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Pure and "impure" spin currents in mesoscopic four-probe semiconductor nanostructures with Rashba and Dresselhaus spin-orbit couplings LIVIU ZÂRBO, BRANISLAV NIKOLIĆ, University of Delaware — The all-electrical induction of spin currents in semiconductor structures has emerged as a major goal of recent intense experimental and theoretical pursuits in spintronics. Here we propose a ballistic four-probe mesoscopic structure consisting of a finite-size two-dimensional electron gas in semiconductor heterostructures with both Rashba and (linear) Dresselhaus spin-orbit (SO) couplings, which can serve as a generator of pure (i.e., not accompanied by any net charge current) spin Hall current in the transverse voltage probes as well as longitudinal spin current in the current probes emerging in response to the injected unpolarized charge flow through the longitudinal leads. Since the Dresselhaus SO coupling is related via unitary transformation to the Rashba SO coupling, the presence of either one of them alone leads to the equivalent phenomenology where longitudinal current has only in-plane polarization in the transverse direction. However, when both couplings are present and not equal to each other, the longitudinal spin current that accompanies the charge transport through the same longitudinal leads also acquires a non-zero ouf-of-plane polarization. We also investigate the explicit dependence of the magnitude of the transverse pure spin Hall current on the interplay of the strengths of the two relevant SO couplings.

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