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Recipes for lateral spin transport between magnetic contacts, advantage of carbon-based materials.

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After the presentation of magneto-transport results [1] on metallic carbon nanotubes (CNT) between LSMO electrodes (MR $\approx$ 60-70%, [$V_{AP} - V_P$] $\approx$ 60mV), I will discuss the general problem of spin transport in a nonmagnetic lateral channel between spin-polarized contacts in both the diffusive and ballistic regimes. In the diffusive regime, a treatment by the classical drift-diffusion equations applied to a multi-terminal structure is used to calculate what can be expected for the output signal with local or non-local voltage probes. A general result is that the output signal ($\Delta R = \Delta V/I$ where ΔV is the local or non-local output voltage), directly related to the spin accumulation splitting in the channel, scales with the smallest of the relevant spin and interfaces resistances. In the best situation, that is with only tunnel contacts having the same (large) resistance R_T and separated by less than the spin diffusion length (λ) in a lateral channel limited to the zone of the contacts, the signal ΔR increases in proportion of R_T as long as the dwell time is smaller than the spin lifetime. ΔR can be thus much larger than the spin resistance of the channel (product of its resistivity by the ratio λ/section). This explain why, in the experiments of Ref.[1] on CNT, ΔR can be as large as 90 MΩ, that is of the order of the tunnel contact resistances and much larger than the spin resistance of the CNT (smaller signals in experiments with CNT or graphene are often due the leak of spin accumulation in lateral channels extending too far outside the contacts). The relative disadvantage for semiconductors comes from the too long dwell time due to much smaller electron velocities than in metallic CNTs (and graphene). We will conclude by a similar analysis of the ballistic regime and a discussion of experiments with graphene.

[1] Hueso et al, Nature 445, 410 (2007).