Spin Hall effects due to phonon skew scattering

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When carriers, electrons or holes, scatter off charged impurities, spin-orbit coupling can have dramatic effects. In particular, it generates a series of inter-related spin Hall effects, heavily investigated for fundamental as well as technological reasons [1, 2]. Mott skew scattering is essential for the understanding of these phenomena [1].

Typical spin injection or extraction experiments exploiting the spin Hall effects are nowadays performed at room temperatures, mostly in ``soft'' metals such as Pt, Au, Ta, i.e., in a regime in which phonons, rather than impurities, are the dominant source of scattering. Yet ``phonon skew scattering'', which is the high-T equivalent of Mott skew scattering, has been ignored so far. Only in a very recent experiment such a mechanism has been invoked, for the first time, in order to explain certain somewhat controversial results [3].

In this work [4] we present the first microscopic study of skew scattering due to the dynamical electron-phonon spin-orbit interaction. Our quantum field theoretical (Keldysh) treatment provides the necessary microscopic basis for a full characterization of this phenomenon.

Concentrating on the experimentally relevant high-temperature regime, we show that our results can be qualitatively understood via beautifully simple -- and up to know overlooked -- classical arguments. Crucially, our conclusions imply that the high-temperature behaviour of the spin Hall conductivity does not scale as the mobility, as is currently argued on phenomenological grounds, but is instead temperature independent. This has critical implications for the interpretation of room-temperature experimental results.

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