

# Mössbauer Spectroscopy

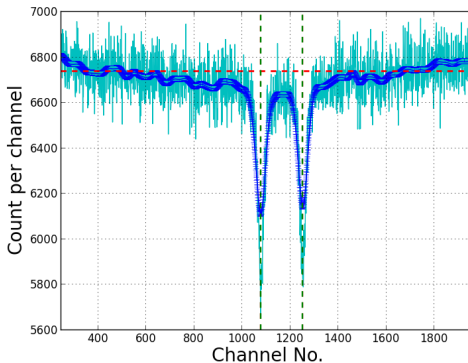
Yichao Yu

MIT

March 16, 2013

## Mössbauer effect and Mössbauer spectroscopy.

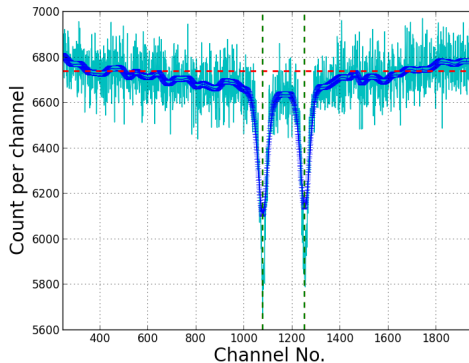
- Nuclear  $\gamma$  spectrum.
- Simple setup.
- Super high resolution. ( $10^{12}$ )



Mössbauer spectrum of  $\text{FeC}_2\text{O}_4$ .

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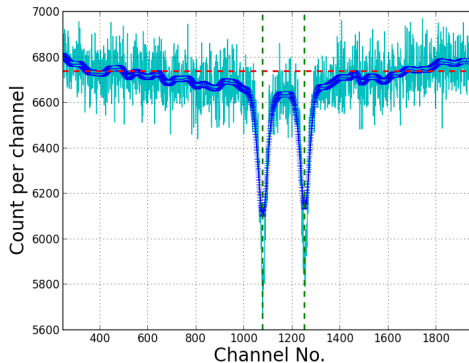
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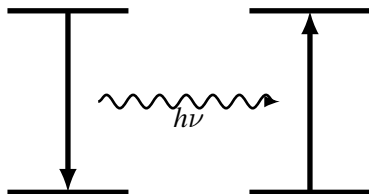
- 1 **Mössbauer effect.**
- 2 **Apparatus and samples.**
- 3 **Data and result.**
- 4 **Conclusion.**

# Nuclear spectrum and recoil.

- Radio active element radiate  $\gamma$ -ray at characteristic frequencies.
- Radiation  $\rightarrow$  Absorption.
- Recoil momentum and doppler shift.

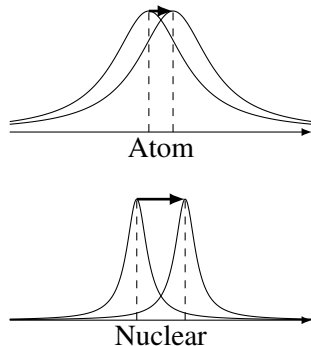
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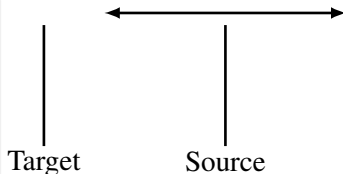
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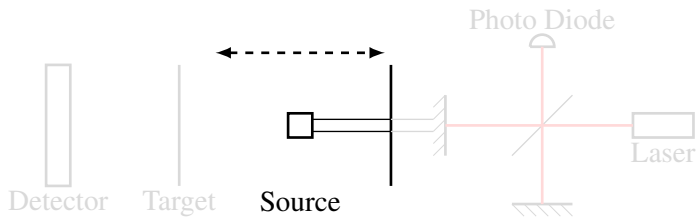
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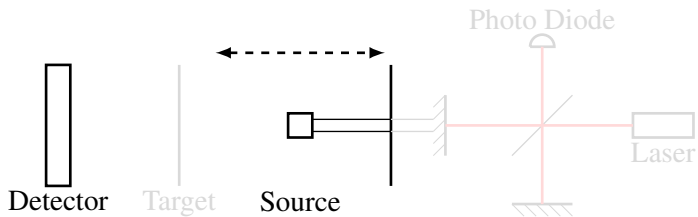
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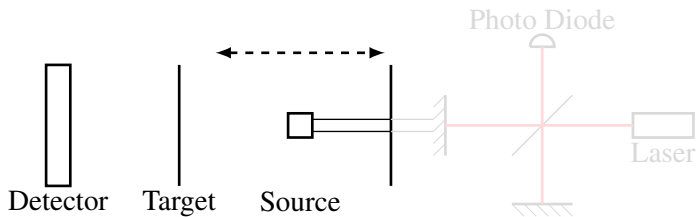
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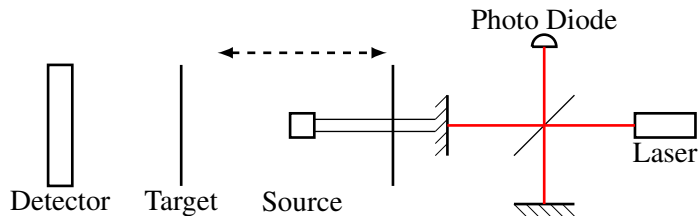
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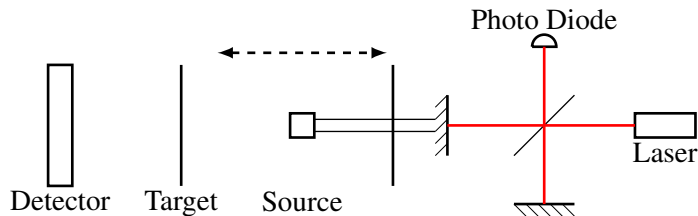


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$$v = 2f\lambda$$

- Source:  $^{57}\text{Co}$ .
- First decay into excited state of  $^{57}\text{Fe}$ .
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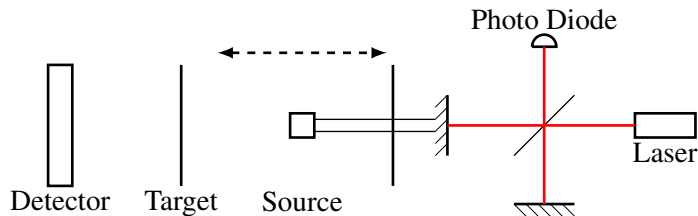
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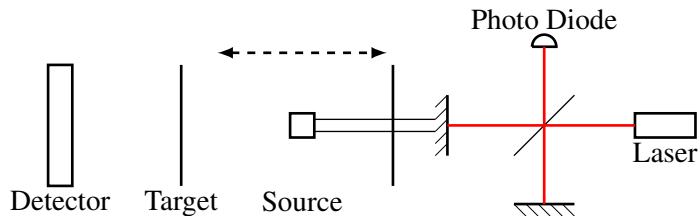


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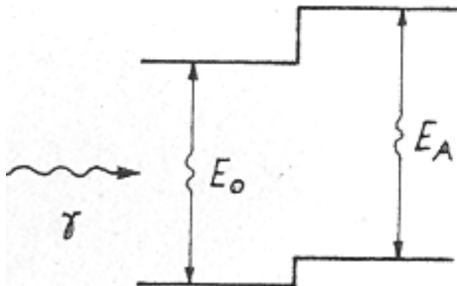
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- Zeeman effect.

$$E = -g_N \mu_N B m_I$$

- Quadrapole Splitting.
- Temperature Shift.

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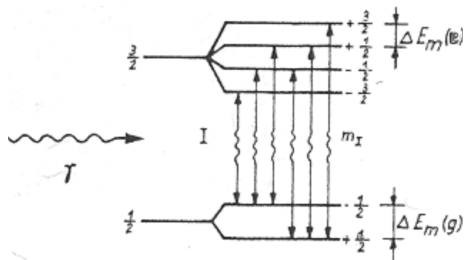
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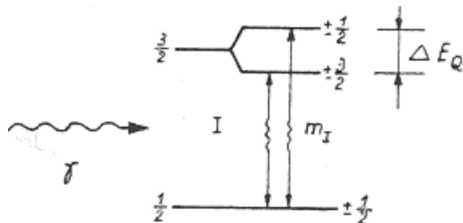
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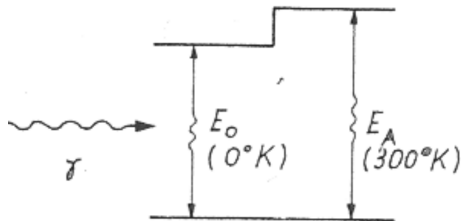
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- $\text{Fe}_2(\text{SO}_4)_3$
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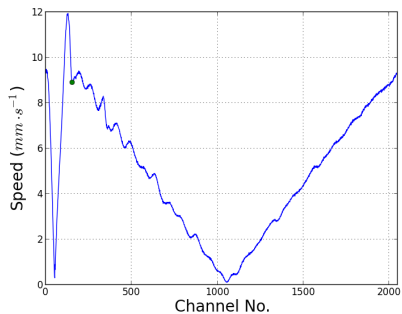
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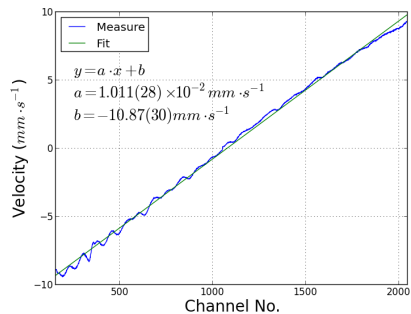
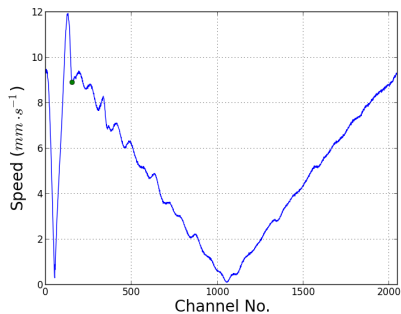
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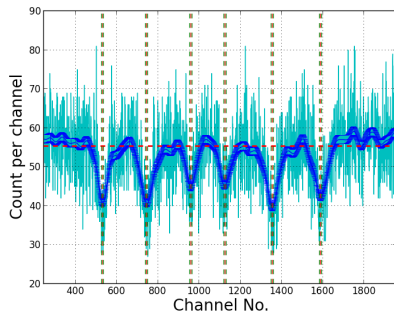


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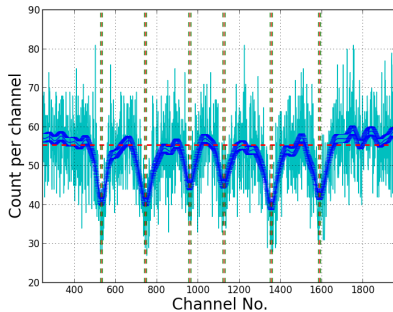
**Zeeman splitting for ground state ( $g_0$ ) and excited state ( $g_1$ ).**

$g_0$	$1.882(13) \cdot 10^{-7} eV$
$g_1$	$1.074(13) \cdot 10^{-7} eV$

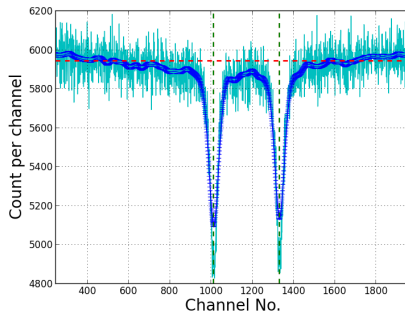


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**Isomer shift ( $\varepsilon$ ) and quadrupole splitting ( $\delta$ ).**

$\varepsilon$	$5.9(1.4) \cdot 10^{-8} \text{eV}$
$\delta$	$1.562(2) \cdot 10^{-7} \text{eV}$

# Temperature effect.

## Samples

- Classic:

$$E_k = \frac{3}{2}k_B T$$

- Debye  $T^3$  approximation:

$$E_k = \frac{3\pi^4 * k_B * T^4}{10\Theta_D^3}$$

- Exact Debye Model:

$$E_k = \frac{9k_B T^4}{10\Theta_D^3} D_3 \left( \frac{T}{\Theta_D} \right)$$

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$t_{low}$	$21(1)^\circ C$
$t_{high}$	$130(5)^\circ C$
$\delta/E$	$1.86(69) \cdot 10^{-13}$

Model	$E_k$
Classic	$1.409(12) \cdot 10^{-2} eV$
Debye $T^3$	$4.59(22) \cdot 10^{-1} eV$
Exact Debye	$1.304(84) \cdot 10^{-2} eV$
(Measured)	$0.99(36) \cdot 10^{-2} eV$

## Conclusion.

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$\varepsilon$

- Zeeman effect:

$g_0, g_1$

- Quadrapole Splitting:

$\delta$

$$\Delta E_1 = \varepsilon - \frac{g_0}{2} - \frac{3g_1}{2} - \frac{\delta}{2} \quad (1)$$

$$\Delta E_2 = \varepsilon - \frac{g_0}{2} - \frac{g_1}{2} + \frac{\delta}{2} \quad (2)$$

$$\Delta E_3 = \varepsilon - \frac{g_0}{2} + \frac{g_1}{2} + \frac{\delta}{2} \quad (3)$$

$$\Delta E_4 = \varepsilon + \frac{g_0}{2} - \frac{g_1}{2} + \frac{\delta}{2} \quad (4)$$

$$\Delta E_5 = \varepsilon + \frac{g_0}{2} + \frac{g_1}{2} + \frac{\delta}{2} \quad (5)$$

$$\Delta E_6 = \varepsilon + \frac{g_0}{2} + \frac{3g_1}{2} - \frac{\delta}{2} \quad (6)$$

