

Multi-gap superconductivity and interaction driven resonances in superconducting films with an insulating thin layer

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MultiSuper Network



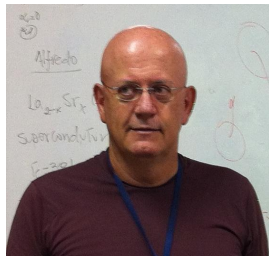
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Multigap superconductivity and interaction driven resonances in superconducting nanofilms with an inner potential barrier

Collaborators



Andrea Perali, Camerino



Mauro M. Doria, Rio de Janeiro

Highlights of the work

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- New type of **interaction driven** resonance since the seminal work of Thompson-Blatt in 1963.

Summary

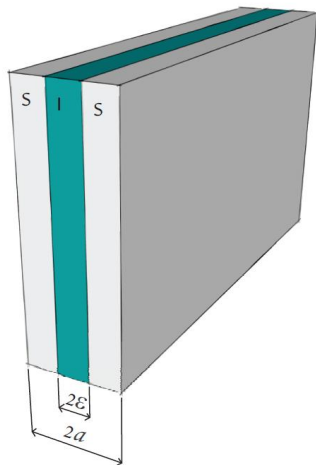
1 System studied

2 Methodology

3 Results

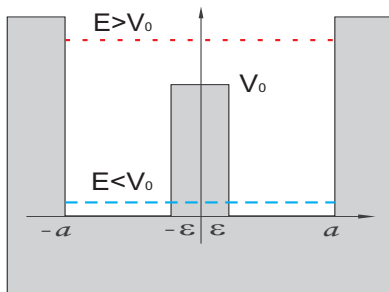
SIS

Superconducting nanofilm with ultrathin isolating barrier in the middle.



SIS

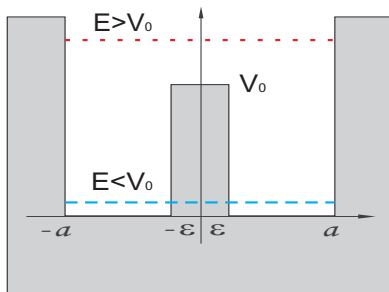
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Our model:

- Infinite potential well to quantum confine the system.

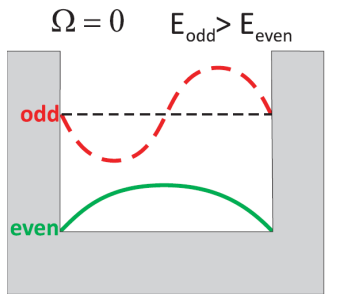
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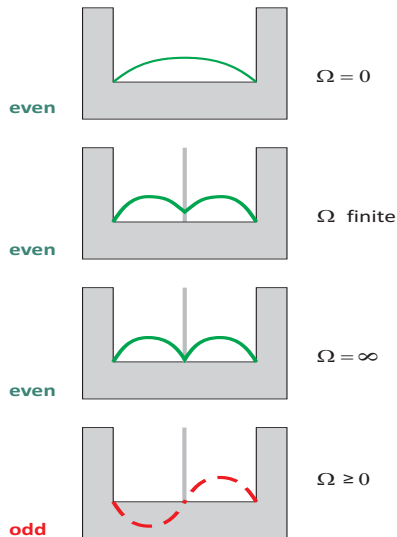
- Infinite potential well to quantum confine the system.
- Delta-function potential $V(x) = \frac{\hbar^2}{m} \Omega \delta(x)$ good replacement for a thin barrier of total area $V_0 \times 2\varepsilon \rightarrow \Omega = \frac{2m\varepsilon}{\hbar^2} V_0$. Dimension of inverse length.

Reflection symmetry allows classifying quantum confined states into even and odd:

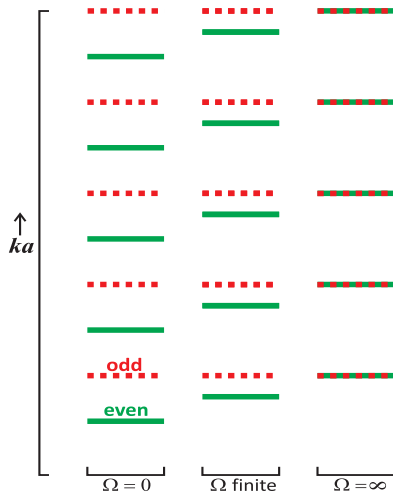


SIS

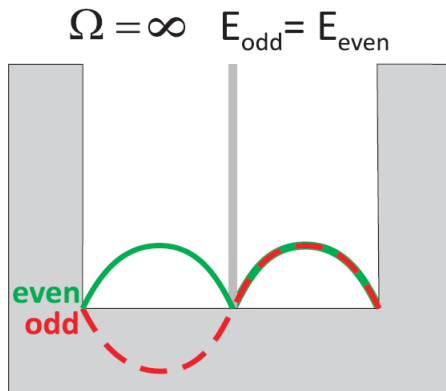
Introducing the barrier modifies the even states, **depressing** them at the barrier site. Odd states are **unaffected**.



Potential is positive \rightarrow energy increases for even states.



At $\Omega = +\infty$ energy degeneracy reflects indistinguishable even and odd states.



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- Use experimental values of Nb for explicit calculations.

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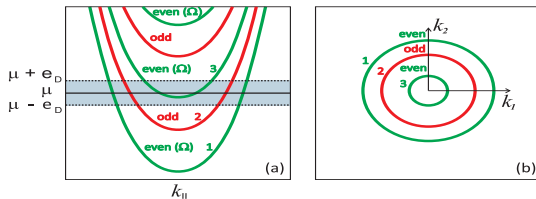
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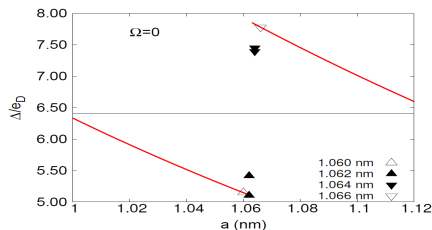
Result 1: multi-gap structure

Recall the Thompson-Blatt model of a thin-film: for a fixed μ a number of energy levels contribute to the value of Δ :



Result 1: multi-gap structure

As the size of the film increases the energy levels change, and when a new one crosses the Debye window Δ abruptly jumps

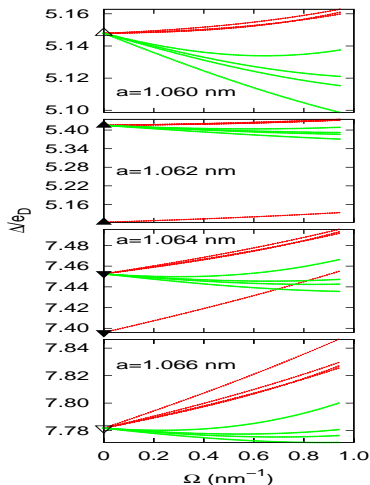


Notice: all the Δ_i degenerate to single value with exception of the **very narrow** resonance window.

(This can be smoothed by a larger Debye window, and discontinuity smoothed by larger coupling, see [Cariglia, Vargas-Paredes, Doria, Bianconi, Milošević, Perali, JSNM 2016])

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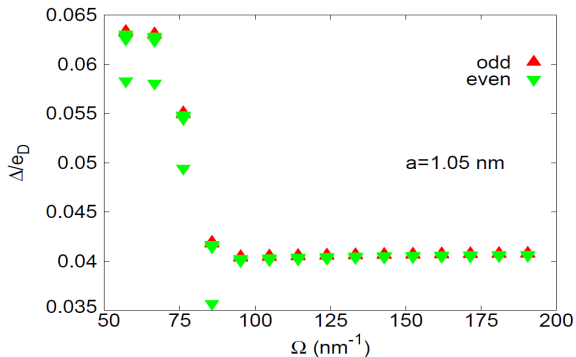
Barrier breaks the degeneracy by non-trivial interaction matrix elements.



Intrinsically multi-gapped structure away from resonances. Differences in gaps are small.

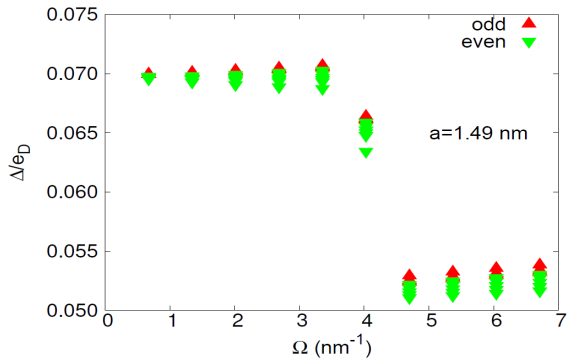
Result 2: new type of resonance

Interaction driven resonance as changing the value of Ω also moves energy levels. Jump in Δ is large.



Result 2: new type of resonance

Another example.



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