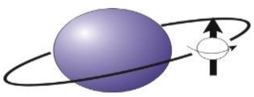
## Background

Electron paramagnetic resonance (EPR) spectroscopy is a valuable tool for investigating paramagnetic species, i.e. species that possesses one or more unpaired electrons, such as radicals, transition metals, and transition metal doped materials. The basic principles behind EPR are very similar to NMR (nuclear magnetic resonance), as both techniques measure the transition between spin states in the presence of external magnetic field. But, where the EPR focuses on the interaction of an external magnetic field with the unpaired electrons in a molecule, and measured transitions between two electron spin states, the NMR focuses on the nuclei spin of individual atoms and measures transitions between the nuclear spin states. The interaction energy of the electron with the magnetic field is much higher than that of the protons with the magnetic field, thus make the EPR much sensitive method than NMR. While the NMR methods will employed for diamagnetic molecules (mainly organic compounds or biomolecules), for organic radicals, transition metals, or inorganic materials, EPR is the technique of choice.

In the EPR experiment we measured the microwave-induced resonance of electrons having a net spin and an orbital angular momentum in a magnetic field. The output spectra can provide information regarding the identity of the radical or metal, the coupled nuclei and paramagnetic centers, the electronic structure in the surrounding of metal ion, the estimation quantities of radicals, the viscosity of the surrounding radicals, the magnetic interaction between paramagnetic species and the relative size of nano-particles.



In CW EPR, the electromagnetic radiation frequency (in the microwave region, MW) is kept constant whilst the magnetic field is scanned. At a specific magnetic field B (field of resonance), the energy splitting (see in scheme) matches that of electromagnetic frequency and absorption occurs. From the magnetic field position of

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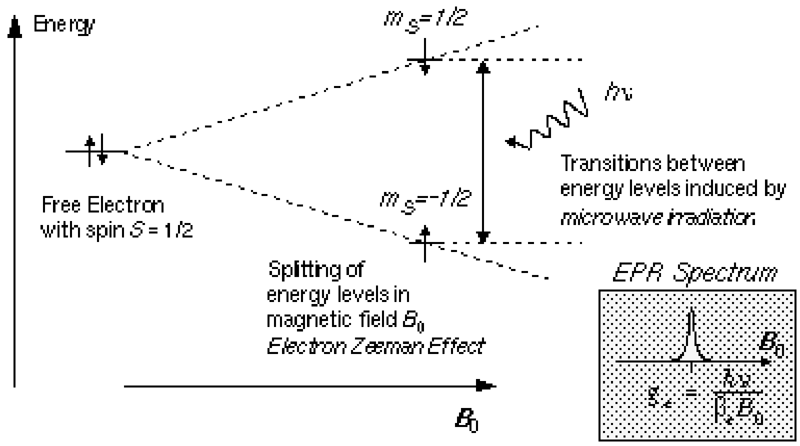
absorption and the spectrum pattern we can characterize the radical/transition metal and its neighbors, the electronic structure of the paramagnetic center and its surrounding nucleolus which having nuclear spin (such as N).




$$\Delta E = E(m_S = +1/2) - E(m_S = -1/2) = g_e \beta_e B_0 / h \text{ (in Hz)}$$

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