Basic properties, fields and units in magnetism

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The field of magnetism is expansive with a wide diversity of complex behaviour and phenomena arising from the natural interaction between magnetic materials and magnetic and electric fields. This lecture will review the properties of magnetic fields and field sources and their common and less common units. The magnetic dipole moment **m** [Am^2] is the fundamental magnetic quantity arising from magnetic materials and electrical currents. In magnetic materials these "currents" are permanent and arise from the quantum mechanical nature of the spin of electrons. Averaging the moments over a volume naturally leads to a moment density, or magnetization **M** [Am^{-1}]. The magnetic field **B** [Tesla] in a magnetised body is a combination of the static magnetic moment **M** and internal and external magnetic fields **H** [A/m] and related by $\mathbf{B} = \mu_0(\mathbf{M} + \mathbf{H})$ where μ_0 is the permeability of free space. The internal demagnetizing field arises due to the macroscopic shape of the magnetic samples and simple geometric shapes can be characterised by a demagnetization tensor $\boldsymbol{N}_{ij}$ where the trace is the vectorial demagnetizing factor $\mathbf{N}_D$ with a summation of 1. The demagnetizing field $\mathbf{H}_D$ is given by $\mathbf{H}_D = - \mathbf{N}_D \mathbf{M}$ and describes the internal contribution to the field in the Maxwellian description. We will discuss the magnetostatic field and its microscopic origins in some detail and consider its effects in a range of different sample geometries. Finally we will describe the practical units for magnetic measurements and theoretical calculations and their importance in relation to the revised definition of the Ampere in the SI system.