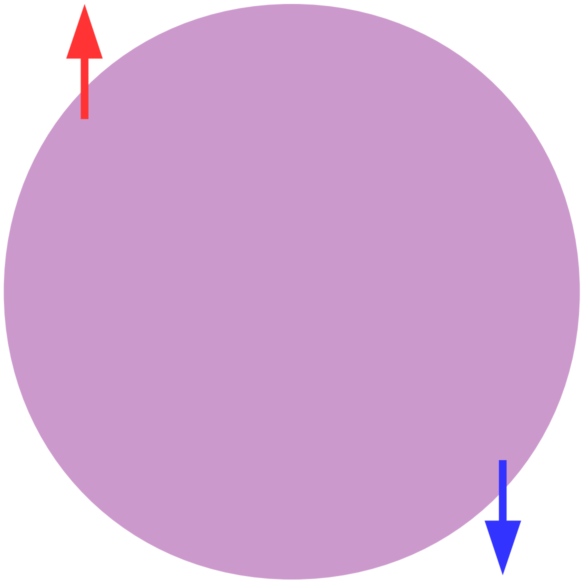
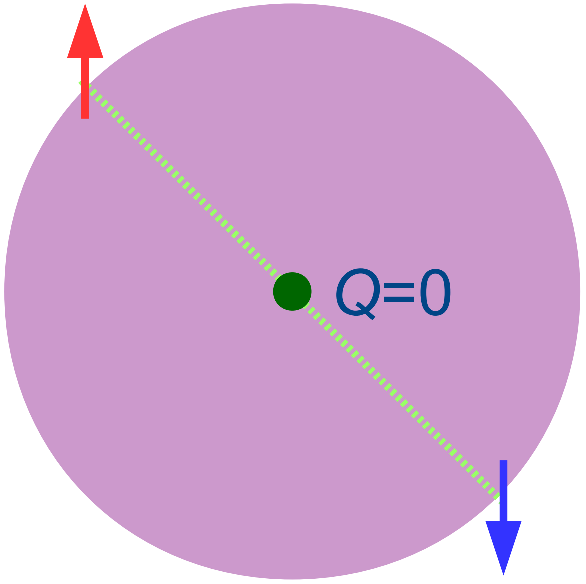
Theory of Condensed Matter group

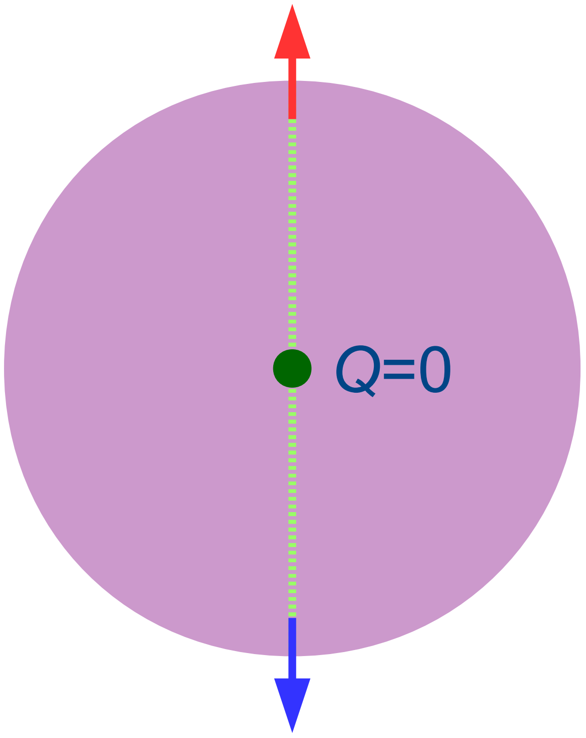
# Cooper pair



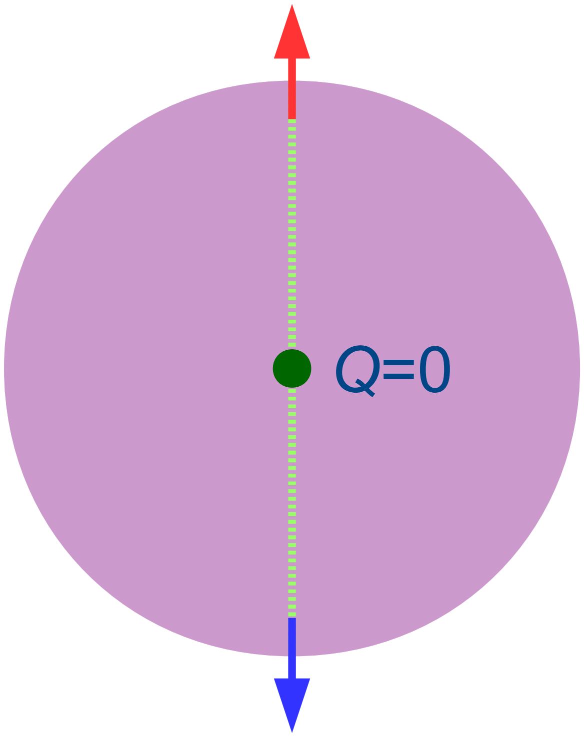
# Cooper pair has no center-of-mass momentum



# Cooper pair can exchange states

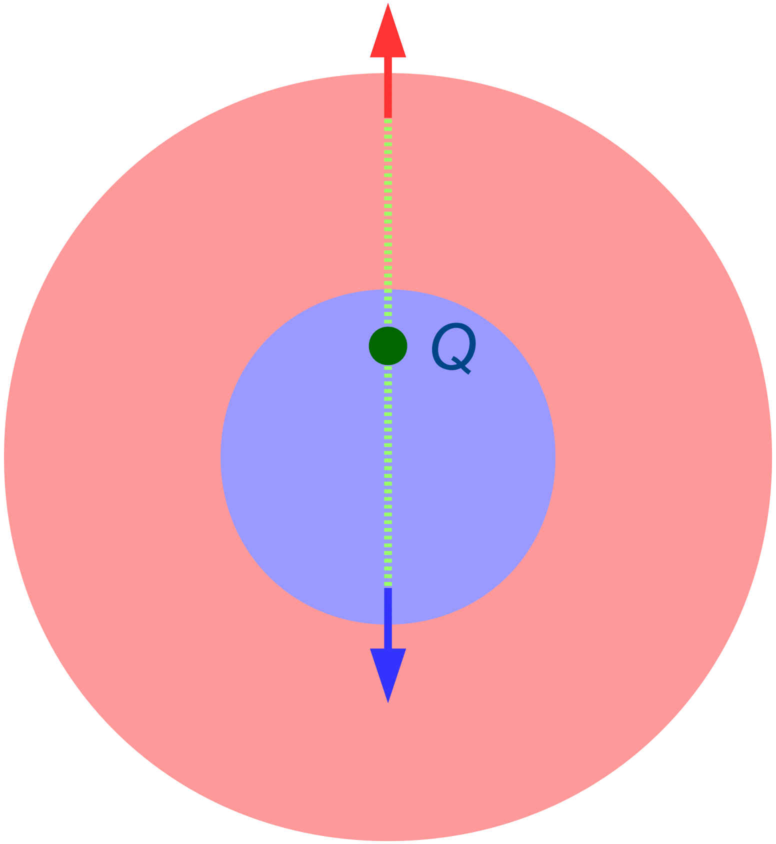


# Binding energy of a Cooper pair

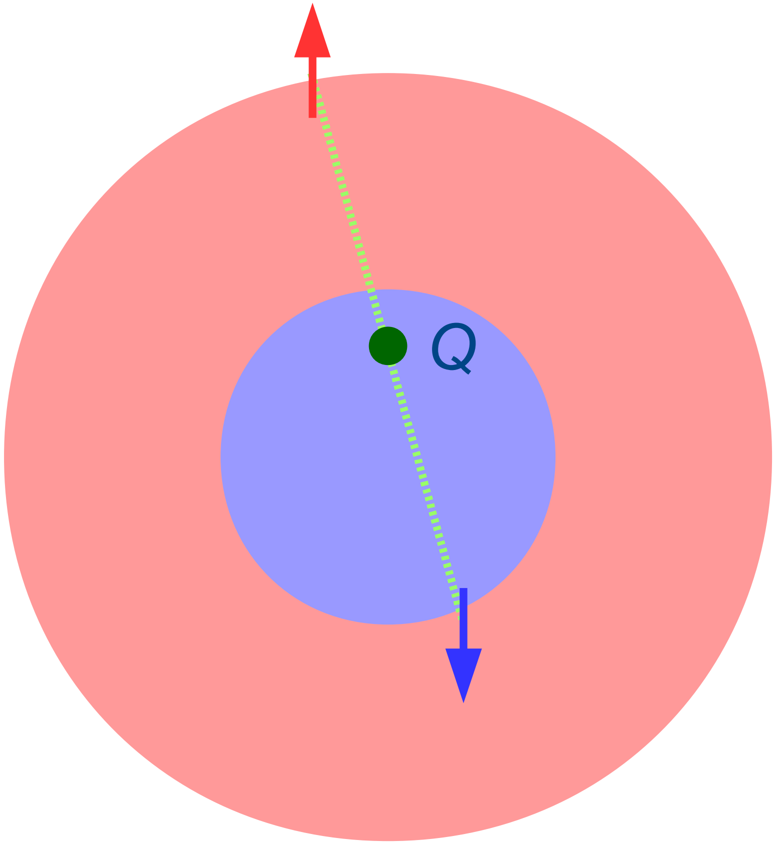



$$E = 2\omega_D \exp\left(-\frac{2\xi'}{g\nu_c}\right)$$

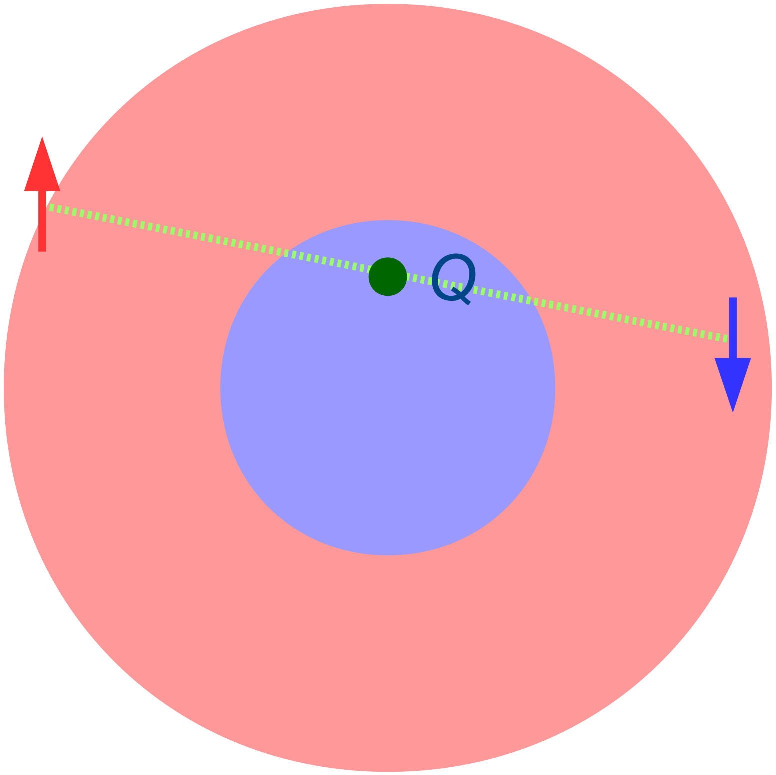
# Cooper pair on an imbalanced Fermi sea



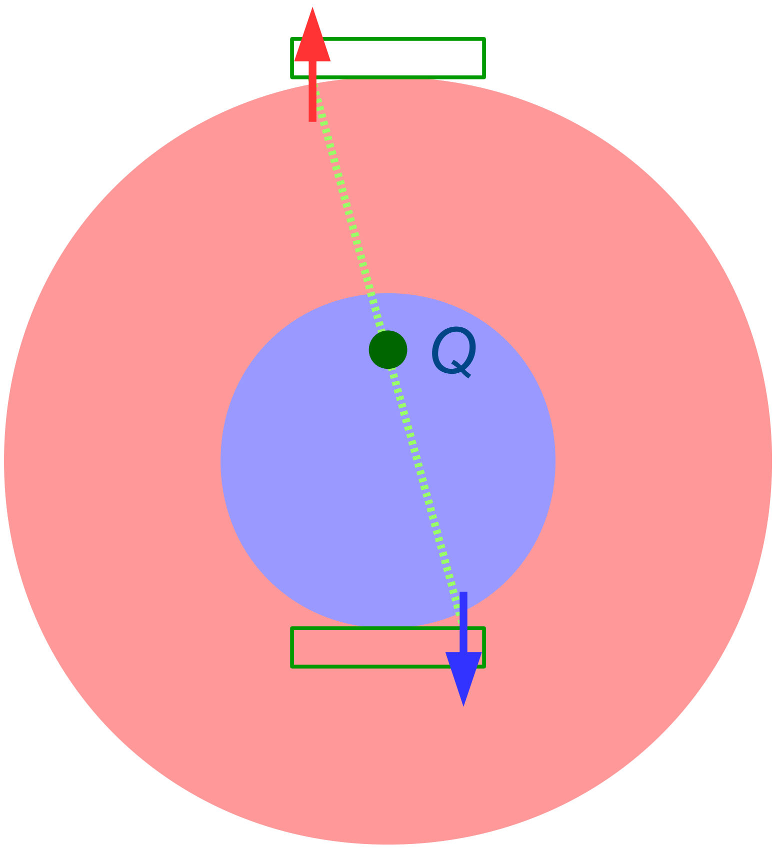
# Cooper pair on an imbalanced Fermi sea



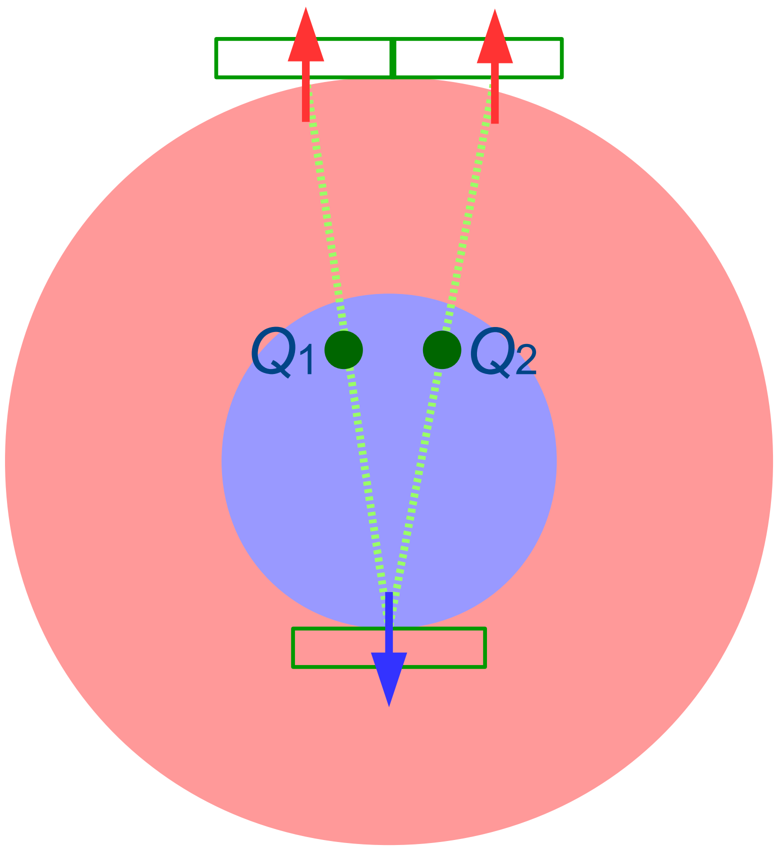
# Inaccessible states



# States that can be correlated



# Take advantage of all available states



# Few-particle instability

## Binding energy of a few-particle instability

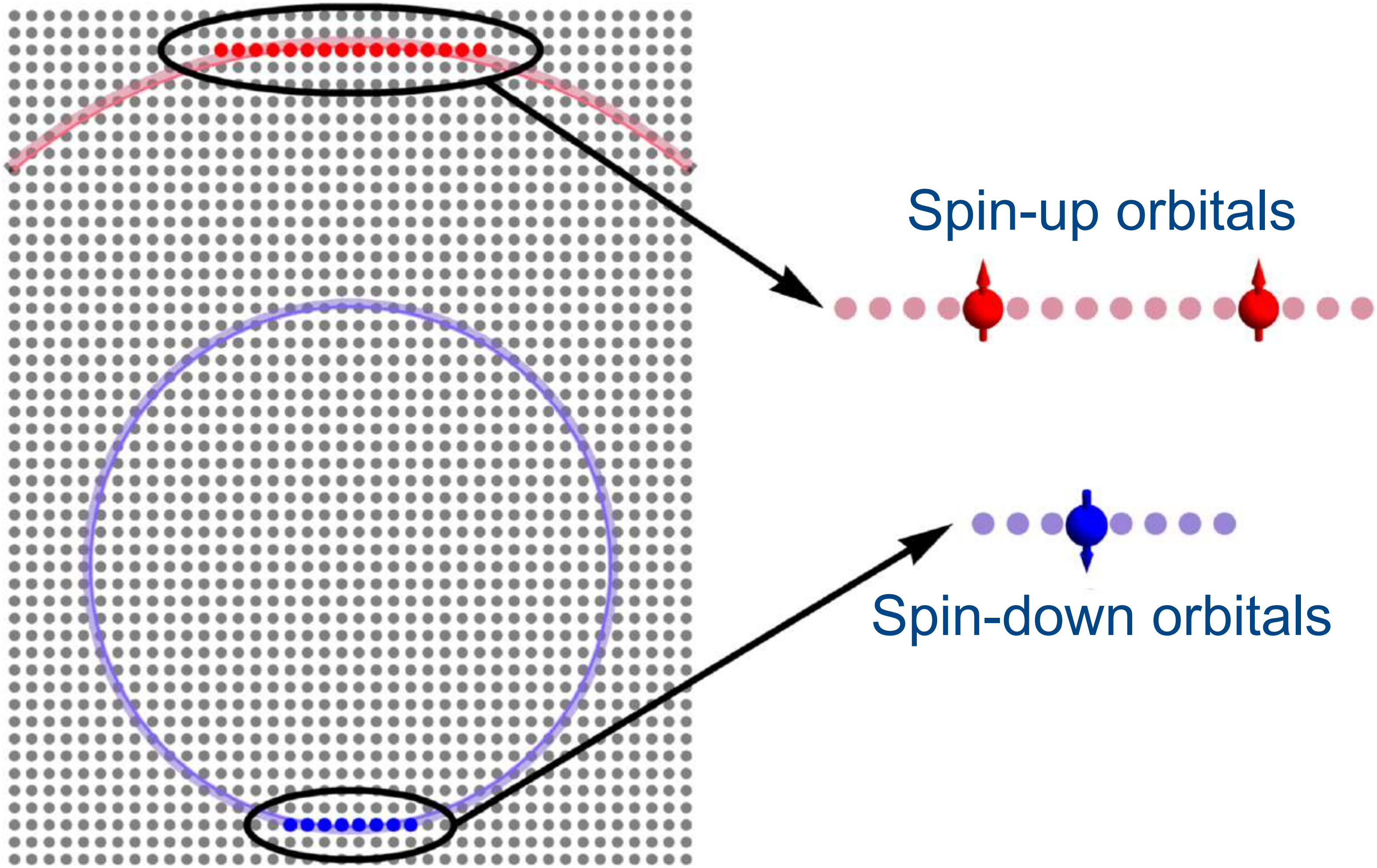
$$E = (N_\uparrow + N_\downarrow)\,\omega_D \exp\left(-\frac{(N_\uparrow + N_\downarrow)\xi'}{g N_\uparrow N_\downarrow}\frac{N_c}{\nu_c}\right)$$

$$E = 2\,\omega_D \exp\left(-\frac{2\xi'}{g\nu_c}\right)$$

## Optimal number of up and down spin electrons in an instability

$$\frac{N_\uparrow}{N_\downarrow} = \frac{\nu_\uparrow}{\nu_\downarrow}$$

# Exact diagonalization



# Many-body theory

Superconducting transition temperature

$$T_c = \omega_D \exp\left( - \frac{(N_\uparrow + N_\downarrow)\xi'}{2gN_\uparrow N_\downarrow} \frac{N_c}{\nu_c} \right)$$

Optimal number of up and down spin electrons in an instability

$$\frac{N_\uparrow}{N_\downarrow} = \frac{\nu_\uparrow}{\nu_\downarrow}$$

# Summary

Optimal number of up and down spin electrons in a Cooper particle is the ratio of the density of states

Cooper particle is the building block for superconducting state, verified by Diffusion Monte Carlo simulations

Energetically favorable to FFLO state