The Abdus Salam International Centre for Theoretical Physics

International Conference on Multi-Condensate Superconductivity and Superfluidity in Solids and Ultra-Cold Gases
14 - 18 May 2018 (Trieste, Italy)

BEC-BCS Cross-over in Multi-condensate Superconductors at the Topological Lifshitz Transitions in Superlattices Quantum Wires in Organics Materials

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Recently interest on high-temperature superconductivity in a potassium-doped aromatic hydrocarbon p-Terphenyl and related organic conductors made of a superlattice of weakly interacting quantum wires [1–3]. In a previous work [4], we have proposed a driving mechanism for high Tc based on the control of the quantum shape resonance between a first superconducting gap in a first condensate where the Fermi energy is near a topological Lifshitz transition and the superconducting gaps in other bands with high Fermi energy. In this scenario the maximum critical temperature occurs where the hot condensate in the appearing new small Fermi surface pocket is in the BCS-BEC crossover. Here we have studied the tuning of the strength of the pairing interaction in the new appearing band to drive the hot condensate in the BCS-BEC crossover regime. To this end we have studied the multi-gaps superconductivity by increasing the pairing coupling term in the hot band near the Lifshitz transition. We have found that the BCS-BEC regime occurs where the ratio between the superconducting gap and the Fermi energy is close to 0.5. The compelling evidence for the BCS-BEC crossover is indicated by the fact that the maximum of the Tc occurs in the range where the ratio of the Fermi energy on the pairing energy cut off is in the range between 0.5 and 1 and the value of the chemical potential, where the maximum of the critical temperature appears, moves with the pairing strength and it does not coincide with the point where the DOS exhibits a maximum.