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Perspectives of Ferroelectric and Multiferroic Tunnel Junctions

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Tunnel junctions are electronic devices in which current-carrying electrons can quantum-mechanically be transmitted between two metal electrodes across a very thin insulating barrier layer. So far almost all the existing tunnel junctions were based on non-polar dielectrics. An exciting possibility to extend the functionality of tunnel junctions is to use a ferroelectric insulator as a barrier to create a ferroelectric tunnel junction (FTJ). [1] The key property of FTJ is tunneling electroresistance (TER) that is a change in the electrical resistance of FTJ with reversal of ferroelectric polarization. Functional properties of FTJ can be further extended by ferromagnetic metal electrodes to make a multiferroic tunnel junction (MFTJ). In such a MFTJ tunneling magnetoresistance (TMR) can be controlled by ferroelectric polarization of the barrier. [1] Thus, MFTJs represent four-state resistance devices that can be controlled both by electric and magnetic fields due to the coexistence of TER and TMR effects. This talk will address the physics of FTJs and MFTJs based on our recent model and first-principles calculations. In particular, we will discuss the effect of a thin non-polar dielectric layer at the FTJ interface that leads to giant values TER, which may be relevant to recent experimental observations.

[1] E. Y. Tsymbal and H. Kohlstedt, *Science* **313**, 181 (2006).