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Kondo Physics at Interfaces in Metallic Non-Local Spin Transport Devices[1]

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Despite the maturity of metallic spintronics there remain large gaps in our understanding of spin transport in metals, particularly with injection of spins across ferromagnetic/non-magnetic (FM/NM) interfaces, and their subsequent diffusion and relaxation. Unresolved issues include the limits of applicability of Elliott-Yafet spin relaxation, quantification of the influence of defects, surfaces, and interfaces on spin relaxation at nanoscopic dimensions, and the importance of magnetic and spin-orbit scattering. The non-local spin-valve is an enabling device in this context as, in addition to offering potentially disruptive applications, it allows for the separation of charge and spin currents. One particularly perplexing issue in metallic non-local spin valves is the widely observed non-monotonicity in the T-dependent spin accumulation, where the spin signal actually *decreases* at low T, in contrast to simple expectations. In this work, by studying an expanded range of FM/NM combinations (encompassing $Ni_{80}Fe_{20}$, Ni, Fe, Co, Cu, and Al), we demonstrate that this effect is not a property of a given FM or NM, but rather of the FM/NM *pair*. The non-monotonicity is in fact strongly correlated with the ability of the FM to form a dilute local magnetic moment in the NM. We show that local moments, resulting in this case from the ppm-level tail of the FM/NM interdiffusion profile, suppress the injected spin polarization and diffusion length *via* a novel manifestation of the Kondo effect, explaining all observations associated with the low T downturn in spin accumulation [1]. We further show: (a) that this effect can be promoted by thermal annealing, at which point the conventional charge transport Kondo effect is simultaneously detected in the NM, and (b) that this suppression in spin accumulation can be quenched, even at interfaces that are highly susceptible to the effect, by insertion of a thin non-moment-supporting interlayer. Important implications for room temperature devices will be discussed.

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[1] L. O'Brien, M. Erickson, D. Spivak, H. Ambaye, R. Goyette, V. Lauter, P. Crowell and C. Leighton, *Nature Communications* **5**, 3927 (2014).

[1]Work in collaboration with: L. O'Brien, J. Watts, D. Spivak, M. Erickson, H. Ambaye, R.J. Goyette, V. Lauter, P.A. Crowell.