

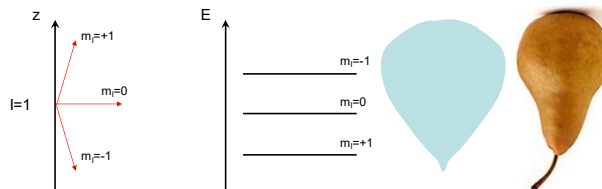
orientation, temperature, radiation

www.hyperfinecourse.org

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Orientation of a nuclear ensemble at a given temperature

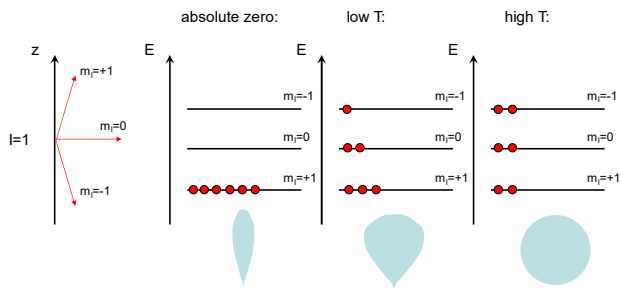
Bring an ensemble of identical nuclei with spin $I=1$ in an environment where the hyperfine levels turn out to be as in this picture :



2

Orientation of a nuclear ensemble at a given temperature

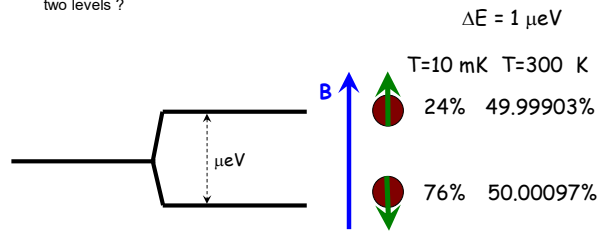
However, thermal excitations play their usual role, and the occupation of each level is given by a Boltzmann distribution :



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Orientation of a nuclear ensemble at a given temperature

Make some estimates yourself, using a Boltzmann distribution, a strong magnetic field, and a simple 2-level hyperfine scheme : what is the relative occupation of the two levels ?



Occupation of a level with energy E_i : $N_i = A e^{-\frac{E_i}{kT}}$

Population difference between two levels ($E_1 < E_2$): $\Delta N = N_1 \left(1 - e^{-\frac{\Delta E}{kT}} \right)$
0.000039

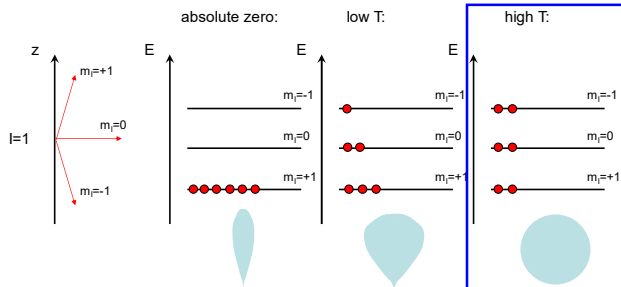
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Orientation of a nuclear ensemble at a given temperature

What is low and high ?

for $k_B T$: $\mu\text{eV} \propto \text{mK}$ (milli-Kelvin)

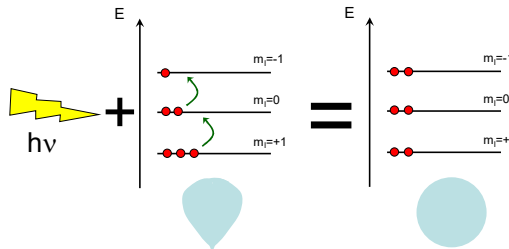
At room temperature, the orientation of an ensemble of nuclear spins is isotropic.



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Radiation absorption by an oriented nuclear ensemble

What happens if you send radiation onto an ensemble of nuclear spins, with an energy that matches the difference between the hyperfine levels ?
(photons with a μeV energy are in the radiofrequency region)



At low T, the rf field destroys the orientation : photon absorption.

6

Radiation absorption by an oriented nuclear ensemble

What happens if you send radiation onto an ensemble of nuclear spins, with an energy that matches the difference between the hyperfine levels ?
(photons with a μeV energy are in the radiofrequency region)

At high T, the weak pumping to higher levels by the rf-field hardly influences the isotropic distribution due to thermal transitions : **no photon absorption.**

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