EA01

The Spin on Electronics!

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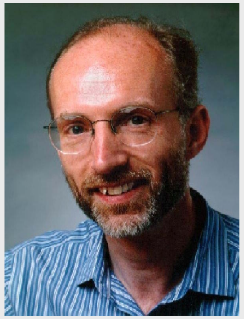
Today, nearly all microelectronic devices are based on storing or flowing the electron's charge. The electron also possesses a quantum mechanical property termed "spin", that gives rise to magnetism. Electrical current is comprised of "spin-up" and "spin-down" electrons, which behave as largely independent spin currents. The flow of these spin currents can be controlled in thin-film structures composed of atomically thin layers of conducting magnetic materials separated by non-magnetic conducting or insulating layers. The resistance of such devices, so-called spin-valves and magnetic tunneling junctions, respectively, can be varied by controlling the relative magnetic orientation of the magnetic layers, giving rise to magnetoresistance tailored for different applications. Recent advances in generating, manipulating and detecting spin-polarized electrons and electrical current make possible new classes of spin based sensor, memory and logic devices, generally referred to as the field of spintronics. In particular, the spin-valve is a key component of all magnetic hard-disk drives manufactured today and enabled their nearly 1,000-fold increase in capacity over the past eight years1. The magnetic tunnel junction allows for a novel, high performance random access solid state memory which maintains its memory in the absence of electrical power. The respective strengths of these two major classes of digital data storage devices, namely the very low cost of disk drives and the high performance and reliability of solid state memories, may be combined in the future into a single spintronic memory-storage technology, the magnetic Racetrack. The Racetrack is a novel three dimensional technology which uses nanosecond long pulses of spin polarized current to move a series of magnetic domain walls along magnetic nanowires2.

1. Stuart Parkin et al., Magnetically engineered spintronic sensors and memory. Proc. IEEE 91, 661-680 (2003).
2. S. S. P. Parkin, US Patent # 6,834,005, 6,898,132, 6,920,062, 7,031,178, and 7,236,386 (2004-2007).



Stuart Parkin is an IBM Fellow and Manager of the Magnetoelectronics group at the IBM Almaden Research Center, San Jose, California and a consulting professor in the Department of Applied Physics at Stanford University. He is also director of the IBM – Stanford Spintronic Science and Applications Center, which was formed in 2004. He received his BA and PhD degrees from the University of Cambridge and joined IBM as a postdoctoral fellow in 1982, becoming a permanent member of the staff the following year. In 1999 he was named an IBM Fellow, IBM's highest technical honor. Parkin's research interests have included organic superconductors, high-temperature superconductors, and, for almost the past two decades, magnetic thin film structures and spintronic materials and devices for advanced sensor, memory, and logic application. He is a Fellow of the Royal Society, the American Physical Society, the Institute of Physics (London), the Institute of Electrical and Electronics Engineers, and the American Association for the Advancement of Science. Parkin is the recipient of numerous honors, including a Humboldt Research Award (2004), the 1999-2000 American Institute of Physics Prize for Industrial Applications of Physics, the European Physical Society's Hewlett- Packard Europhysics Prize (1997), the American Physical Society's International New Materials Prize (1994), the MRS Outstanding Young Investigator Award (1991) and the Charles Vernon Boys Prize from the Institute of Physics, London (1991). In 2001, he was named R&D Magazine's first Innovator of the Year and in October 2007 was awarded the Economist Magazine's "No Boundaries" 2007 Award for Innovation. In 2007 Parkin was named a Distinguished Visiting Professor at the National University of Singapore, a Visiting Chair Professor at the National Taiwan University, and an Honorary Visiting Professor at University College London, The United Kingdom. Parkin has been awarded Honorary Doctorates by the University of Aachen, Germany and the Eindhoven University of Technology, The Netherlands. Parkin has authored ~350 papers and has ~63 issued patents.

EA02

Resonant and Non-resonant Rotating Eigenmodes of Current-driven Vortex Gyrotropic Motions in Soft Magnetic Elliptical Nanodots

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One of the nontrivial dynamic excitation modes in the magnetic vortex(MV) state of nanomagnets is the in-plane translation mode, which exhibits a gyrotropic motion of the vortex core(VC) around its equilibrium position with a characteristic eigenfrequency of several hundred MHz[1,2]. Supprisingly, we found from our previous studies[3] that bistate VC orientations can be selectively switched between the upward and the downward magnetizations of the VC by applying rotating magnetic fields or currents. From an application point of view, this property can become a key technology for information recording in a new type of MRAM - vortex random access memory (VRAM)[4].

In this presentation, in order to gain physical insight into the underlying mechanism of VC switching by in-plane rotating fields or spin-polarized currents, we theoretically solved the rotating eigenmodes existing in vortex gyrotropic motions in soft magnetic elliptical nanodots. The simple mathematical expressions were calculated by adopting rotating-mode-dependent dynamic susceptibility tensors using linearized Thiele equation of motion [5]. The analytical equations indicated that there exist two rotational eigenmodes in linear-regime steady-state vortex motions and that only one eigenmode, of either the counterclockwise (CCW) or clockwise (CW) rotational motion, leads to resonance. The mode showing the resonance effect is determined by the vortex polarization. The shape of the VC orbital motions for the two eigenmodes is determined only by the lateral shape of the nanodot. Additionally, the orbital radii and phases of the two eigenmodes remarkably contrast, varying according both to the frequency of applied currents across the vortex eigenfrequency, and the vortex polarization. On the basis of this theoretical work, it can be understood how linear-regime steady-state vortex motions driven by spin-polarized currents vary with the vortex polarization as well as the frequency of applied currents[6]. The numerical solutions of the mathematical expressions reveal that overall linear-regime steady-state vortex motions under arbitrary polarized oscillating currents can be well interpreted through the superposition of the two rotational eigenmotions.

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