Superconductivity-induced features in electronic Raman spectrum of monolayer graphene

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Raman spectroscopy can be used to extract a wealth of information about graphene-related materials such as the number of layers, defect density, doping level or presence of strain in the sample [1]. In all those cases, the Raman shift, equal to the difference between the energies of the incident and detected photons, arises because part of the energy is spent on exciting the crystal lattice of graphene. However, purely electronic processes in which the final state contains an electronic excitation, can also give rise to a Raman shift. In particular, it has been predicted [2] and later confirmed experimentally [3,4] that in monolayer graphene, a Raman process resulting in the creation of an electron-hole pair leads to a characteristic linear feature in the Raman spectrum, a consequence of the linear electronic density of states.

Here, we study the Raman spectral features due to electronic excitations in doped monolayer graphene in the presence of superconducting ordering induced, for example, by the proximity effect [5]. We consider an *s*-wave order parameter, with symmetries either A_{1g} or B_{2u} in the D_{6h} group, corresponding to spin singlet and spin triplet, respectively. The opening of a superconducting gap Δ at the Fermi level gives rise to a peak at a Raman shift $\omega \sim \Delta$ with the strength of the signal proportional to the value of the chemical potential as well as Δ, and also depending on the polarization of the incident and detected light. The shape of the peak is the same for both of the symmetry phases and reflects the density of states in the vicinity of the gap (Fig.1).
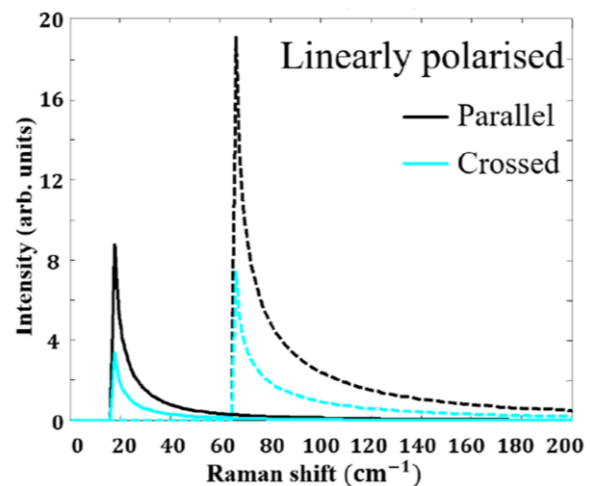
Figure 1: Low-energy electronic contribution to the Raman spectrum of superconducting graphene with chemical potential 150 meV, for incoming photon energy 1 eV and linear polarization of the incoming/scattered light. The solid and dashed lines correspond to a gap Δ=2 meV and Δ=8 meV, respectively.

References

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