Spin–orbit coupling effect on a particle density correlation in a two–dimensional electron gas

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Symmetry breaking as an origin of significant physical phenomena, like magnetism or superconductivity, is an important issue in condensed matter physics. Particularly interesting is a presence or a lack of time–reversal and inversion symmetries which determine the symmetry of a superconducting groundstate. Their role has been extensively studied in experiment and theory in non–centrosymmetric superconductors [1]. A unique opportunity to control the time–reversal and inversion symmetry breaking is provided by the spin–orbit coupling interaction in two–dimensional systems where these two symmetries can be lifted by applying external magnetic or electric fields, respectively [2].

The spin–orbit coupling interaction, $\vec{\gamma}(\mathbf{k}) \cdot \hat{\sigma}$, is determined by the scalar product of a gyroscopic vector $\vec{\gamma}(\mathbf{k})$ and the spin operator $\hat{\sigma}$ with $\vec{\gamma}(\mathbf{k}) = \vec{\gamma}(-\mathbf{k})$ representing a time–reversal symmetry breaking and $\vec{\gamma}(\mathbf{k}) = -\vec{\gamma}(-\mathbf{k})$ standing for the inversion symmetry breaking. In both cases the interaction leads to the energy band splitting. We discuss the effect of the above two types of the spin–orbit coupling interaction on a density correlation function in a two–dimensional electron gas and conclude on a possible Cooper pair formation: dominated by the intraband pairing for a broken time–reversal symmetry and with a prevailing interband pairing for a broken inversion symmetry. We also point out that our result can be verified experimentally by the Fourier–transformed scanning tunneling microscopy of a single nonmagnetic impurity in two–dimensional or quasi two–dimensional electron systems [3].

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[3] L. Capriotti, D. J. Scalapino, and R. D. Sedgewick, Phys. Rev. B **68**, 014508 (2003).