Skyrmion Gas Manipulation for Unconventional Computing

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The topologically protected magnetic spin configurations known as skyrmions offer promising applications due to their stability, mobility and localization. In this work, we emphasize how to leverage the 2-dimensional mobility of an ensemble of such particles to perform computing tasks. In this vein we will present two examples. In the first, we propose a device employing a skyrmion gas to reshuffle a random signal into an uncorrelated copy of itself. This is demonstrated by modelling the ensemble dynamics in a collective coordinate approach where skyrmion-skyrmion and skyrmion-boundary interactions are accounted for phenomenologically. Numerical results are used to develop a proof-of-concept for an energy efficient (~μW) device with a low area imprint (~μm^2) capable of enabling future scalable implementations of stochastic computing circuits.

The second example will consist of a skyrmion network embedded in a frustrated magnetic film to be used as a suitable physical implementation for reservoir computing applications. The significant key ingredient of such a network is a two-terminal device with non-linear voltage character-istics originating from single-layer magnetoresistive effects, like the anisotropic magnetoresistance or the recently discovered non-collinear magnetoresistance. In order to characterize how such a skyrmion-based system would function, we simulate and analyze i) the current flow through a single magnetic skyrmion due to the anisotropic magneto-resistive effect and ii) the combined physics of local pinning and the anisotropic magneto-resistive effects.

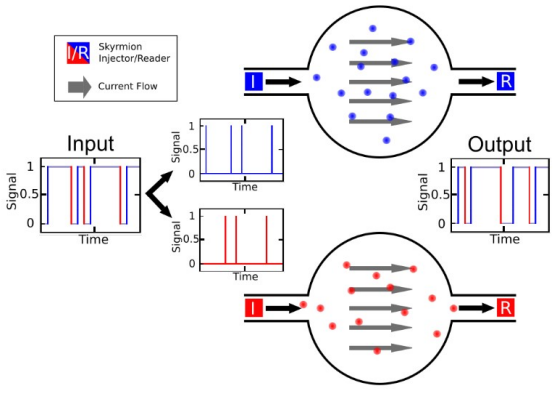

Figure 1. Skyrmion Signal Reshuffler

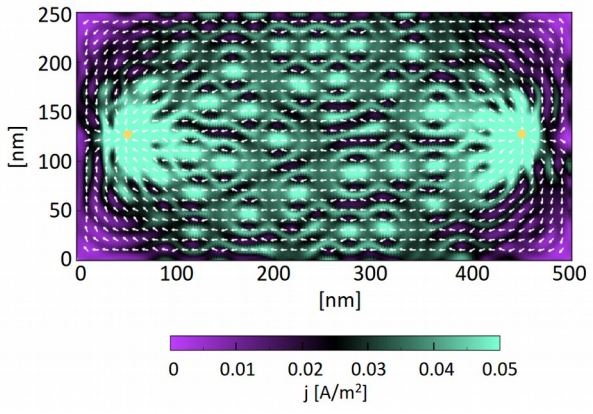

Figure 2. Skyrmion-influenced AMR profile