Dirac equation and generalized spin-orbit interaction

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In frame of Dirac quantum field theory that describes electrons and positrons as elementary excitations of the spinor field, the generalized operator of the spin-orbit interaction is obtained using non-relativistic approximation in the Hamilton operator of the spinor field taking into account the presence of an external potential. This operator is shown to contain a new term in addition to the known ones. For the quantum well potential it is shown that Shrödinger equation with such generalized operator of the spin-orbit interaction describes all spin states obtained from the Dirac equation directly [1]. Dependence of the spin-orbit interaction on spin states in quasi-two-dimensional electron systems localized within the quantum well, is investigated. It is demonstrated that electric current in the quantum well layer induces spin polarization of the carriers near boundary planes of the layer with opposite polarizations on the opposite layers. This polarization results from the spin-orbit interaction and is known as spin Hall effect, which is observed experimentally in heterostructures of the corresponding geometry [2].

1. Eremko A. A., Brizhik L., Loktev V. M. Generalized spin-orbit interaction and its manifestation in two-dimensional electron systems. UJP, 2019 (submitted).
2. Kato Y. K., Myers R. C., Gossard A. C., and Awschalom D. D. Observation of the spin Hall effect in semiconductors. Science, 2004, 306, 19101913.