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Topological insulators in applied fields: magnetoelectric effects and exciton condensation

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"Topological insulators" are insulating in bulk but have protected metallic surface states as a result of topological properties of the electron wavefunctions. Several examples of three-dimensional topological insulators have been discovered recently in ARPES experiments that directly probe the surface state, including its spin structure. One way to characterize the topological insulator is through its magnetoelectric response in a weak applied field: it generates an electrical polarization in response to an applied magnetic field, and a magnetization in response to an applied electrical field. This talk first reviews the origin of this response and its generalization to other insulators and topological states. A strong applied electrical field can combine with Coulomb interactions to generate an unusual "exciton condensate" involving both surfaces of a thin film of topological insulator. This exciton condensate has several topological features that distinguish it from an ordinary superfluid; the most significant is that vortices support midgap localized states ("zero modes" in the particle-hole symmetric case) with effective fractional charge $\pm e/2$.