Problems in magnetisms for a new class of soft X-ray sources

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In this talk we first show that the characteristic spatial and temporal length scales associated with the fundamental interactions responsible for magnetism in matter are in the nanometer range, respectively in the subpicosecond regime. At these scales, new problems appear, which are unresolved.

1. The motion of a domain walls and the dynamics of other types of topological excitations and magnetic singularities, which tend to be non deterministic and can only be studied by single shot experiments
2. The evolution of the internal spin structure of domain walls or similar topological singularities during their motion, driven by Oersted field and/or spin torque.
3. The spin motion following the excitation of a the non-equilibrium electron distribution
4. identical particles are indistinguishable in Quantum Mechanics, but this is certainly true al large time scales. At very short time scales - shorter than the exchange time scale - the particles might become - for an elusive moment at least - distinguishable.
5. The spin state during the tunneling process: how long does it take for the spin to escape the potential barrier?
6. The very interpretation of quantum mechanics is based on the fact that any attempt to measure the state of a quantum mechanical system projects its state into one of the possible eigenstates of the relevant Hamiltonian. If very short times are available, one might start asking questions like "How long is the time required for this projection process" and " how does it evolve in time".

There are some preliminary experiments on these problems, but the new generation of X-ray sources is likely to provide the momentum necessary to find scientifically solid answers.