Spintronics*

S. D. Bader
Materials Science Division and Center for Nanoscale Materials
Argonne National Laboratory, Argonne, IL 60439 USA

The grand scientific challenges for the next decade in condensed matter and materials physics include many exciting questions, as outlined in Figure 1. Today we will focus on the area of spintronics, which encompasses the ever-evolving field of magnetic electronics.[1] As the semiconductor roadmap reaches its end because fundamental limits of conventional devices will soon be approached, fields such as spintronics are being examined as holding the potential to extend the information technology revolution. A major issue with present day electronics is in its demand for increased power. Thus, information and energy technologies are rapidly becoming related. Spintronics offer the possibility to communicate via pure spin currents as opposed to electric charge currents. The talk will provide a brief perspective of recent developments to switch magnetic moments by spin-polarized currents, electric fields and photonic fields, as outlined in Figure 2. Developments in the field of spintronics continue to be strongly dependent on the exploration and discovery of novel nanostructured materials and configurations [2]. An array of exotic transport and thermoelectric effects dependent on the interplay between spin and charge currents have been explored theoretically and experimentally in recent years. The talk highlights select promising areas for future investigation, and, features recent work at Argonne [3] including, most strikingly, in the realm of medical applications that transcend magnetic hyperthermia techniques [4].

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Six CMMP Science Challenges for the Next Decade

- How do complex phenomena emerge from simple ingredients?
- What is the physics of life?
- What happens far from equilibrium and why?
- What new discoveries await us in the nanoworld?
- How will the energy demands of future generations be met?
- How will the information technology revolution be extended?

Age of physics -> Age of Biology

Age of Control or Age of Emergence

Age of Energy and Technology

Figure 1

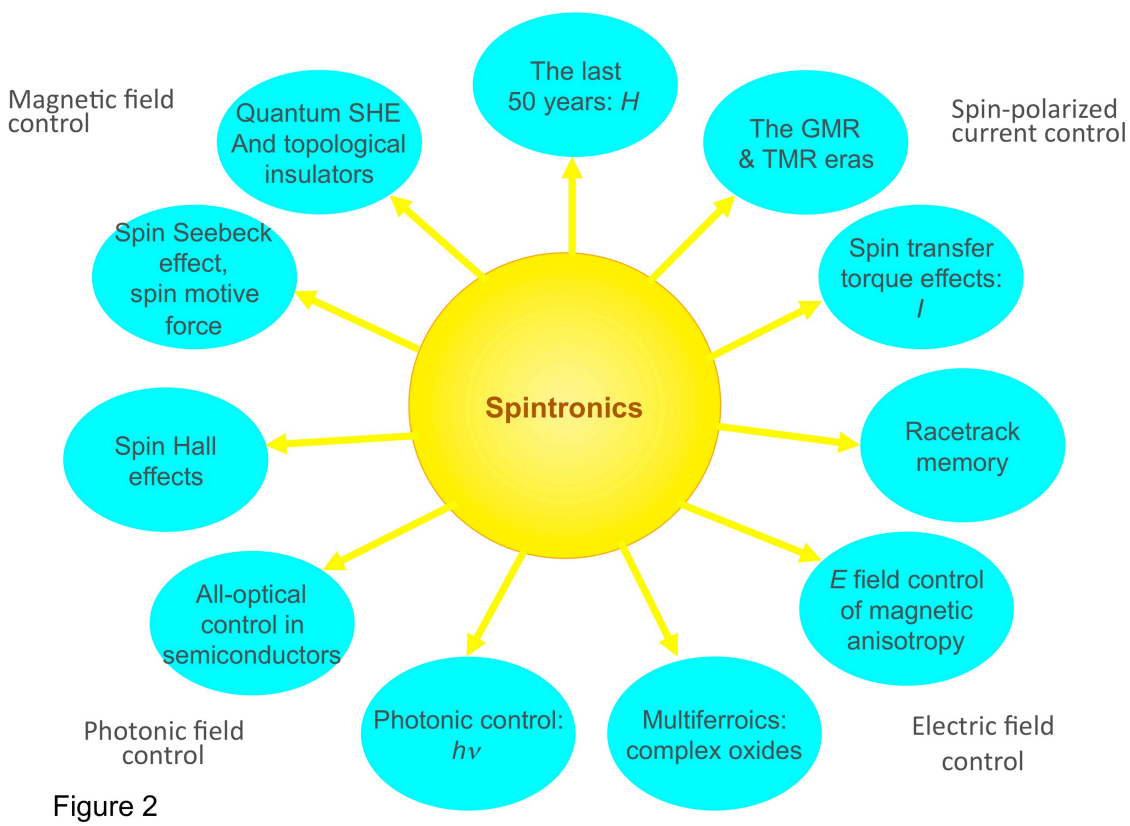

Figure 2