Dressing electromagnetic field as a tool to control electronic properties of nanostructures

O. V. Kibis
Novosibirsk State Technical University, Russia

Advances in laser physics achieved in recent decades have made possible the using of lasers as tools to manipulate electronic properties of various quantum systems. Since the strong interaction between electrons and an intense laser field cannot be described as a weak perturbation, it is necessary to consider the system “electron + field” as a whole. Such a composite electron-photon object, which was called “electron dressed by field” (dressed electron), became commonly used model in modern physics [1,2]. The field-induced modification of energy spectrum of dressed electrons — also known as a dynamic (ac) Stark effect — was discovered experimentally in atoms many years ago and has been studied theoretically in various electronic systems. Particularly, it follows from recent studies that the electromagnetic dressing leads to unusual electronic effects in nanostructures. In nanostructures with broken both time-reversal and inversion symmetry, the electromagnetic dressing results in composite electron-photon states which cannot be scattered elastically. As a consequence, the dressed electron gas in such nanostructures can flow without dissipation [3]. This quantum macroscopic phenomenon leads to the unconventional superconductivity which can take place, particularly, in asymmetrical quantum wells exposed to an in-plane magnetic field [4]. In the Dirac materials with linear electron dispersion, the strong interaction between massless Dirac fermions and circularly polarized photons leads to the composite electron-photon states with the gapped energy spectrum. Therefore, the electron-photon interaction results in metal-insulator transition. The stationary energy gap, induced by photons, and concomitant effects can be observed, particularly, in graphene exposed to a laser-generated circularly polarized electromagnetic wave [5]. Thus, the electromagnetic dressing can be considered as an effective tool to control electronic properties of various nanostructures.

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