Dephasing in Strongly Anisotropic Black Phosphorus

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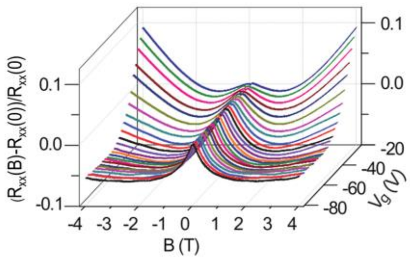

Fig. 1: Weak localization peak: plot of the normalized longitudinal resistance $(R_{xx}(B)-R_{xx}(0))/R_{xx}(0)$ versus magnetic field B and back gate voltage V_g at T = 0.26 K.

Black phosphorus (bP) is a direct band gap semiconductor, which, thanks to its layered structure, can be exfoliated down to the monolayer. It has attracted great interest for various properties, among which anisotropic transport, optical, and thermoelectric properties have been recently observed and related to the puckered structure of the bP layers [1]. Here we present recent results on bP devices, in particular experimental observation of weak localization in a 65 nm-thick black phosphorus field effect transistor [2]. Weak localization (WL) is a quantum effect, related to coherent scattering at low temperatures. Using the Hikami-Larkin-Nagaoka model [3], the dephasing length L_φ (or inelastic scattering length) can be inferred from weak localization. Our study is performed for various gate voltages (V_g), in the hole-doped regime, at temperatures down to 250 mK (see Fig. 1). L_φ is found to increase with increasing hole density, attaining a maximum value of 55 nm at a hole density of approximately 10^{13}cm^{-2}. The temperature dependence of L_φ was also investigated. Above 1 K it decreases, with a weaker temperature dependence than $T^{-1/2}$, the one expected for electron-electron interaction in two dimensions. Rather, the observed power law was found to be close to that observed previously in quasi-one-dimensional systems such as metallic nanowires and carbon nanotubes. We attribute this result to the puckered structure of bP which forms a strongly anisotropic medium for localization. Therefore, the anisotropic structure of black phosphorus plays a crucial role also for quantum interference effects such as WL.

References:

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