NMR on
Oriented Nuclei
(NMR/ON)

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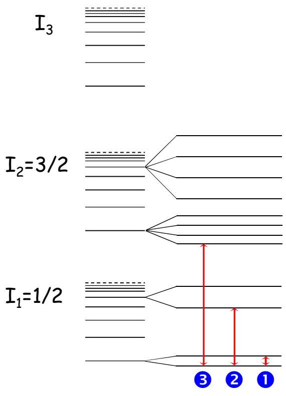
Classification of nuclear methods

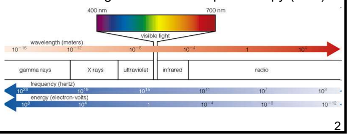


These 3 energy scales distinguish
3 different classes of experimental methods:

❶
- Nuclear Magnetic Resonance (NMR)
- Nuclear Quadrupole Resonance (NQR)

❷
- laser spectroscopy
- Electron Paramagnetic Resonance (EPR)

❸
- Low-Temperature Nuclear Orientation (LTNO)
- NMR on Oriented Nuclei (NMR/ON)
- forward scattering of synchrotron radiation
- Mössbauer Spectrocopy (MS)
- Conversion Electron Mössbauer Spectrocopy (CEMS)
- Perturbed Angular Correlation spectroscopy (PAC)



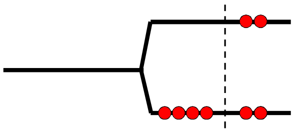
NMR on Oriented Nuclei (NMR/ON)

Conventional NMR :

- energy absorption due to a tiny room temperature orientation of a large amount of nuclei (macroscopic sample) is measured.

NMR/ON :

- cool down to mK-region first : nuclear orientation
- measure anisotropy of radiation at fixed T, as a function of applied rf field
- the frequency at which the orientation is destroyed corresponds to ΔE



- not the right rf-frequency
- orientation
- anisotropy in emitted $\alpha\beta\gamma$-rays

- matching rf-frequency
- orientation destroyed
- no anisotropy in emitted $\alpha\beta\gamma$-rays

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NMR/ON :

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- measure anisotropy of radiation at fixed T, as a function of applied rf field
- the frequency at which the orientation is destroyed corresponds to ∆E

Advantages :

➔ applicable to much smaller quantities of nuclei (ppm dilution in bulk sample)

➔ detecting a resonance is always more accurate than fitting an integral curve: higher accuracy than LTNO

NMR on Oriented Nuclei (NMR/ON)

Example :

PHYSICAL REVIEW B **68**, 012403 (2003)

Nuclear magnetic resonance on oriented nuclei of ^{91}Sr*Fe*

K. Nishimura,[1] S. Ohya,[2] T. Ohtsubo,[2] M. Sasaki,[2] J. Goto,[3] T. Izumikawa,[4] M. Tanigaki,[5] A. Taniguchi,[5]
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Nuclear magnetic resonance on oriented nuclei was used in combination with beta-ray detection and ion implantation, leading to the successful observation of the resonance of ^{91}Sr*Fe*. The magnetic hyperfine field (B_{HF}) was deduced as $B_{HF}(\mathrm{Sr}Fe) = -23.83(7)$ T using the known nuclear g factor. This result explains the existing problem of disagreement in B_{HF} values for Sr*Fe* between theory and experiment. An experimental nuclear spin-lattice relaxation rate was obtained and is briefly discussed in comparison with a theoretical estimate.

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- Detect the magnetic hyperfine field of isolated substitutional Sr impurities in a bcc-Fe crystal

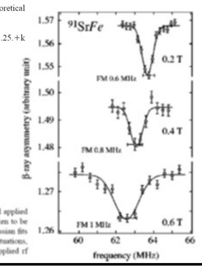

FIG. 1. Beta-NMRON spectra of ^{91}Sr in Fe for external applied fields of 0.2, 0.4, and 0.6 T. The beta-ray asymmetry is taken to be a ratio of counts, $N(0°)/N(180°)$. The solid lines are Gaussian fits of the data points. Vertical error bars reflect statistical fluctuations, and horizontal error bars indicate the FM width of the applied rf field.

NMR vs. NMR/ON

Why would you care to use NMR/ON (a complicated experimental method) if you can obtain the same kind of information by NMR (much easier to apply) ?

A matter of sensitivity:

NMR needs a lot of nuclei to have a measurable energy absorption of the radiowaves (the population difference is very small).

With NMR/ON, the population difference is much larger, hence more absorption with less nuclei.

Therefore, the extra effort of NMR/ON pays of when you have very few nuclei (as in the case of isolated Sr impurities in Fe – you will not use this method for a real Sr-alloy).