Neutrons: a soft quantum probe for magnetism

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Neutron Scattering provides information on crystallographic and magnetic structures at different spatial distances, from atomic to mesoscopic scales. Combined with spin polarization analysis, neutron diffraction, small angle scattering and neutron reflectometry allow one to determine orientation and amplitude of magnetic moments in bulk samples, thin films, and interfaces. On the other hand, inelastic neutron scattering, accounts for the detailed atomic motions and magnetic excitations - individual or collective - within a many-body system in vastly different time and length scales, typically ps to ms and sub-nm to μm.

After a brief introduction on the properties of neutrons as quantum probe for magnetism in condensed matter, I will describe the most common experimental setups used in continuous and pulsed neutron sources, discussing characteristics and limits of the various components of a neutron spectrometer, including devices for selecting and analysing neutron energy, momentum, and spin polarization states. The master formula providing the neutron scattering amplitude probability will be derived in a simple way and applied to different cases. In particular, I will focus on the scattering amplitude associated with the interaction of neutrons with the magnetic field distribution generated by electrons spin and currents in a material and I will show how the magnetic neutron scattering cross section provides information on the correlation between the magnetization components, that is how the magnetization on a given site influence the magnetization of the surrounding.

References

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