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Conventional spin current in Dirac equation SOO YONG LEE, HYUN-WOO LEE, POSTECH — The spin current has been one of main concerns in the field of the spintronics. Recently Rashba [PRB **68**, 241315 (2003)] pointed out that in certain nonmagnetic systems with the spin-orbit coupling, the conventional definition of the spin current leads to a rather strange prediction, namely a nonzero spin current should flow even without external biases. Though the nonvanishing equilibrium spin current does not violate the time reversal symmetry, it still led many scientists to reexamine the definition of the spin current. Recalling that the spin-orbit coupling arises due to the relativistic effects, we examine in this work properties of the conventionally-defined spin current for a Dirac electron subject to an electrostatic potential V(r). Interestingly it is found that in this fully relativistic treatment, the equilibrium spin current vanishes for a wide class of V(r) including those representing the zincblende structure and the asymmetric quantum well, which is in clear contrast with the nonvanishing equilibrium spin current obtained from some effective nonrelativistic Hamiltonians. The origin of this difference is also examined.

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