Magnetization processes: From quasi-statics to precessional dynamics

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This set of three lectures on magnetization processes (MP) will cover diverse aspects of thin film magnetism across many different time and length scales.

MP1 – Quasi-static processes, domain states, and nontrivial spin textures
This lecture will introduce basic domain theory and magnetic hysteresis. We will focus on strong ferromagnets for which the continuum (micromagnetic) approximation is useful. We will discuss how domain structures form and describe quasi-static processes relevant for hysteresis curves [1,2], touching on topics such as hard and soft materials. We will also discuss thermal effects and the magnetic aftereffect. Connections between nucleation processes and spin textures such as domain walls and magnetic bubbles will be described [3].

MP2 – Precessional dynamics, dissipation processes, elementary and soliton excitations
In this lecture we will discuss precessional dynamics of the magnetization using the Landau-Lifshitz formalism. We will describe elementary excitations such as long wavelength spin waves and Stoner excitations [4], with particular emphasis on how the former can be useful for probing magnetic properties experimentally. We will also give an overview of dissipation processes and how these can be described using spin wave theory and reconciled with Landau-Lifshitz dynamics [4-6]. Finally, we will discuss briefly how reduced-variable models can be obtained from the Landau-Lifshitz equation to describe the dynamics of domain walls and vortices.

MP3 – Spin-transfer and spin-orbit torques, current topics in magnetization dynamics
This lecture will introduce phenomena induced by spin-polarized electrical currents, such as spin-transfer and spin-orbit torques. We will discuss briefly how the Landau-Lifshitz formalism can be extended to describe these effects [4] and how such torques can lead to magnetization processes that are not accessible by magnetic fields alone. This will lay the foundations to discuss recent advances in magnetism and spintronics, such as domain wall devices, spin-torque nano-oscillators, and spin-torque magnetic memories.

References

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