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Ultrafast Spin Dynamics

Chiral spintronics: non collinear spin textures with application to Racetrack Memory

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Today we live in a digital world in which vast quantities of digital data are generated and stored in the cloud. These data have allowed for transformations of nearly all aspects of our lives in just a decade or so. Much of this digital data is stored in magnetic hard disk drives, a fifty-year-old technology that relies on the mechanical motion of a recording read-write head across a whirling disk covered with a thin magnetic film. This talk discusses the physics of a novel disruptive technology, Racetrack Memory, derived from the emerging field of *chiral spintronics* that could replace magnetic disk drives. Racetrack Memory is a dense, high performance, low energy consuming, non-volatile solid-state memory-storage technology, that stores digital data in the form of the presence or absence of *chiral* domain walls. These magnetic domain walls are moved by spin currents, to and thro, along magnetic racetracks to reading and writing elements, thereby allowing for digital storage densities 100 times greater than is possible in today's charge-based memory technologies. Racetrack Memory is made possible by remarkable recent discoveries in spin-based phenomena that rely on *spin-orbit coupling.* These make possible the current induced motion of series of chiral domain walls at high speeds that exceed 1,000 m/s in atomically engineered synthetic antiferromagnetic racetracks. The same type of Dzyaloshinskii-Moriya exchange interactions that stabilize chiral Néel domain walls in such racetracks also enable the formation of topological spin textures such as spin helices and skyrmions. Recently we have discovered magnetic antiskyrmions and elliptical Bloch skyrmions in a family of tetragonal Heusler compounds. These magnetic nano-objects have unique properties that make them highly attractive as potential storage elements in racetrack memories. Finally, we discuss our recent discovery of fractional skyrmions and anti-skyrmions.