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Non-Abelian Gauge Field Theory of the Spin-Orbit Interaction and a Perfect Spin Filter

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We first point out that the spin-orbit interaction in the 2D electron gas can be regarded as a non-Abelian (Yang-Mills) gauge field. The physical field generated by the gauge field gives the electron wave function a spin-dependent phase which is frequently called the Aharonov-Casher (AC) phase. We next construct a perfect spin filter, from which only electrons with one component of the spin come out upon injecting electrons with mixed spins. Utilizing the AB and AC phases, we succeeded to make the interference condition of an AB ring completely destructive for one component of the spin while completely constructive for the other component of the spin over the entire energy range.