Mössbauer Spectroscopy

Yichao Yu

MIT

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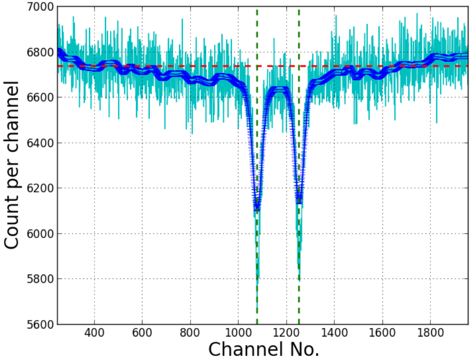
Mössbauer effect and Mössbauer spectroscopy.

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



Mössbauer spectrum of FeC_2O_4.

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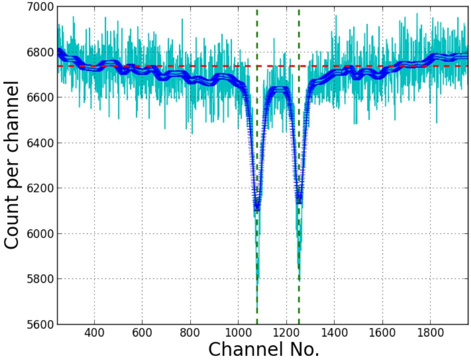

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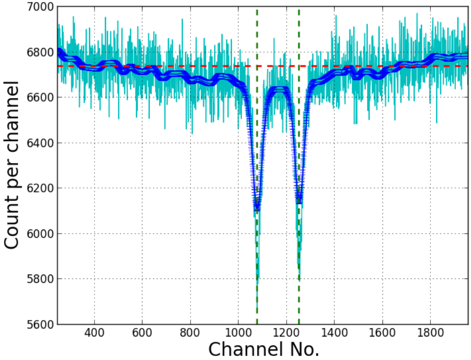

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1. **Mössbauer effect.**

2. **Apparatus and samples.**

3. **Data and result.**

4. **Conclusion.**

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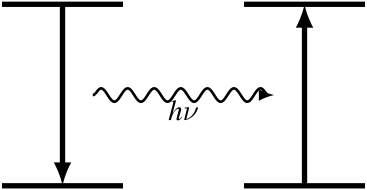

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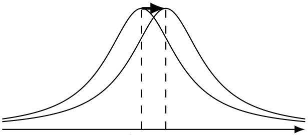

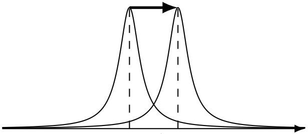

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- Discoveried in 1957 by Mössbauer.
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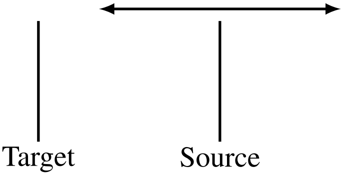

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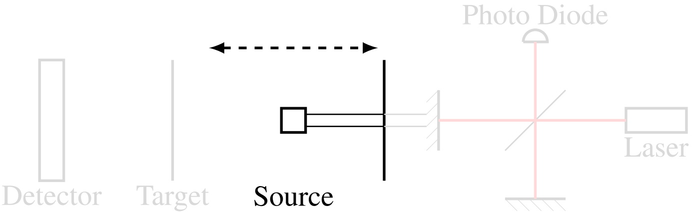

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- First turned into excited state of ^{57}Fe.
- Energy $14.4keV$.

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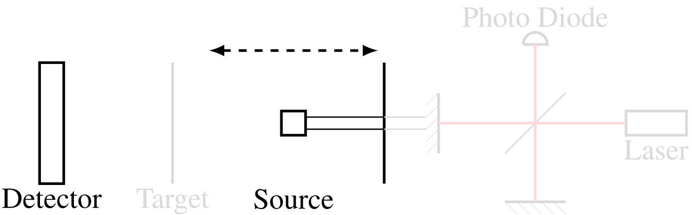

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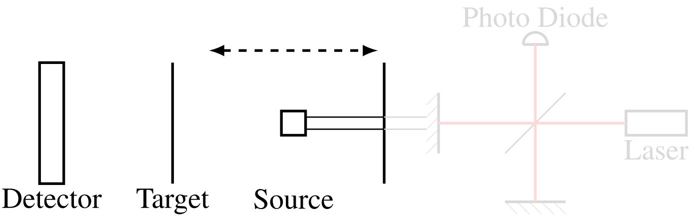

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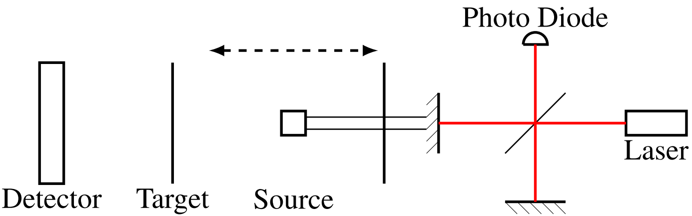

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Effects and samples.

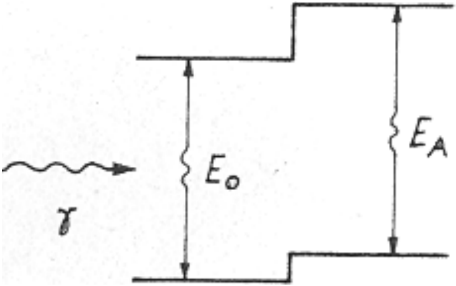
Effects

- Isomer Shift.
- Zeeman effect.

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

- Quadrapole.
- Temperature Shift.

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



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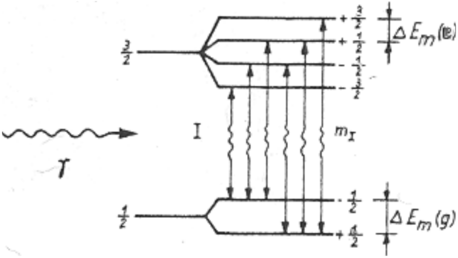

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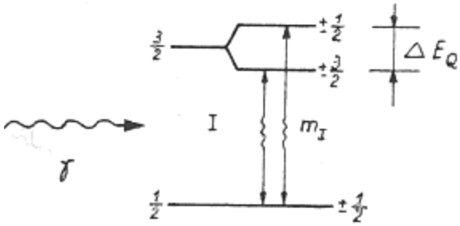

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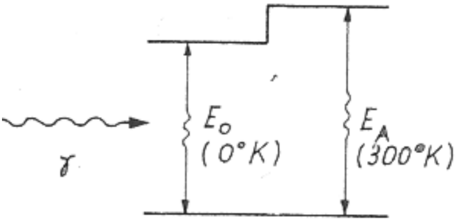

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- ^{57}Fe
- $FeSO_4$
- $Fe_2(SO_4)_3$
- Fe_2O_3
- Stainless steel (Varying temperature).
- $Na_4Fe(CN)_6$ For line width.

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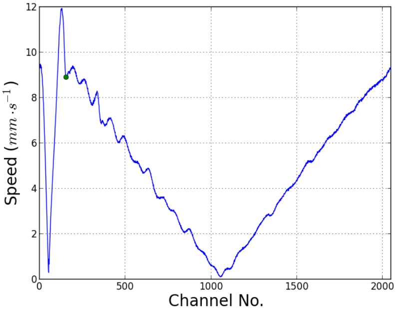

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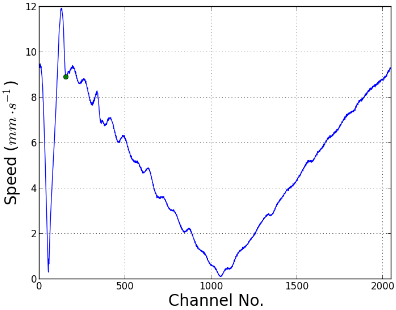

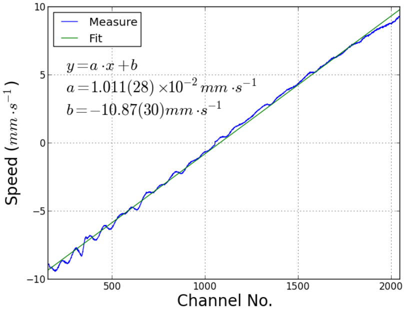

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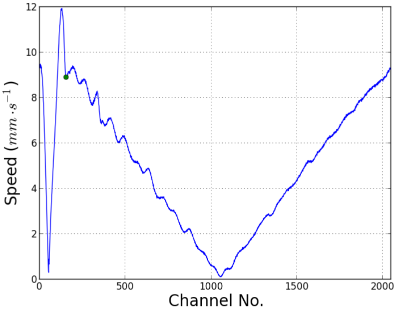

Speed ($mm \cdot s^{-1}$)
Channel No.
0
2
4
6
8
10
12
0
500
1000
1500
2000

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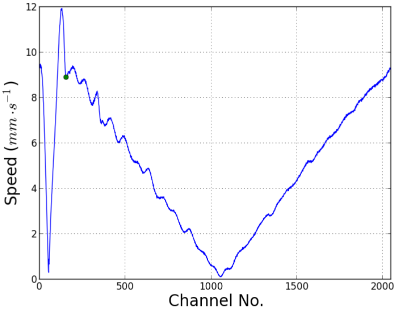
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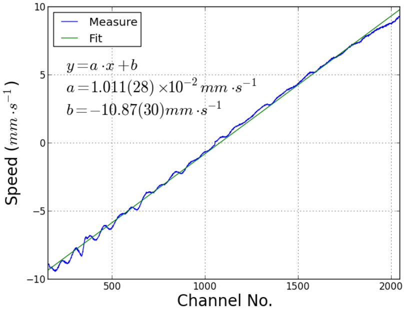
Measure
Fit
$y = a \cdot x + b$
$a = 1.011(28) \times 10^{-2}\, mm \cdot s^{-1}$
$b = -10.87(30) mm \cdot s^{-1}$
Speed ($mm \cdot s^{-1}$)
Channel No.
500
1000
1500
2000
−10
−5
0
5
10

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.

- Calibrated the velocity using laser.
- Measured Mössbauer spectrum of a variety of materials.
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