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Spin relaxation in organic semiconductors

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Intriguing magnetic field effects in organic semiconductor devices have been reported: anomalous magnetoresistance in organic spin valves and large effects of small magnetic fields on the current and luminescence of organic light-emitting diodes. Influences of isotopic substitution on these effects points at the role of hyperfine coupling. We performed studies of spin relaxation in organic semiconductors based on (i) coherent spin precession of the electron spin in an effective magnetic field consisting of a random hyperfine field and an applied magnetic field and (ii) incoherent hopping of charges. These ingredients are incorporated in a stochastic Liouville equation for the dynamics of the spin density matrix of single charges as well as pairs of charges. For single charges we find a spin diffusion length that depends on the magnetic field, explaining anomalous magnetoresistance in organic spin valves. For pairs of charges we show that the magnetic field influences formation of singlet bipolarons, in the case of like charges, and singlet and triplet excitons, in the case of opposite charges. We can reproduce different line shapes of reported magnetic field effects, including recently found effects at ultra-small fields.