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Bogoliubov–de Gennes Approach to Inhomogeneous Superconducting Gap in Nanowires and Nanotubes

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Traditional theories of superconductivity have been developed in the reciprocal space based on the translational symmetry. Such symmetry is absent in many inhomogeneous superconductors that contain structural grains or interfaces, whose study requires a real space theory of superconductivity [1]. In this work, we study the inhomogeneity of superconducting gap in nanostructures by using the Bogoliubov–de Gennes equations and an attractive Hubbard model [2]. In Fig. 1(a), the superconducting gap (Δ) versus temperature (T) is shown for a nanowire of an infinite–length and a cross section of 9 atoms (illustrated in the inset) with an on–site interaction of $U=-|t|$ and the chemical potential at μ=0, while the critical temperature (T_c) as a function of diameter (D) is exposed in Fig. 1(b) for an infinite–length nanotube (illustrated in its inset) with $U=-|t|$, μ=0 (red squares) and $\mu=-4|t|$ (blue circles), being t the single electronic hopping integral. Observe the appearance of a unique critical temperature at $k_BT_c\approx0.01|t|$ in Fig. 1(a), in spite of different Δ at non–equivalent sites. Notice also in Fig. 1(b) both slight increase and decrease behaviors of calculated T_c, in consistence with those observed in WS_2 [3] and carbon [4,5] nanotubes.

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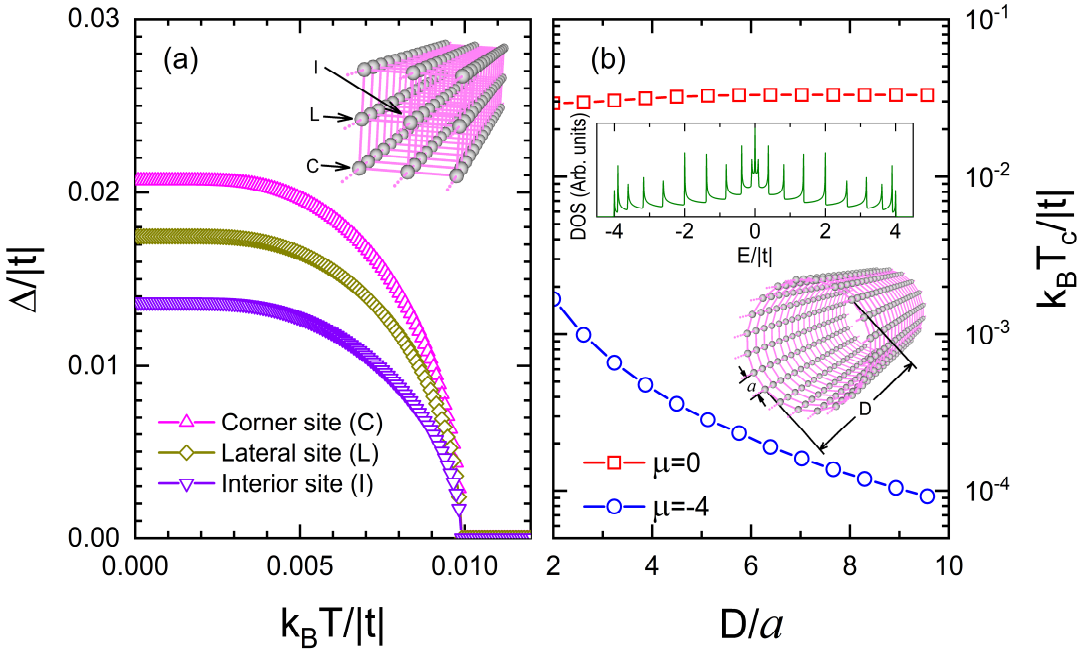

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