# Nonlinear response and tunable excitonic absorption in gapped graphene systems


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Abstract

In this work we develop a microscopic theory of a strong electromagnetic radiation interaction with bilayer graphene where an energy gap is opened by a static electric field perpendicular to graphene planes (created by external gates). We show that at resonant photon energy close to the energy gap and by adiabatically changing the gate potentials on time, one can produce full inversion of the electron population between valence and conduction bands. We found that due to relative flatness of the bottom (top) of conduction (valence) band in multilayer graphene systems in the presence of perpendicular electric field [1], the density of coherently created particle-hole pairs becomes quite large, which can make Bose-Einstein condensation of electron-hole pairs possible. We consider also excitonic states in monolayer and bilayer graphene systems with opened energy gap $U$ for different values of $U$ and parameters describing the band structure. To take into account the Coulomb interaction, we use Hartree-Fock approximation that leads to a closed set of equations for the single-particle density matrix, which in turn produce our final results for the excitonic absorption. Our numerical results obtained for excitonic absorption of gated graphene bilayer as a function of detuning $\beta = \hbar\omega - U \;/ R^*$ for different values of effective velocity $v_3 = \sqrt{3}\gamma_3 a / 2\hbar$ ($\gamma_3$ describes the interaction between *B* atoms in the neighboring layers, and $a$ is the lattice constant) are presented in Fig.1. We found that for a smaller value of the parameter $v_3 = 0.5 \cdot 10^5 m/s$ the exciton binding energy becomes smaller (blue dotted curve). And finally, when $v_3$ is almost zero, i.e. when we do not take into account the parameter $\gamma_3$ that is responsible for the azimuthal asymmetry of energy bands the absorption peak decreases and the exciton binding energy becomes much smaller ( dash-dotted curve in Fig.1).


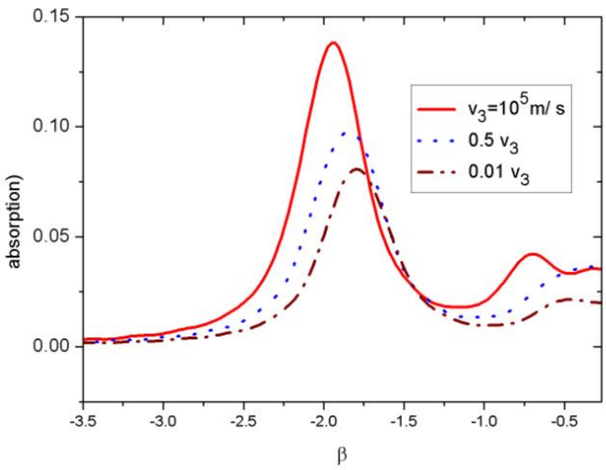


**Fig.6.** Excitonic absorption in bilayer graphene as a function of the detuning $\beta = \hbar\omega - U \;/ R^*$ for different values of the parameter $v_3$.

References


[1] A. A. Avetisyan, B. Partoens, and. F.M. Peeters, " Phys. Rev. B **80**, 2009,\195401.