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Electrical control of exchange coupling in disordered multiferroics

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The revival of the magnetoelectric (ME) effect [1] has vitally been boosted by recent intensified research on multiferroic materials [2], which promise to maximise the ME efficiency. While the primordial bilinear ME effect requires stringent symmetry properties, higher order ME effects are less demanding. In particular the biquadratic ME effect has recently attracted growing interest, *e.g.* in ferroelectromagnetic RE manganites, where it is related to the magnetocapacitance or magnetodielectric effect. In disordered systems with broken translational symmetry it is even dominating, while ME effects of lower order may be absent. In type I multiferroics, where magnetic and electric ordering have different origins, it controls the exchange interaction via quadratic spin-lattice interaction. This has been realized in the magnetic relaxor $Pb(Fe_{0.5}Nb_{0.5})O_3$, in quantum paraelectric $EuTiO_3$ and in the magnetoelectric multiglass $Sr_{0.98}Mn_{0.02}TiO_3$ [3]. We have measured nonlinear ME_E effects in these 'disordered multiferroics' using SQUID susceptometry [4] and interpret the EH^2- and E^2H^2-type magnetoelectric (ME) effect in terms of electric field or polarization controlled exchange coupling.

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