Intervalley impurity scattering in graphene

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The valley number in graphene can be treated as a quantum number, pseudospin, in many senses similar to the spin of electrons. In analogy with spintronics, the term "valleytronics" was invented where the pseudospin is treated as a possible unit of information, both classical and quantum. The intervalley scattering is practically important process responsible for the pseudospin conservation.

The subject of the present contribution is the intervalley impurity scattering in graphene, which we consider beyond the frames of the Born approximation. We use the tight-binding model with the neutral or charged impurities. Both the intravalley and intervalley processes are examined. These processes are determined by the short-range scattering with the large momentum transfer. However, the long-range Coulomb interaction essentially modifies the short range interaction. In particular, this is due to the large Coulomb interaction constant in the suspended graphene. The long-range Coulomb interaction affects the intervalley scattering rate *W* via the squared probability of electron presence near the impurity, the Sommerfeld factor F_S:

$$W = W_B F_S, \quad F_S \propto \frac{e^{2\pi g}}{2\gamma^4 \chi^4} \left| \frac{\Gamma(\gamma + ig)}{\Gamma(2\gamma)} \right|^4 (s/\varepsilon a)^{2-2\sqrt{1-4g^2}}, \quad \gamma = \frac{1}{2}\sqrt{1-4g^2},$$

where W_B is the Born scattering probability, $g = Ze^2/s\hbar$ is the interaction constant (we suppose $|g| < 0.5$), $Z = \pm 1$ for the attraction or repulsion, correspondingly, s is the Fermi velocity, a is the lattice constant, and ε is the electron energy.

The Born scattering rate W_B does not feel the difference between the attracting and repulsing potentials. This is not the case if the Coulomb interaction is taken into account. The repulsion does not permit electrons to approach the impurity on the small distance to be scattered by the core potential with the transfer of the intervalley momentum. On the contrary, the long-range attraction strongly increases the probability of the electron presence near the core and the probability of the short-range scattering. The Coulomb interaction brings the strong non-analytical dependence of *W* on the electron energy.

We discuss the consequences of the intervalley relaxation mechanism for the valley-selective processes in garphene.