Scanning probe manipulation of resonances localized in graphene antidots

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The Klein tunneling [1] phenomenon prevents formation of electrostatic confinement within graphene sheets due to the leakage of the charge currents carried by Dirac electrons across potential steps. However, formation of localized states is still possible [2] for rotationally invariant potentials and states with electron currents circulating within the confinement area. We consider an antidot defined in a finite flake of graphene forming a type of a resonant cavity with nanoribbon leads attached. We develop a computational method to study the quantum transport problem in the tight-binding formalism with the currents flowing along the π bonds between the nearest neighbor atoms. We find narrow peaks of the transfer probability corresponding to resonant states localized within the antidot as well as the resonances of the cavity. We demonstrate that position of peaks corresponding to the cavity states shifts slightly with the size of the flake indicating their quasi-bound character. For the resonant states of long lifetime we observe current loops within the antidot. We consider probing the properties of the localized resonances with a scanning probe technique [3]. For that purpose we study conductance of the system as a function of the position of the probe. We discuss variation of the positions of the resonant peaks and their widths as functions of the position of the probe with a model short-range potential. The lifetime and its variation with the peak position are directly studied with the time-dependent tight-binding calculations. We consider the leakage of the circular currents that become deflected by the tip.

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