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Percolative Theory of Organic Magnetoresistance and Fringe-Field Magnetoresistance

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A recently-introduced percolation theory [1,2] for spin transport and magnetoresistance in organic semiconductors describes the effects of spin dynamics on hopping transport by considering changes in the effective density of hopping sites, a key quantity determining the properties of percolative transport. Increases in the spin-flip rate open up “spin-blocked” pathways to become viable conduction channels and hence, as the spin-flip rate changes with magnetic field, produce magnetoresistance. Features of this percolative magnetoresistance can be found analytically in several regimes, and agree with measurements of the shape and saturation of measured magnetoresistance curves [3-5]. We find that the threshold hopping distance is analogous to the branching parameter of a phenomenological two-site model [6], and that the distinction between slow and fast hopping is contingent on the threshold hopping distance. Regimes of slow and fast hopping magnetoresistance are uniquely characterized by their line shapes. Studies of magnetoresistance in known systems with controllable positional disorder would provide an additional stringent test of this theory. Extensions to this theory also describe fringe-field magnetoresistance, which is the influence of fringe magnetic fields from a nearby unsaturated magnetic electrode on the conductance of an organic film [7]. This theory agrees with several key features of the experimental fringe-field magnetoresistance, including the applied fields where the magnetoresistance reaches extrema, the applied field range of large magnetoresistance effects from the fringe fields, and the sign of the effect.

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