Abstract:
The goal of spintronics is to utilize the spin of the electron in addition to its charge. Many may be unaware of the important role that ORNL played in the development of spintronics. The first spintronic device was the current-in-plane giant magnetoresistive (GMR) read sensor for hard drives. I will describe how theory and computational modeling at ORNL played a useful role in understanding and optimizing these devices in the mid to late 1990’s. The second major spintronic device was the magnetic tunnel junction (MTJ) which has been applied both as a read sensor for hard drives and for the construction of a new type of non-volatile memory known as magnetic random access memory or MRAM. In this case theory and computational materials design has been able to give important guidance that has led to a major breakthrough for both types of application as well as a much better understanding of the underlying physics. The materials design aspects of the new MTJs (in which ORNL also played a major role) will be briefly outlined. The third major spintronic device will probably be based on current perpendicular to the plane GMR (CPP GMR). There are compelling reasons to expect that it will be needed for read sensors for future hard drives. It will also probably be needed for the next version of magnetic random access memory which will utilize a recently discovered spintronic phenomenon called spin-torque switching. The ideal electronic structure for CPP-GMR would be a material that is a metal for one spin channel and an insulator for the other. I will present some simple concepts that can be used to understand such “half-metals” and show how they can be used to generate an infinite number of half-metallic heterostructures.

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