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Achieving High-Temperature Ferromagnetic Topological Insulator

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Topological insulators (TIs) are insulating materials that display conducting surface states protected by time-reversal symmetry, wherein electron spins are locked to their momentum. This unique property opens new opportunities for creating next-generation electronic and spintronic devices, including TI-based quantum computation. Introducing ferromagnetic order into a TI system without compromising its distinctive quantum coherent features could lead to a realization of several predicted novel physical phenomena. In particular, achieving robust long-range magnetic order at the TI surface at specific locations without introducing spin scattering centers could open up new possibilities for devices. Here, we demonstrate topologically enhanced interface magnetism by coupling a ferromagnetic insulator (FMI) to a TI (Bi2Se3); this interfacial ferromagnetism persists up to room temperature, even though the FMI (EuS) is known to order ferromagnetically only at low temperatures (<17 K). The induced magnetism at the interface resulting from the large spin-orbit interaction and spin-momentum locking feature of the TI surface is found to greatly enhance the magnetic ordering (Curie) temperature of the TI/FMI bilayer system. Due to the short range nature of the ferromagnetic exchange interaction, the time-reversal symmetry is broken only near the surface of a TI, while leaving its bulk states unaffected. The topological magneto-electric response originating in such an engineered TI could allow for an efficient manipulation of the magnetization dynamics by an electric field, providing an energy efficient topological control mechanism for future spin-based technologies. Work supported by MIT MRSEC through the MRSEC Program of NSF under award number DMR-0819762, NSF Grant DMR-1207469, the ONR Grant N00014-13-1-0301, and the STC Center for Integrated Quantum Materials under NSF grant DMR-1231319.