Mössbauer Spectroscopy

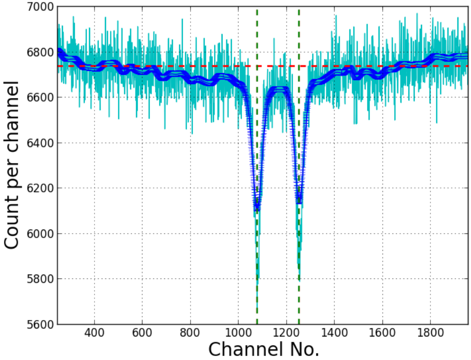
Yichao Yu

MIT

March 6, 2013

Mössbauer effect and Mössbauer spectroscopy.

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



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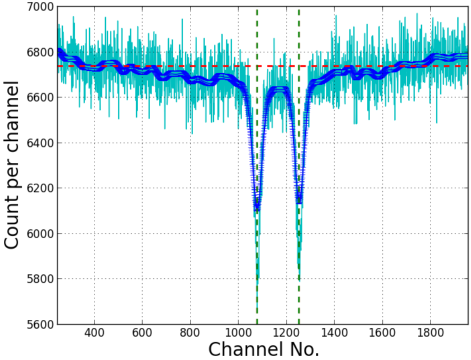

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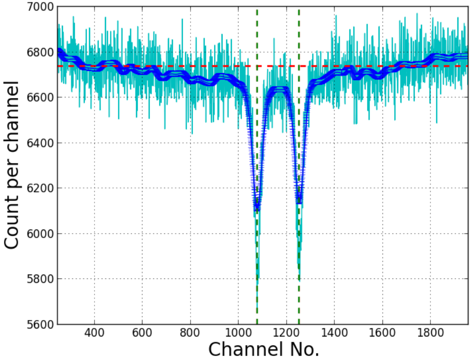

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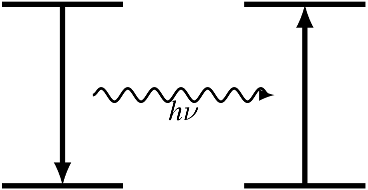

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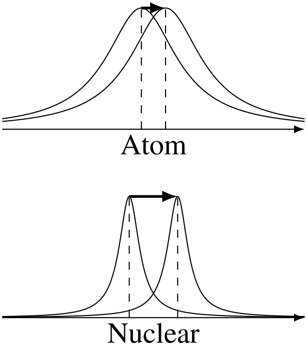

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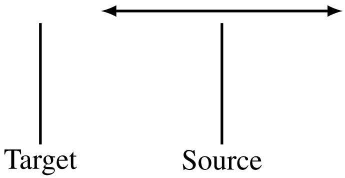

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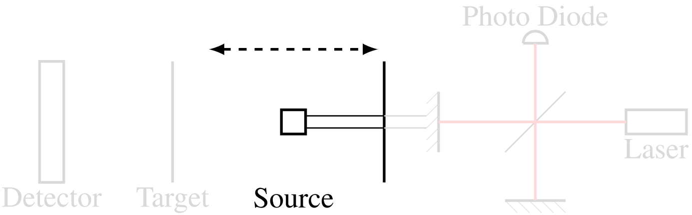

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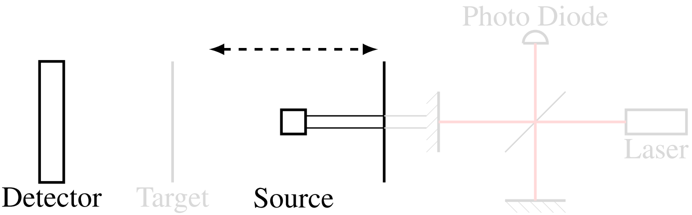

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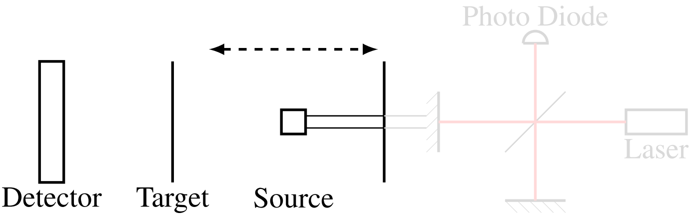

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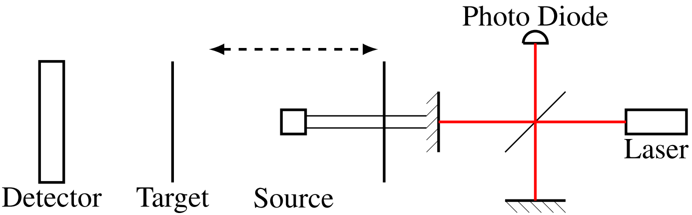

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$$v = 2f\lambda$$

- Source: ^{57}Co.
- First decay into excited state of ^{57}Fe.
- Energy $14.4keV$.

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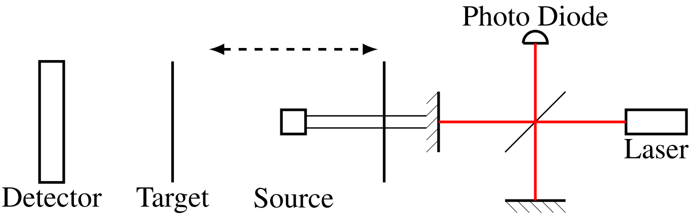

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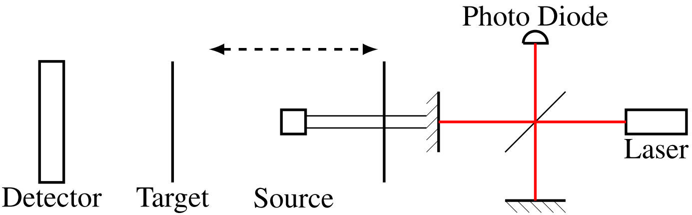

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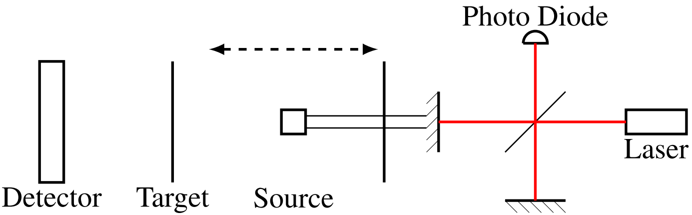

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Effects and samples.

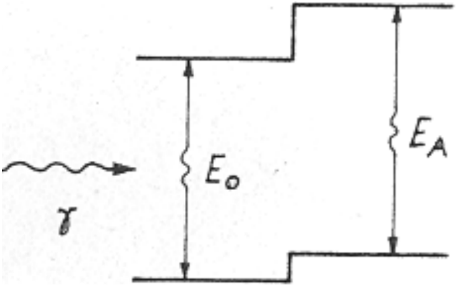
Effects

- Isomer Shift.
- Zeeman effect.

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

- Quadrapole Splitting.
- Temperature Shift.

$$\frac{\delta}{E} = \frac{v^2}{2c^2} = \frac{E_k}{mc^2}$$



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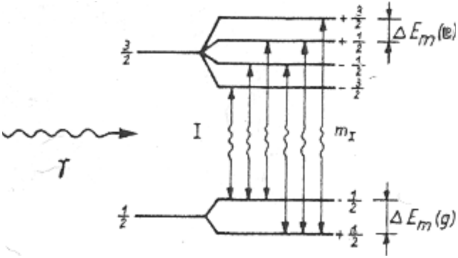

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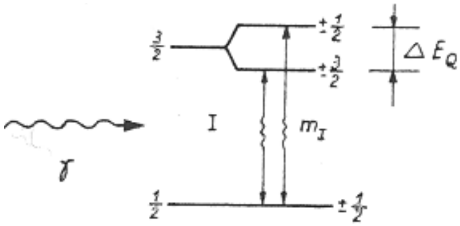

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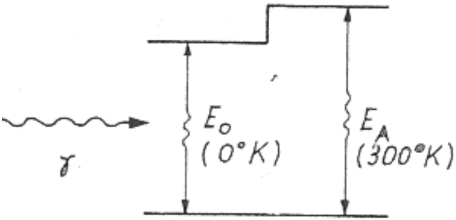

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- ^{57}Fe
- $FeSO_4$
- $Fe_2(SO_4)_3$
- Fe_2O_3
- Stainless steel (Varying temperature).
- $Na_4Fe(CN)_6$ For line width.

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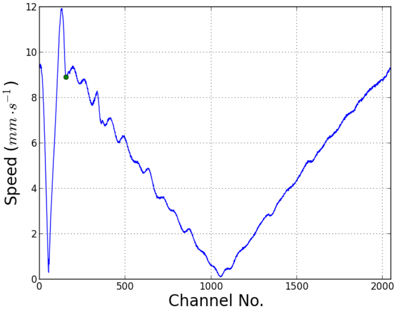

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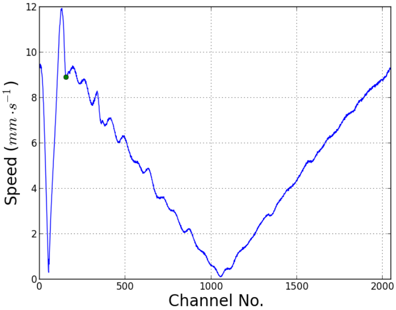

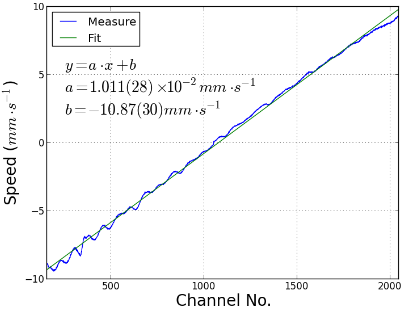

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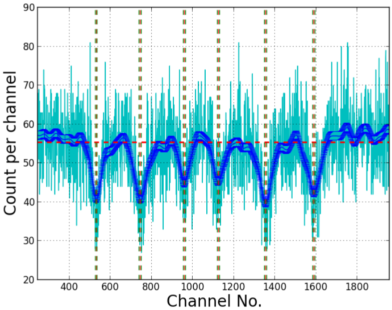

Zeeman splitting for ground state (g_0) and excited state (g_1).

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

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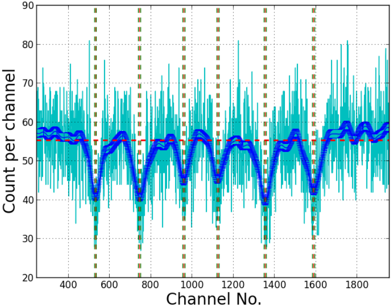

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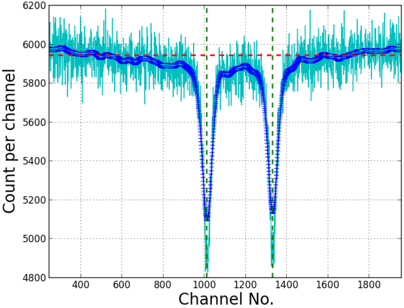

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Isomer shift (ε) and quaduapole splitting (δ).

ε	$5.9(1.4) \cdot 10^{-8} eV$
δ	$1.562(2) \cdot 10^{-7} eV$

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:

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

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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:

$$\delta$$

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

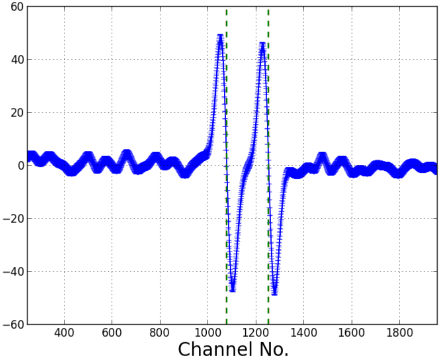
$$\Delta E_2 = \varepsilon - \frac{g_0}{2} - \frac{g_1}{2} + \frac{\delta}{2} \qquad (2)$$

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

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

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

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