Self-Organization of Bi Bilayers in Nanowires

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In thin single-crystal Bi nanowires (d<80 nm) with the $(10\bar{1}1)$ orientation along the nanowire axis, in a transverse magnetic field, we have observed the self-organization of helical edge states of Bi(111) bilayers, which leads to series-connected conglomerates of Bi(111) bilayers; in a transverse magnetic field, each of them contains a closed conducting loop, which results in the appearance of Aharonov-Bohm (AB) oscillations.

The single nanowire samples were prepared by the high frequency liquid phase casting in a glass capillary using an improved Ulitovsky technique; they were cylindrical single-crystals with $(10\bar{1}1)$ orientation along the wire axis. In this orientation the trigonal axis C_3 is inclined to the wire axis at an angle of ~70°.

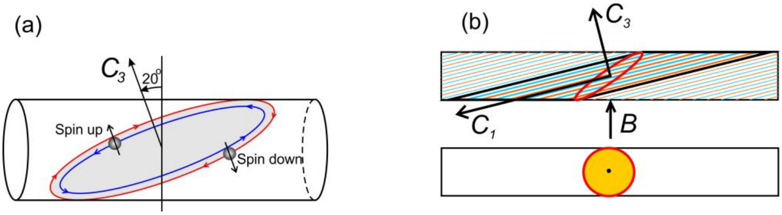

Fig. 1. (a): Location of Bi bilayer in nanowire.; (b): Sketch of the conglomerate of Bi bilayers.

Non monotonic changes in transverse magnetoresistance, which are equidistant in a direct magnetic field, were observed at low temperatures in a wide range of magnetic fields up to 14 T [1,2]. The period of oscillations depended on wire diameter *d* as for the case of longitudinal magnetoresistance; moreover, in a wide range of angles θ between the direction of applied magnetic field *B* and the C_3 wire axis (~50°) the period maintained a constant value. The amplitude of oscillations depended on angle θ and increased in intensity with increasing angle θ.

It was recently suggested that Bi(111) bilayers can exhibit the quantum spin Hall effect [3]. 2D single-bilayer has a pair of helical edge states carrying spin currents with opposite spins (Fig.1 (a)). In 45-nm nanowire, the self-organization of helical edge states leads to series-connected conglomerates of bilayers, each of which in a transverse magnetic field contains a closed conducting loop (see Fig.1 (b)), which results in the appearance of AB oscillations. The number of bilayers in the conglomerate decreases with increasing angle θ between the direction of applied magnetic field *B* and the C_3 axis, thus improving conditions for the occurrence of AB oscillations, which leads to the observed dependence of the amplitude of the AB oscillations on angle θ [1].

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