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Nanotube exciton spectrum: Triangular quantum well model.
SLAVA V. ROTKIN, Lehigh University, Physics Department, 16 Memorial Dr E, Bethlehem, PA 18015, e-mail: rotkin@lehigh.edu, ALEXEY G. PETROV, Ioffe Institute, St.Petersburg, Russia — The analytical solution for the problem of NT-exciton is found using the approximation for the **screened** Coulomb potential between the electron and hole. We derive the screening via calculating a self-consistent dielectric function with **both spatial and time dispersion** taken into account, $\varepsilon(\vec{q},\omega)$, which characterizes the response to the $\vec{q}$ component of the Coulomb potential at the frequency ω. The latter corresponds to the energy of the exciton and is to be sought. We calculated the RPA dielectric function of the SWNT in the orthogonal tight-binding approach. Then, the inverse Fourier transform of the screened Coulomb potential gives the shape of the potential well for the electron-hole pair (direct Coulomb interaction term). We show that this screened potential can be approximated by a triangular quantum well, which model allows ananlytical solutions for the exciton wavefunction and the binding energy. The exchange term is short-ranged and can be added as the delta-function barrier in the middle of the well. The exciton binding energy is calculated to be a universal function of E_g, the one-particle band gap, R, the NT radius and λ, the electric length in the triangular quantum well potential. The effective Bohr radius is also a universal function of R and λ. The analytical expression for the oscillator strength of the optical transition is presented.

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