A multi-particle superconductor?

Thomas Whitehead
Gareth Conduit

A multi-particle

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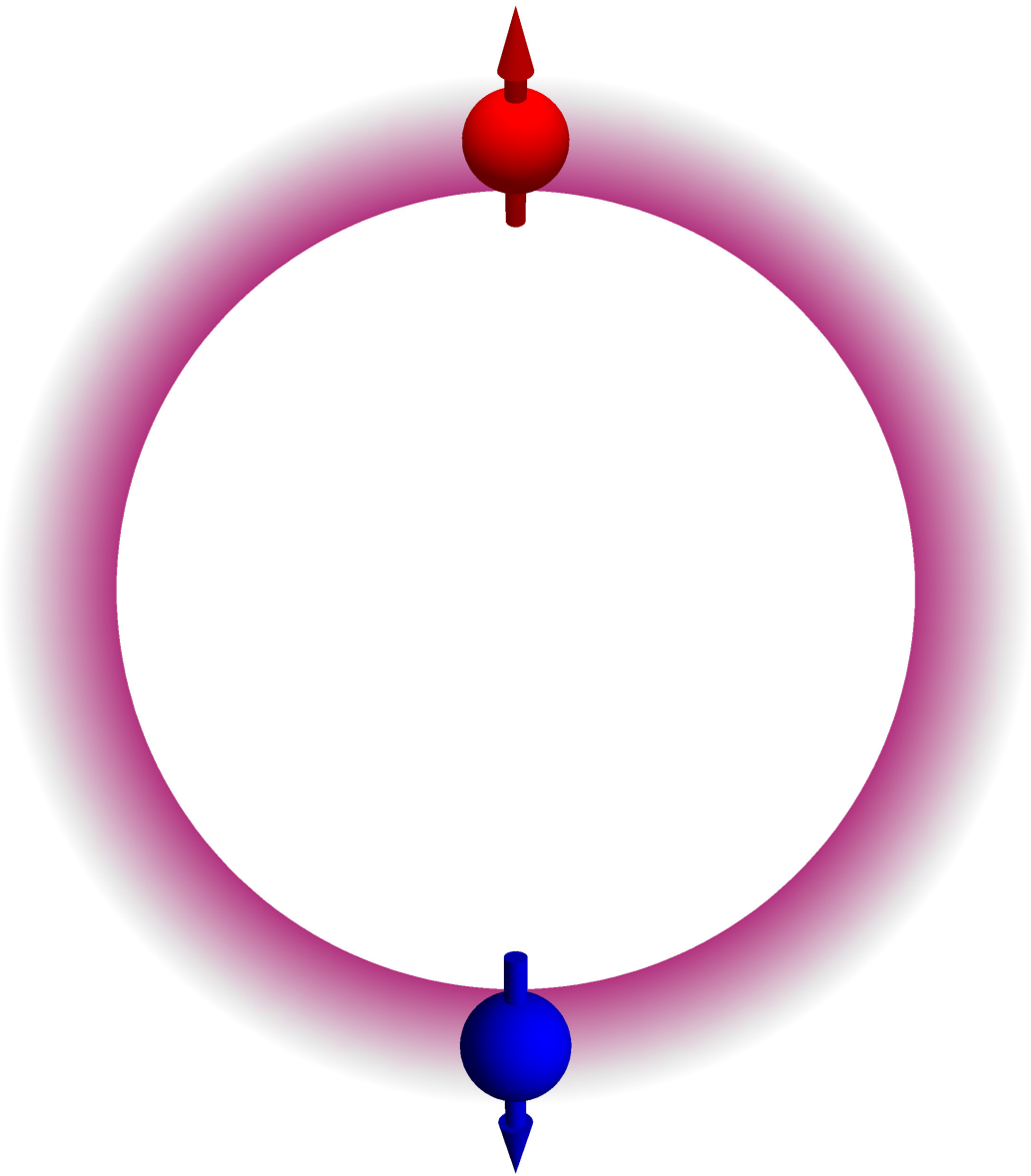
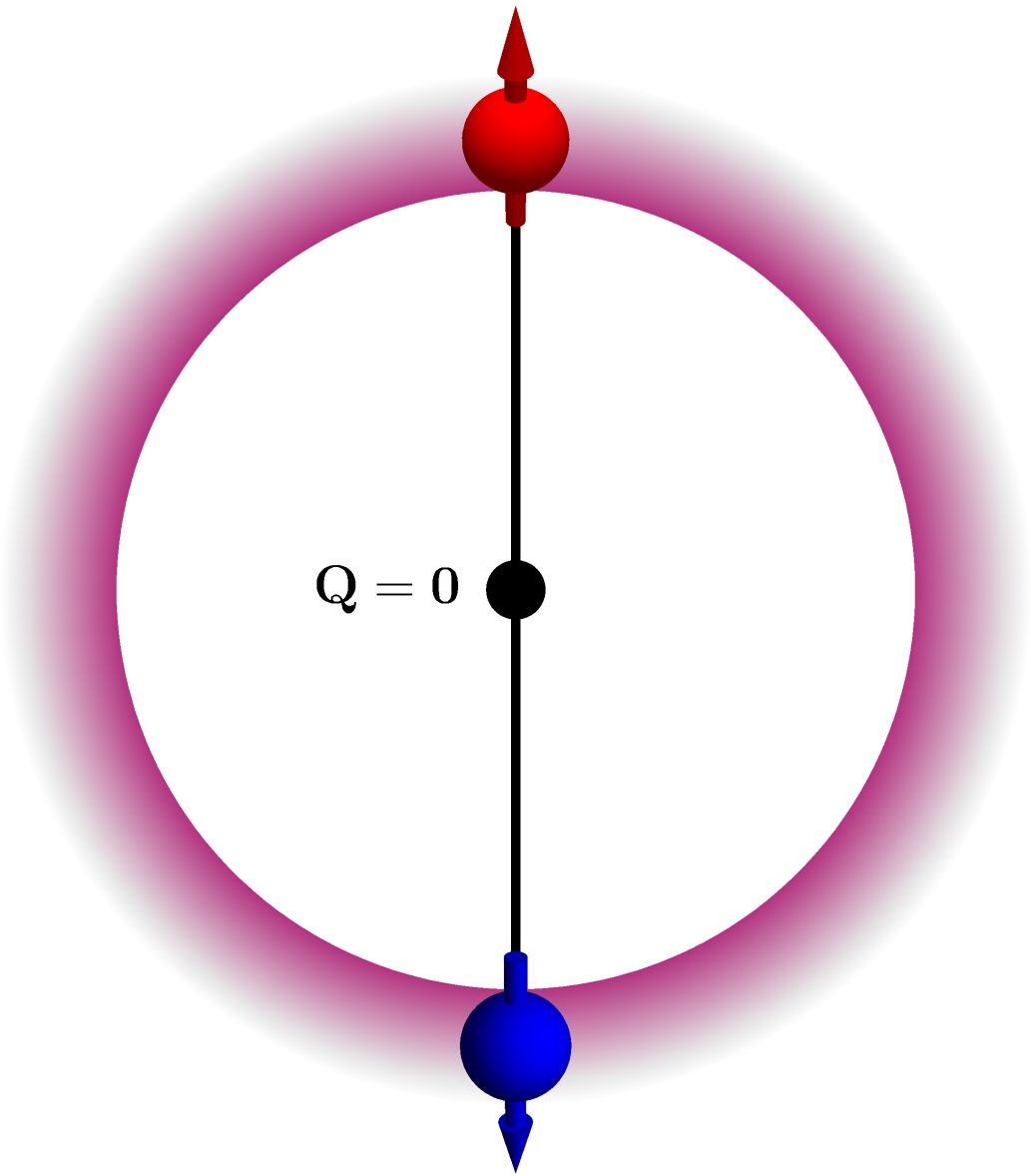
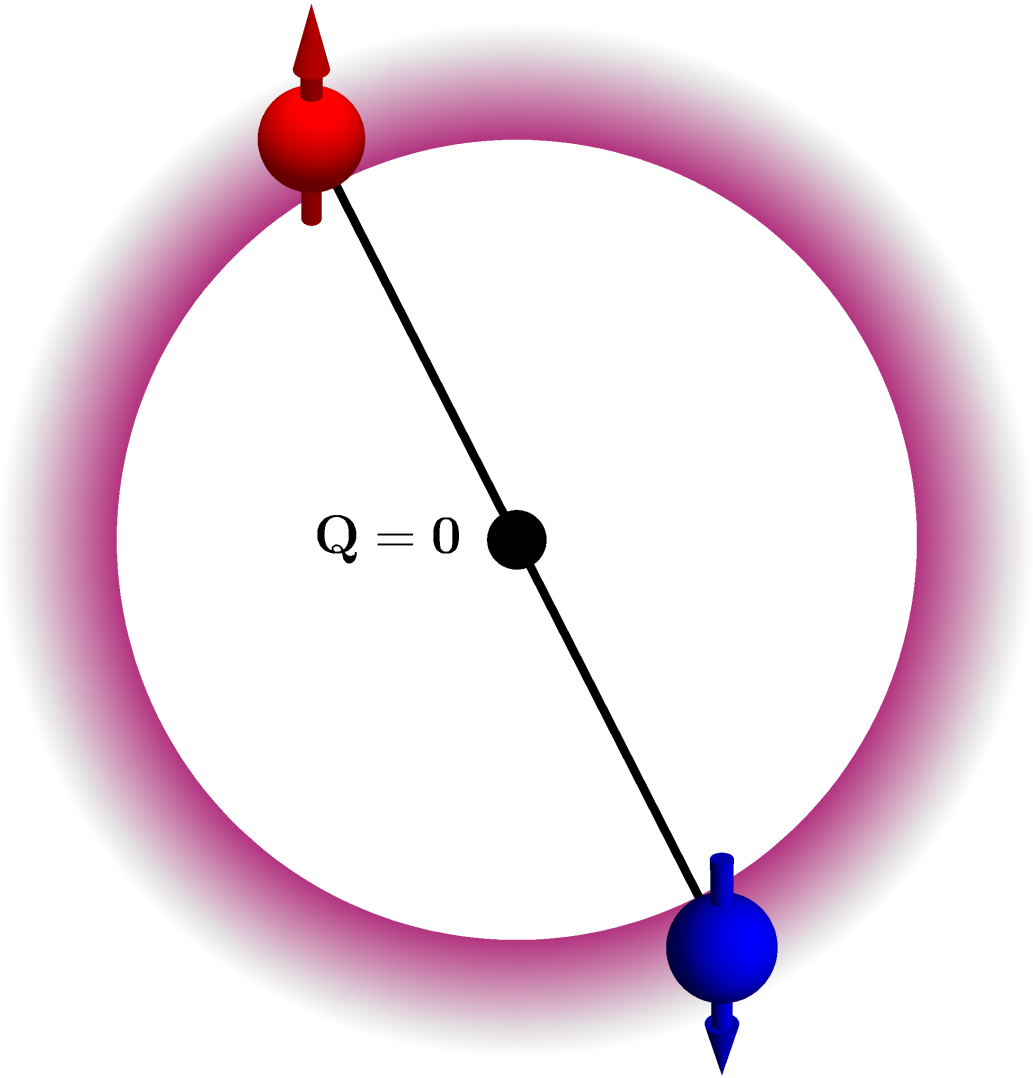
Outline




$\mathbf{Q} = \mathbf{0}$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Cooper pairs

- Pairs of electrons
- COM momentum $\mathbf{0}$
- Pairs ‘condense’ into superconducting state

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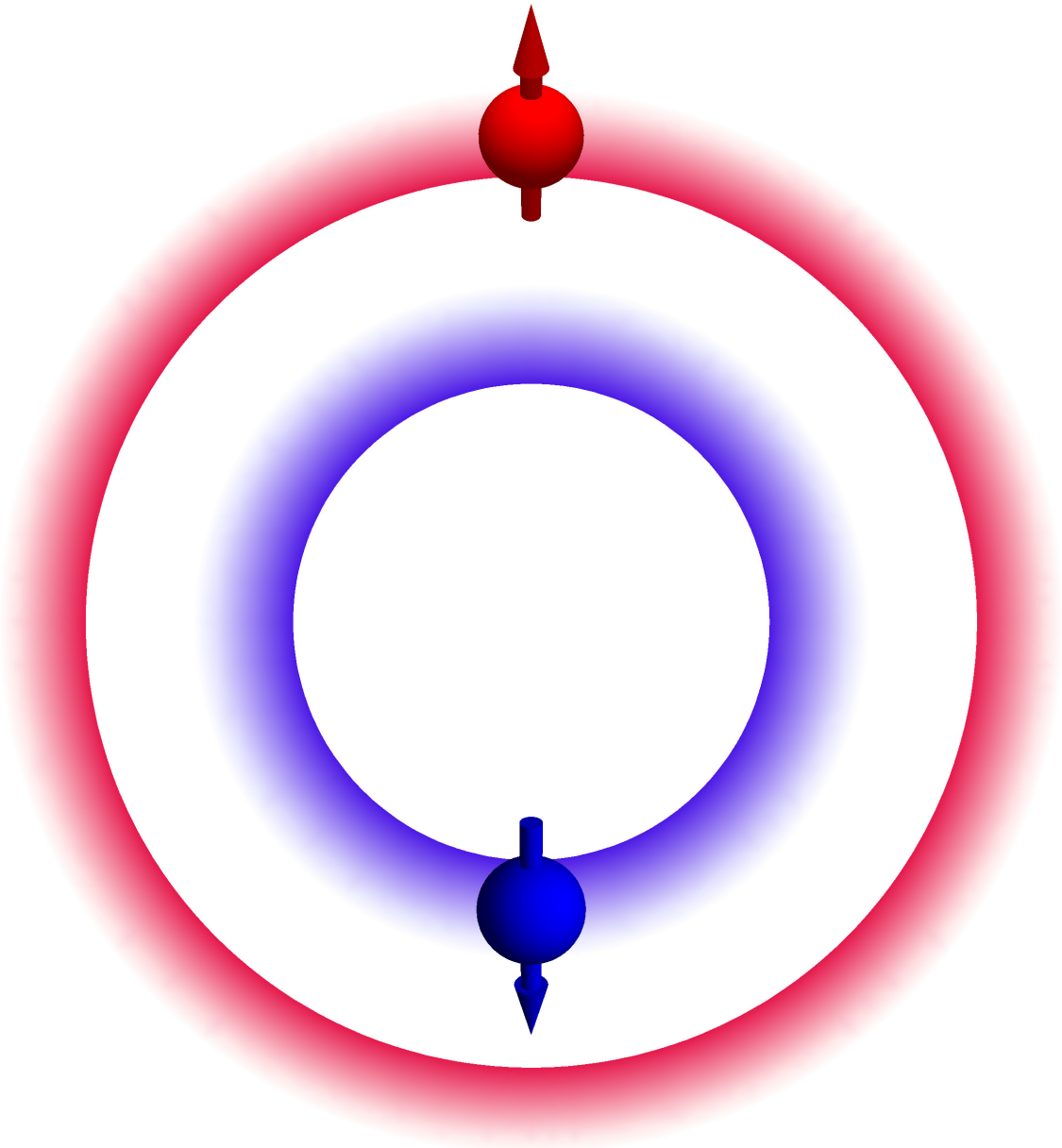
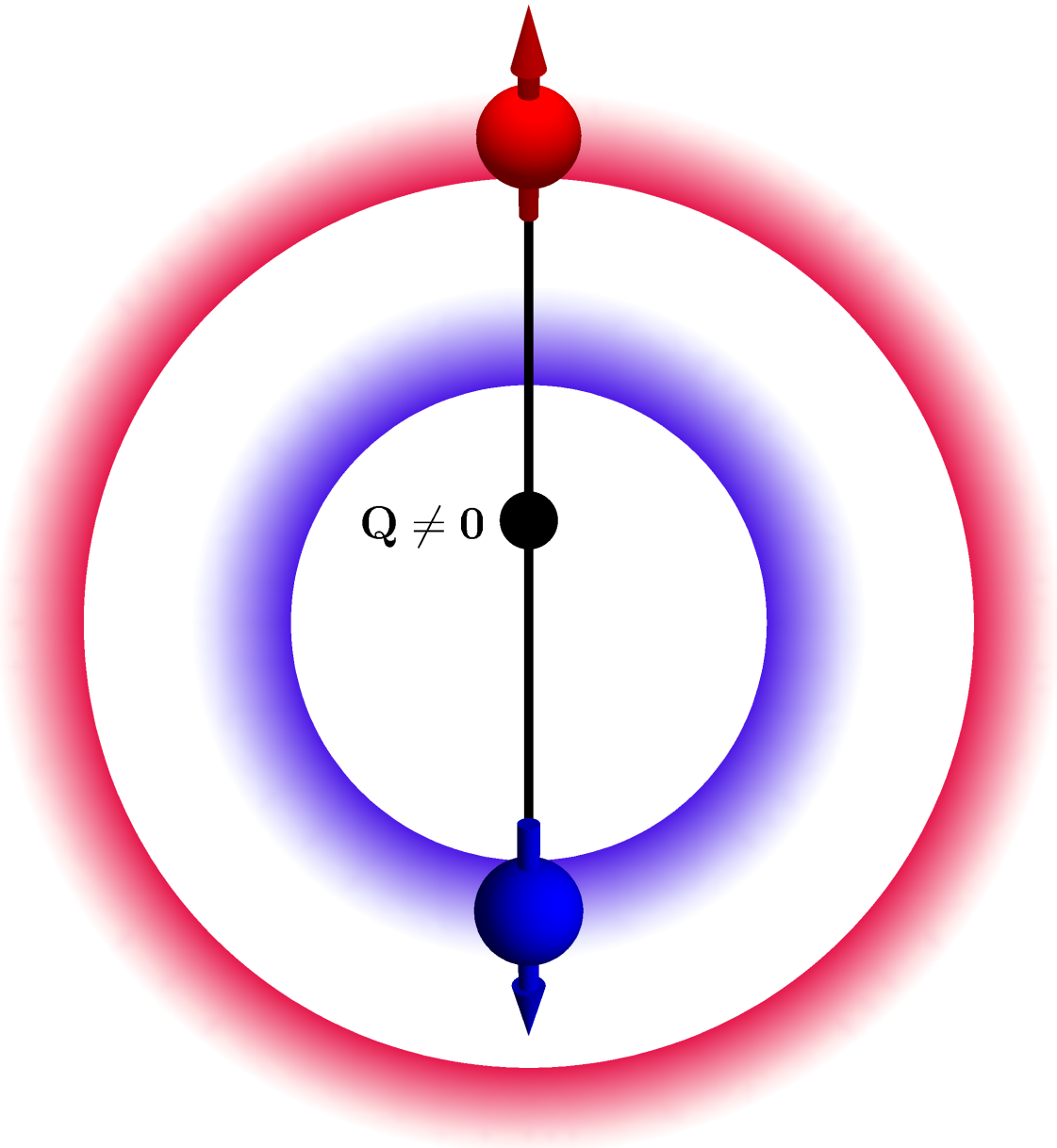
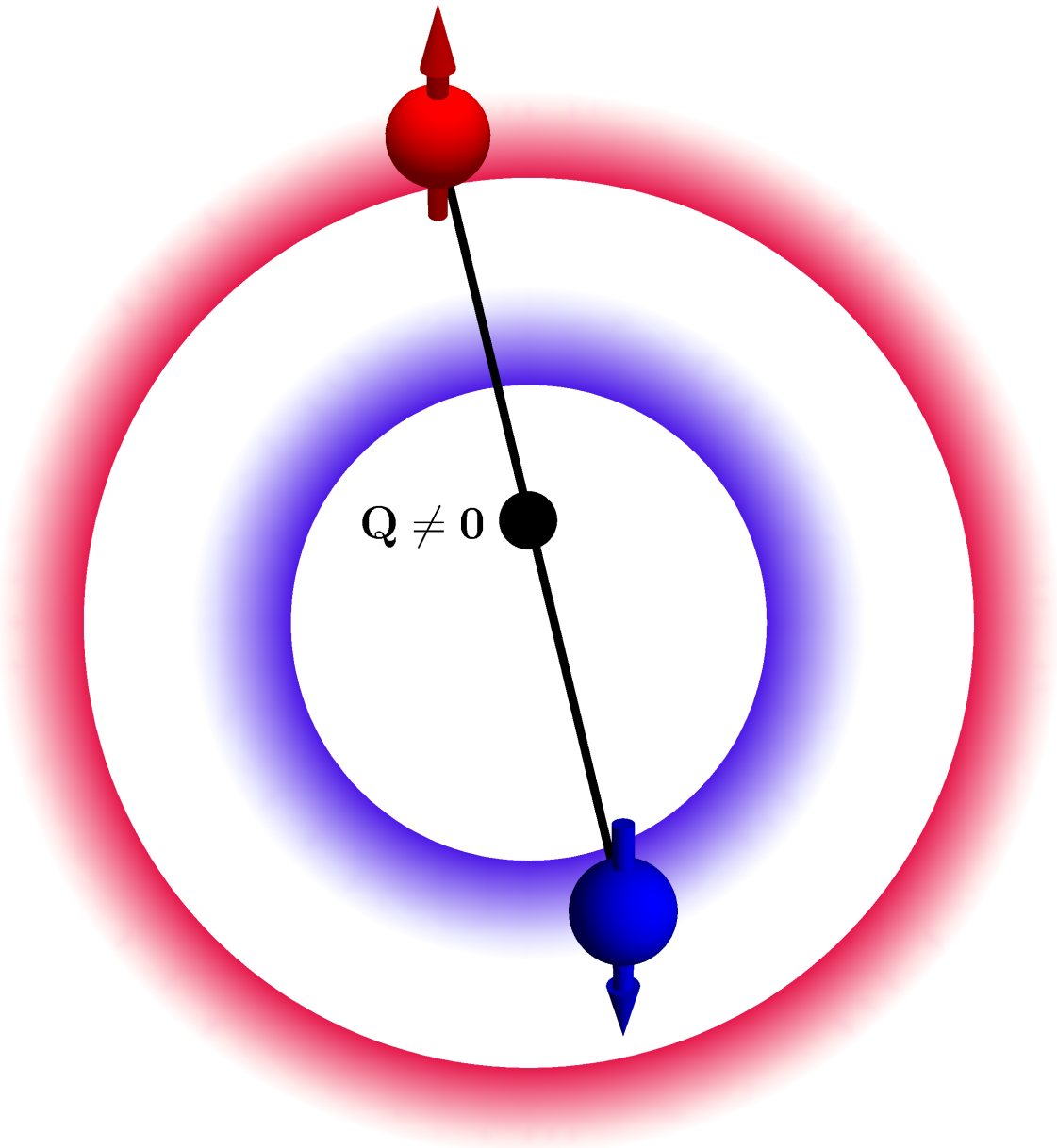
- Pairs of electrons
- COM momentum $\mathbf{0}$
- Pairs 'condense' into superconducting state
- Assumes equal-sized Fermi seas

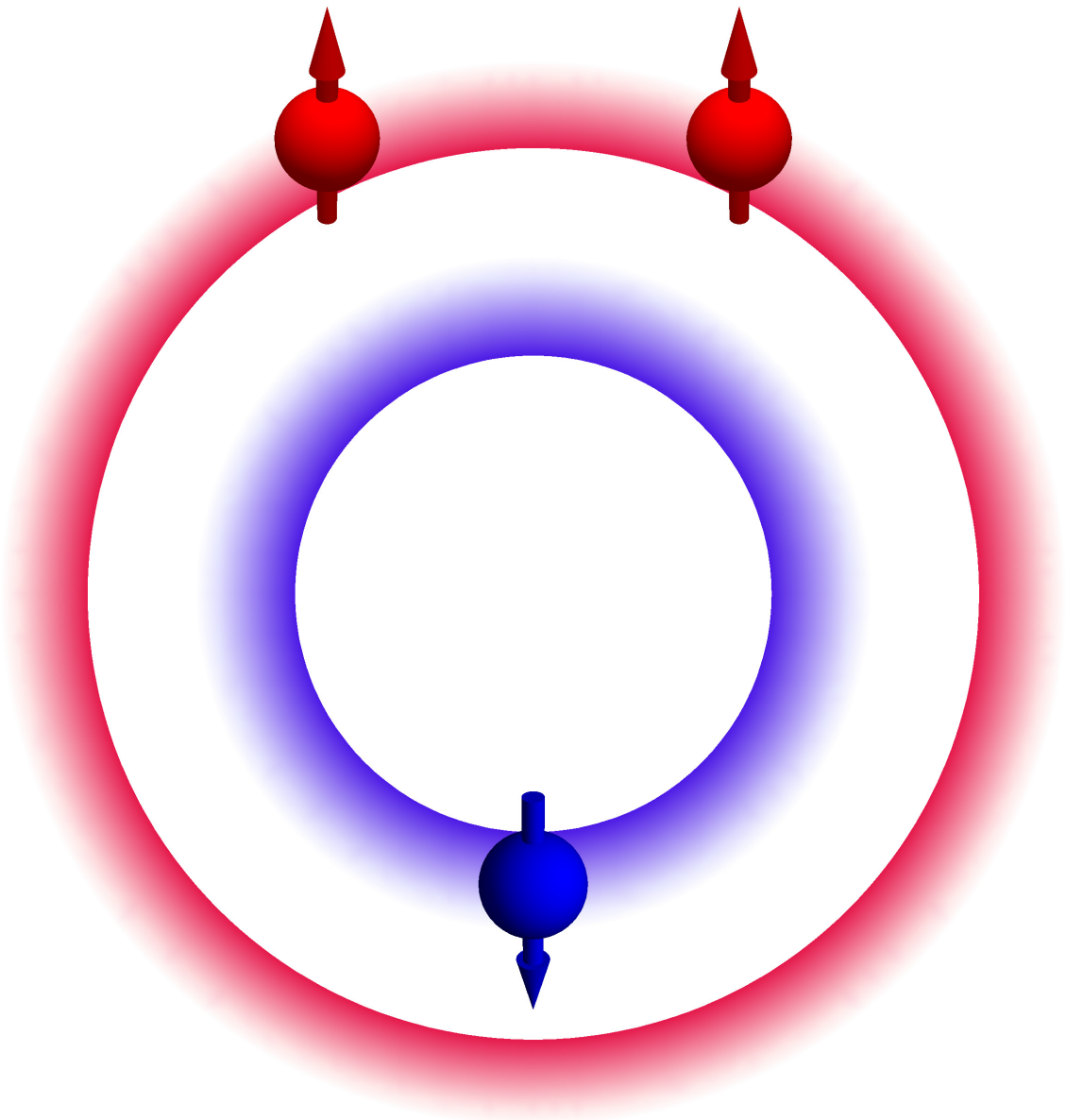


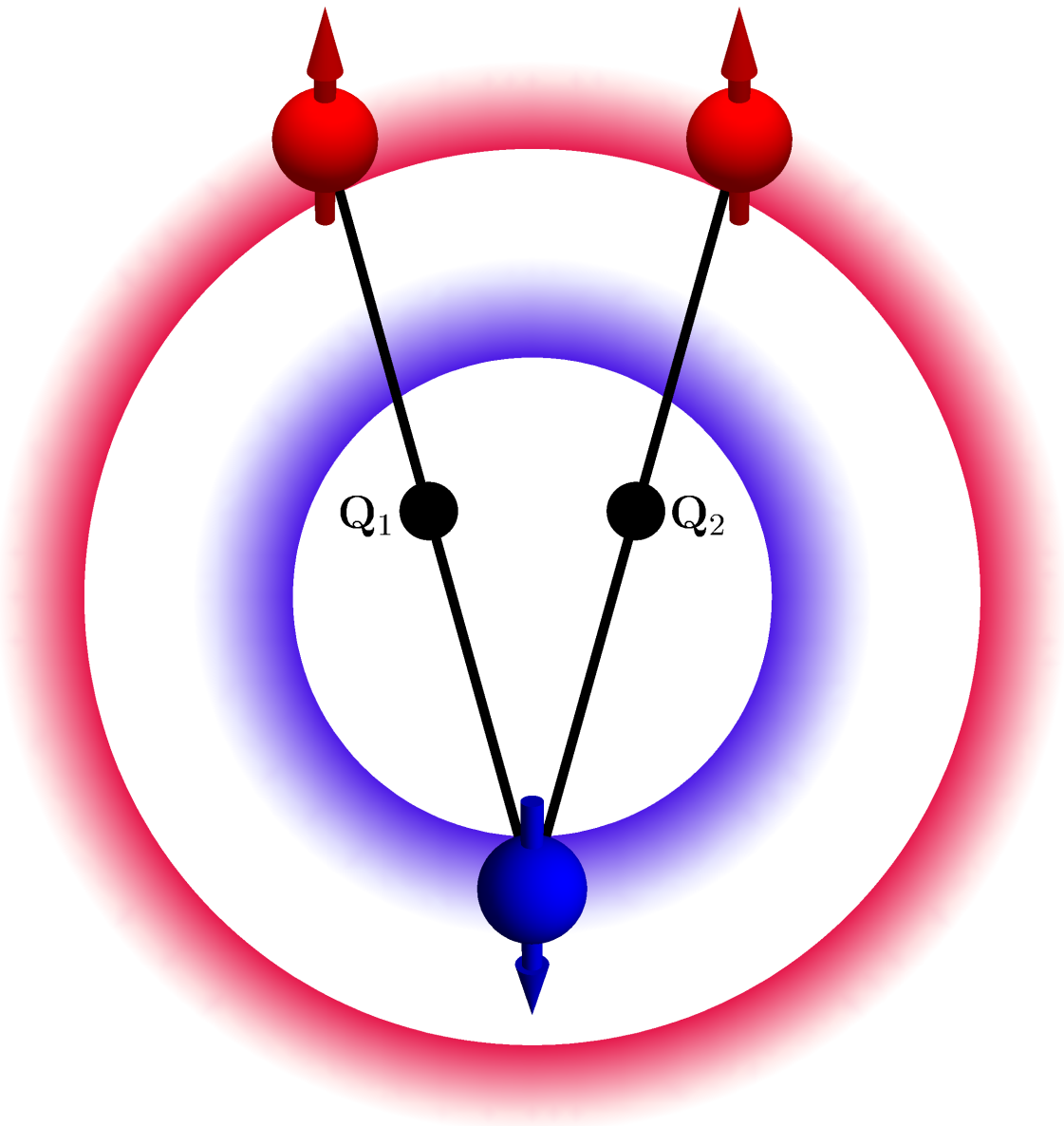

$\mathbf{Q} \neq \mathbf{0}$


$\mathbf{Q} \neq \mathbf{0}$

Problems with FFLO

- Limited number of pairs with same $\mathbf{Q}$
- More of one species than the other
  - Not all majority-spin electrons can pair



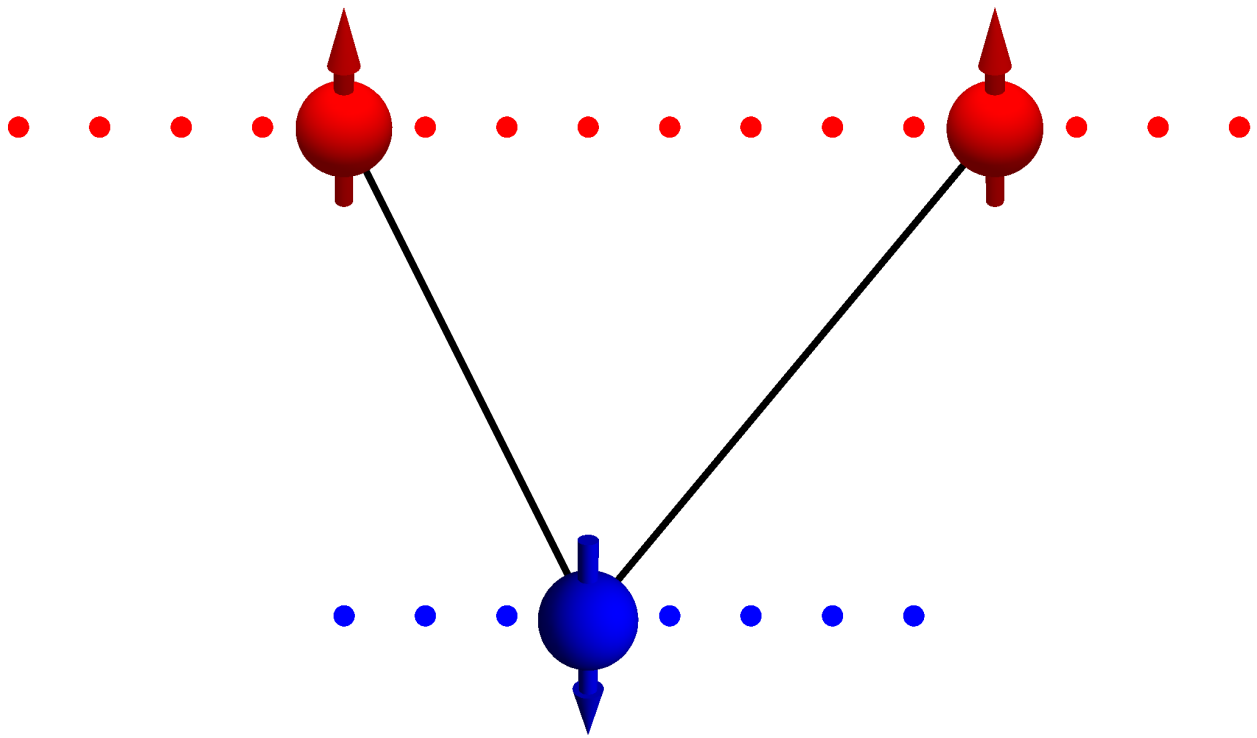

Q_1
Q_2

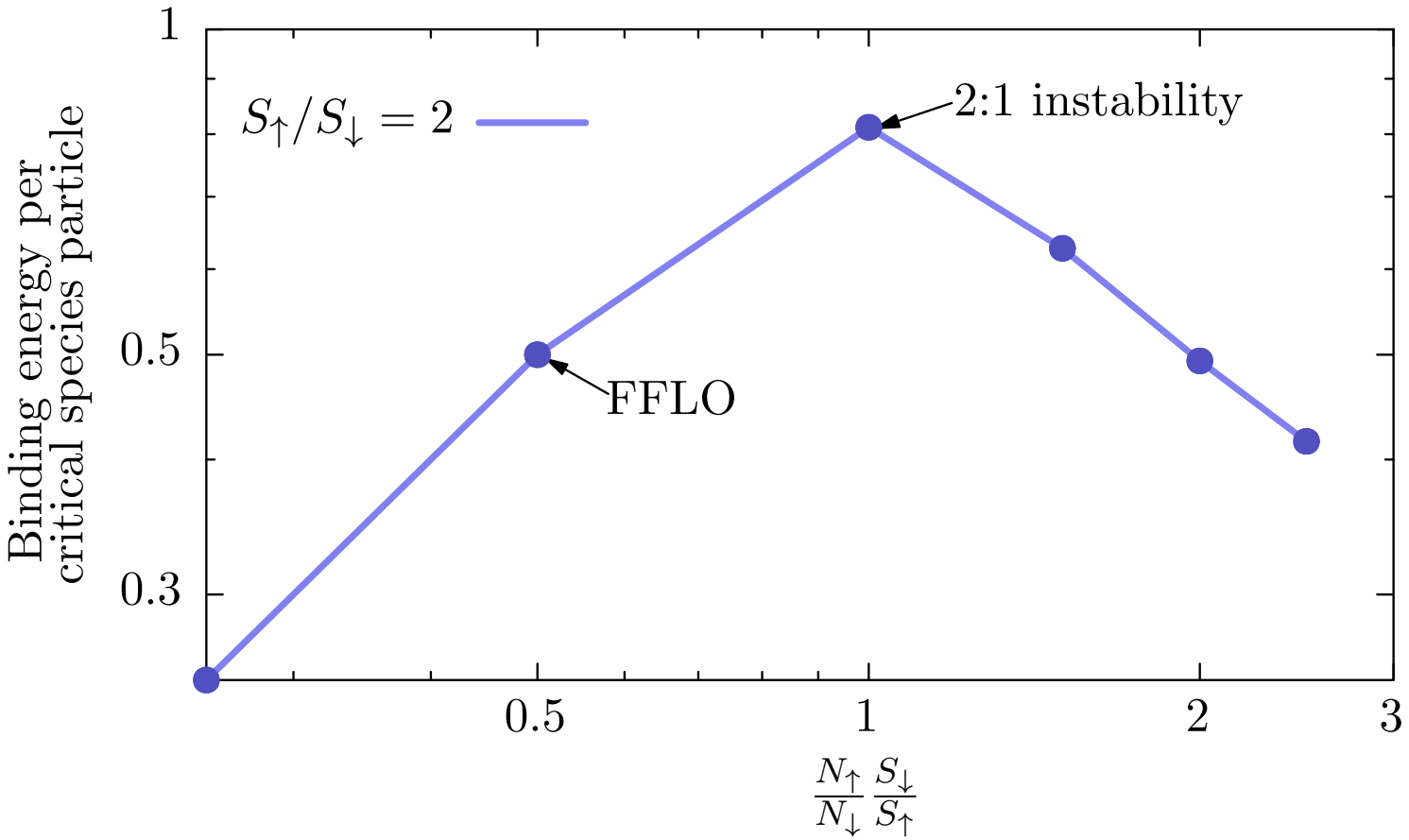
Multi-particle instability

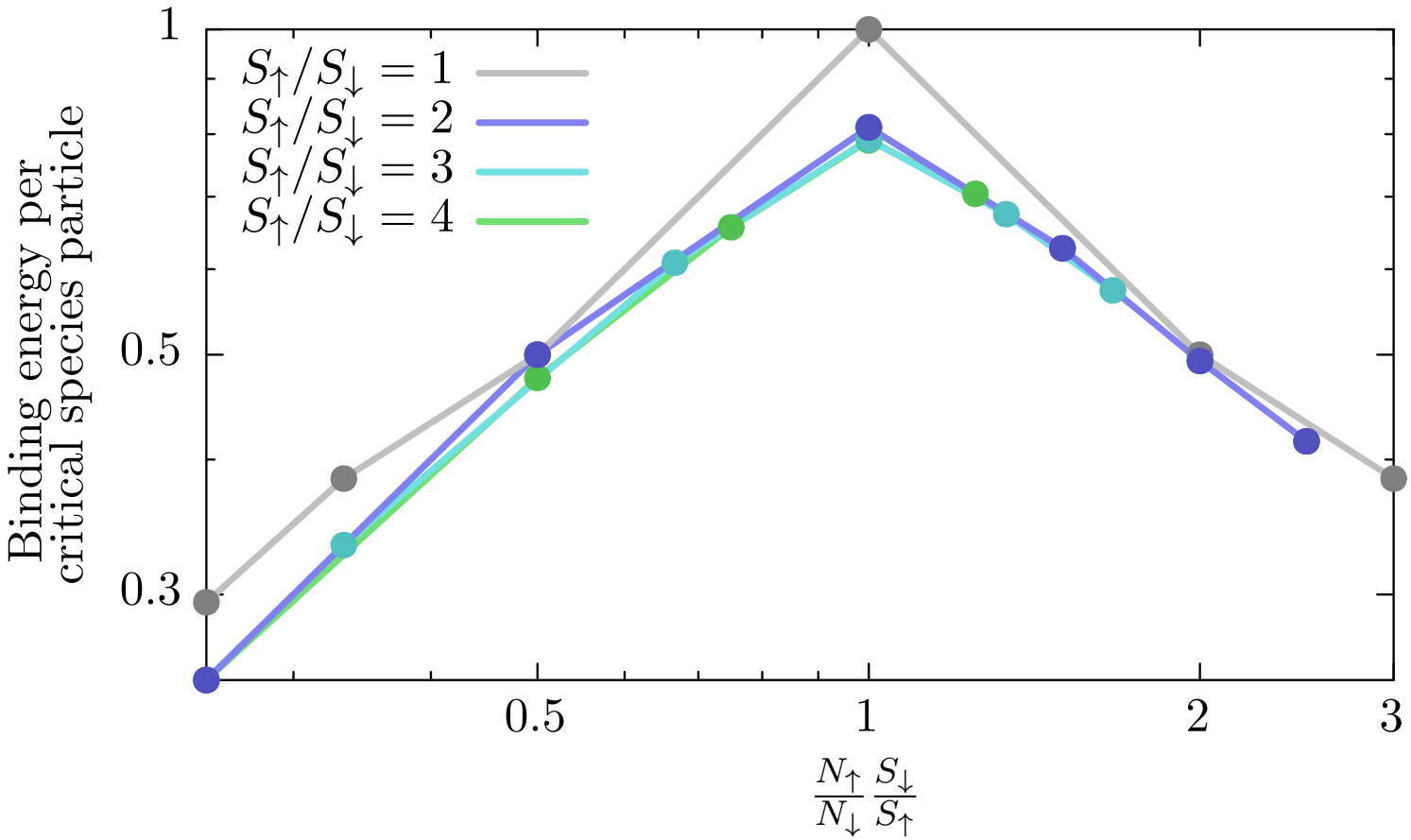
- More particles means more binding energy
- Optimum ratio of number of particles

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

N_σ: number of particles, S_σ: density of states in momentum




Binding energy per critical species particle
1
0.5
0.3
$S_\uparrow/S_\downarrow = 2$
2:1 instability
FFLO
0.5
1
2
3
$\frac{N_\uparrow}{N_\downarrow}\frac{S_\downarrow}{S_\uparrow}$


Binding energy per critical species particle
1
0.5
0.3
$S_\uparrow/S_\downarrow = 1$
$S_\uparrow/S_\downarrow = 2$
$S_\uparrow/S_\downarrow = 3$
$S_\uparrow/S_\downarrow = 4$
0.5
1
2
3
$\frac{N_\uparrow}{N_\downarrow}\frac{S_\downarrow}{S_\uparrow}$

Summary

- Imbalanced Fermi seas have multi-particle instability
- Energetically favourable over FFLO instability
- Examples using exact diagonalisation

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- Imbalanced Fermi seas have multi-particle instability
- Energetically favourable over FFLO instability
- Examples using exact diagonalisation
- Basis for superconducting state?