XMCD Characterization of Complex Magnetism in Diluted Magnetic Semiconductors

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Recently, diluted magnetic semiconductors (DMS), where transition-metal atoms are incorporated into the semiconductor hosts, have become promising materials for future spin-electronics device applications. However, because those materials are synthesized using molecular beam epitaxy under thermal non-equilibrium conditions, the microscopic characterization of their atomic and electronic structures has not been straightforward. X-ray magnetic circular dichroism (XMCD) is a very powerful technique for the studies of DMS since it is a site-specific magnetic probe and therefore can be used to study local magnetic properties. In particular, XMCD at the transition-metal 2p→3d absorption edge can be used to identify the valence, spin, and crystal-field of the transition-metal ions in DMS. By utilizing the temperature and magnetic-field dependences of XMCD signals, one can isolate the ferromagnetic component from the paramagnetic and diamagnetic components, and study the electronic and magnetic properties of each component. In this talk, results are presented for DMS for which room-temperature ferromagnetism has been reported, $Zn_{1-x}Co_xO$ [1], $Zn_{1-x}V_xO$ [2], and $Ti_{1-x}Co_xO_2$, as well as for a prototypical DMS $Ga_{1-x}Mn_xAs$ [3].

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