# Mössbauer Spectroscopy

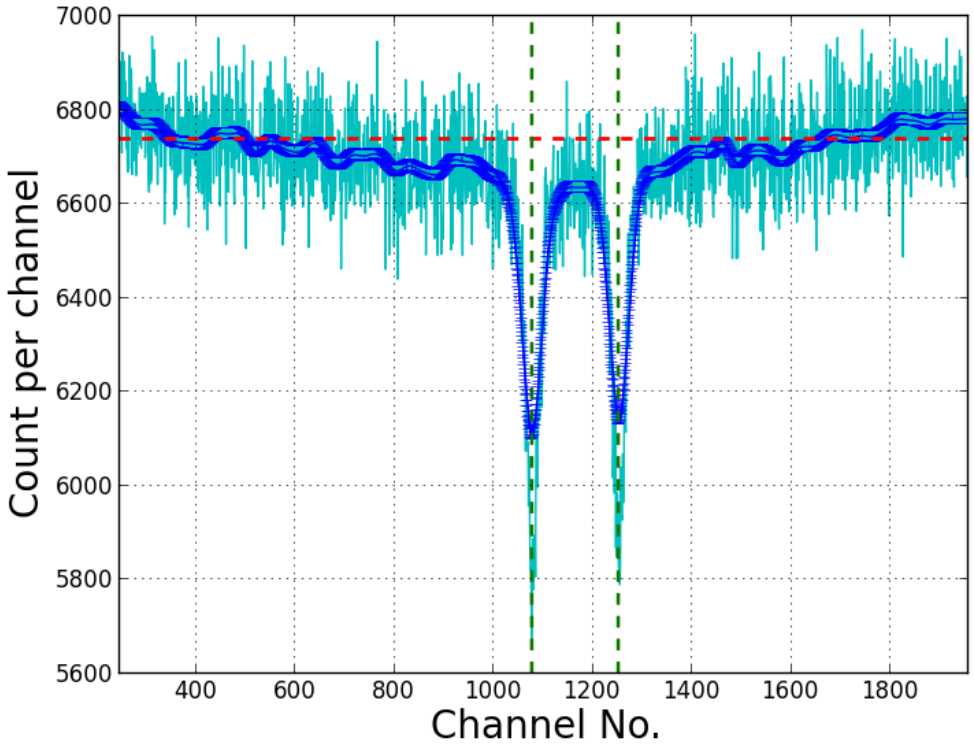
Yichao Yu

MIT

March 6, 2013

## Mössbauer effect and Mössbauer spectroscopy.

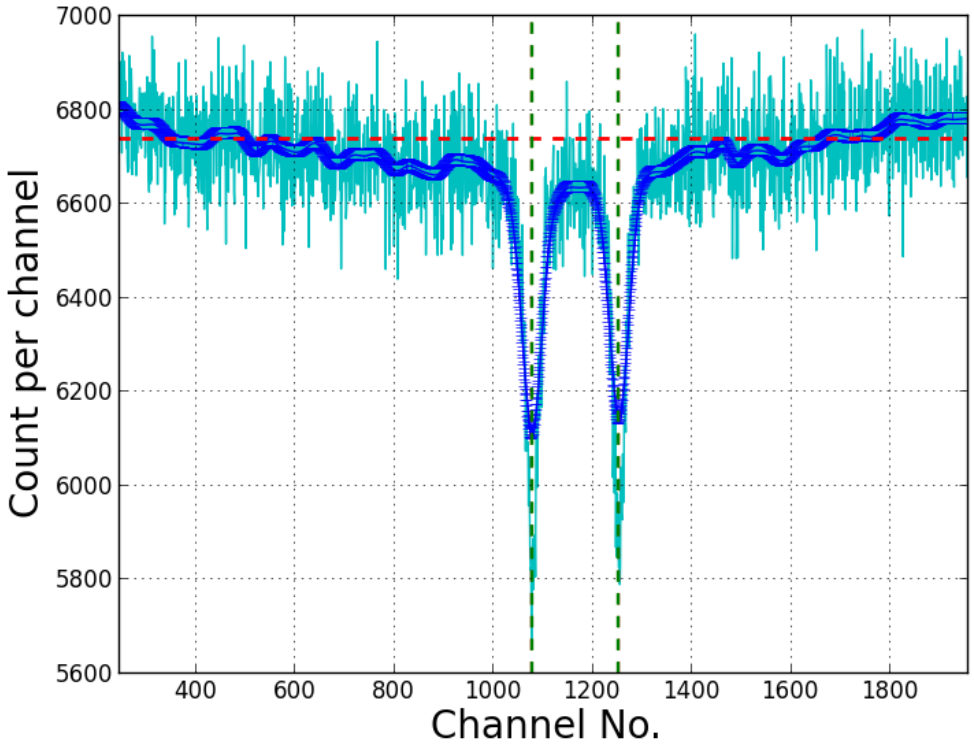
- Nuclear $\gamma$ spectrum.
- Simple setup.
- Super high resolution. $(10^{12})$




Mössbauer spectrum of $FeC_2O_4$.

## Mössbauer effect and Mössbauer spectroscopy.

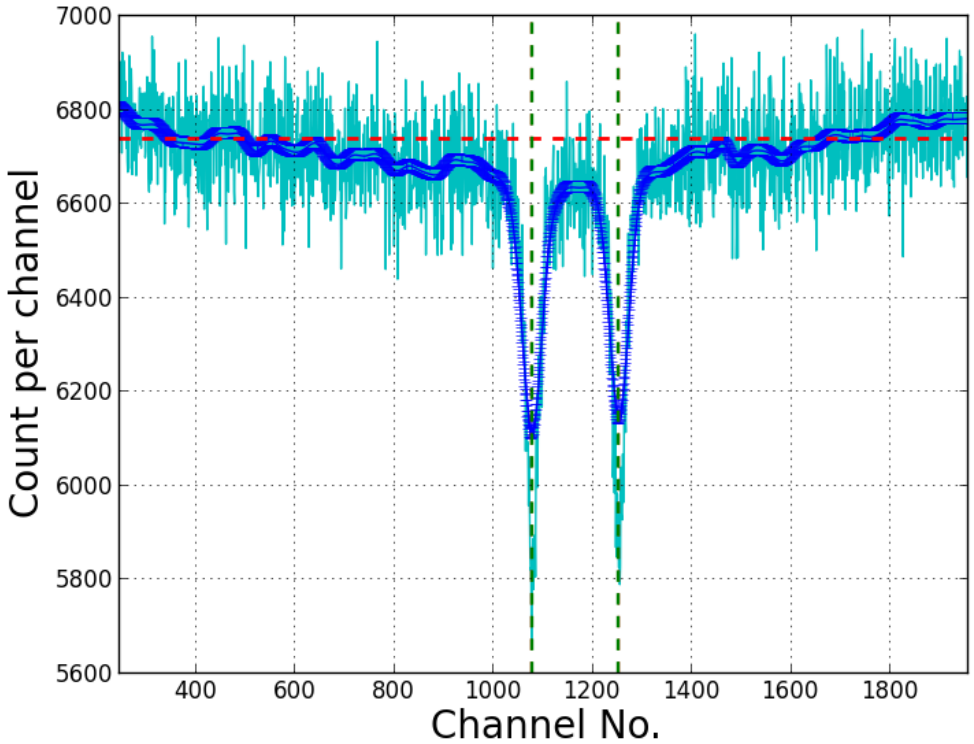
- Nuclear $\gamma$ spectrum.
- Simple setup.
- Super high resolution. $(10^{12})$




Mössbauer spectrum of $FeC_2O_4$.

## Mössbauer effect and Mössbauer spectroscopy.

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




Mössbauer spectrum of $FeC_2O_4$.

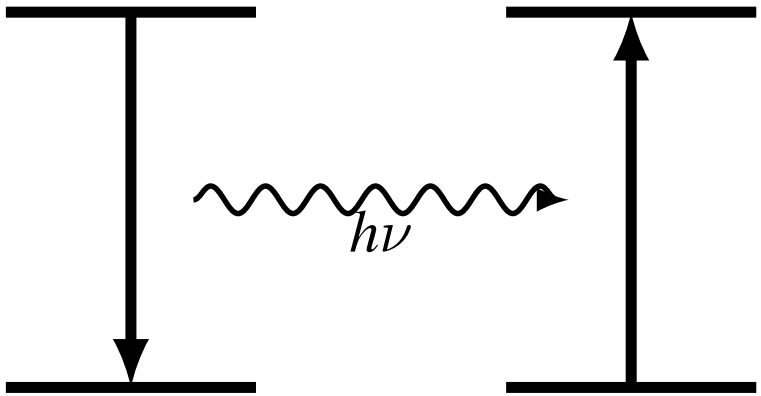
1. **Mössbauer effect.**
2. **Apparatus and samples.**
3. **Result of Rotation Curve.**
4. **Conclusion.**

# Nuclear spectrum and recoil.

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

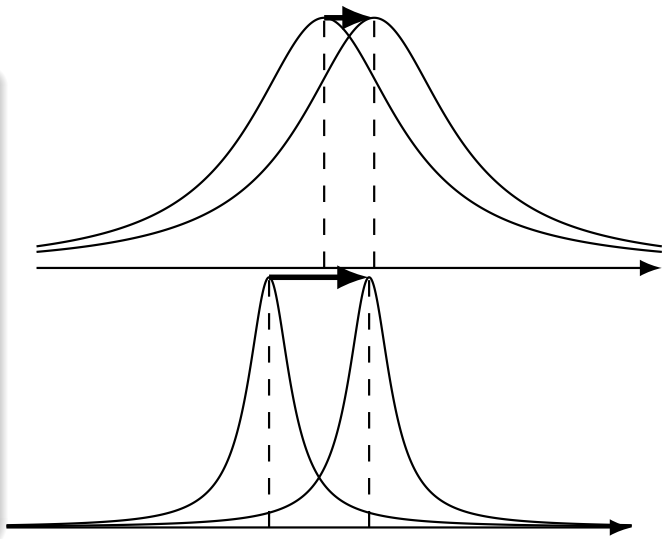
# Nuclear spectrum and recoil.

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



# Nuclear spectrum and recoil.

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



# Mössbauer effect.

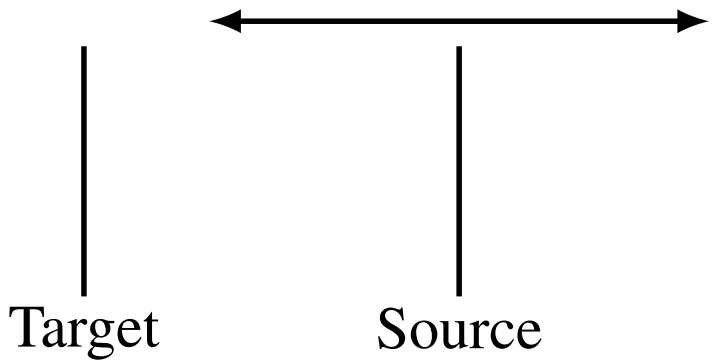
- Discoveried in 1957 by Mössbauer.
- Momentum transfer with the whole cristal. $\rightarrow$ Recoilless.
- Scanning frequency using doppler effect.

# Mössbauer effect.

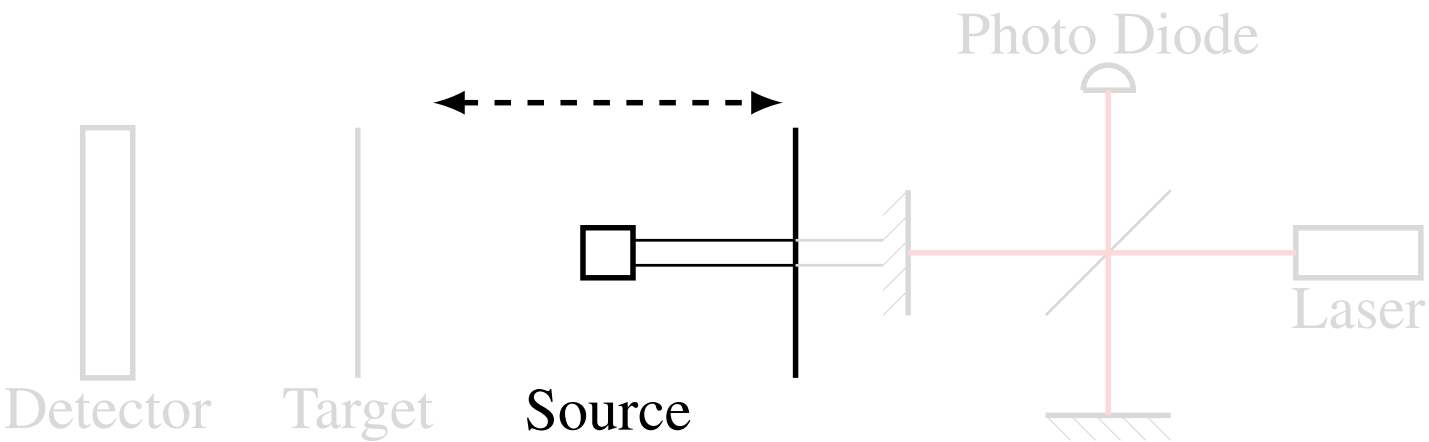
- Discoveried in 1957 by Mössbauer.
- Momentum transfer with the whole cristal. $\rightarrow$ Recoilless.
- Scanning frequency using doppler effect.

# Mössbauer effect.

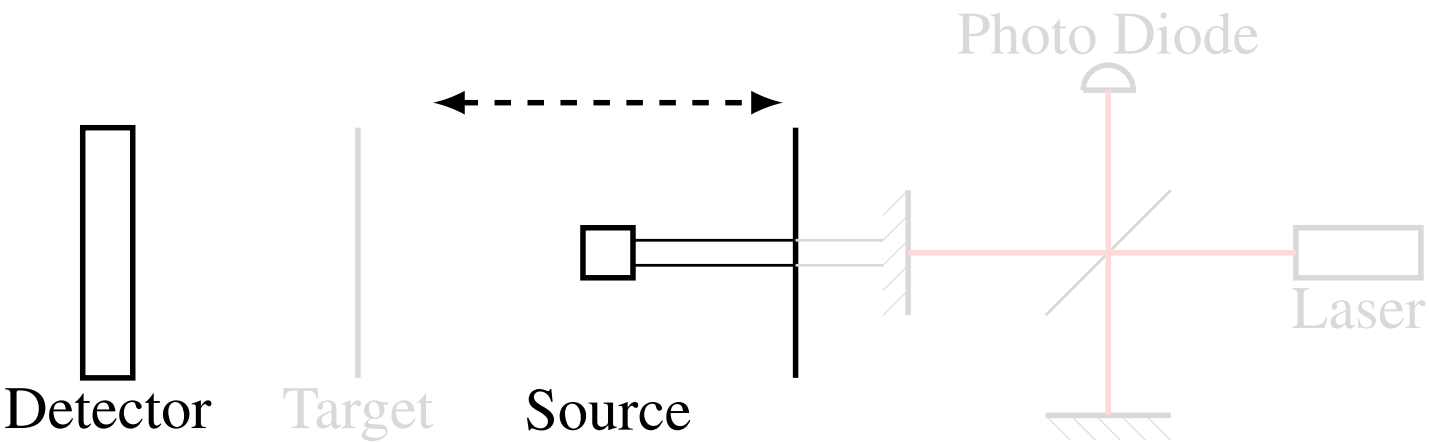
- Discoveried in 1957 by Mössbauer.
- Momentum transfer with the whole cristal. $\rightarrow$ Recoilless.
- Scanning frequency using doppler effect.



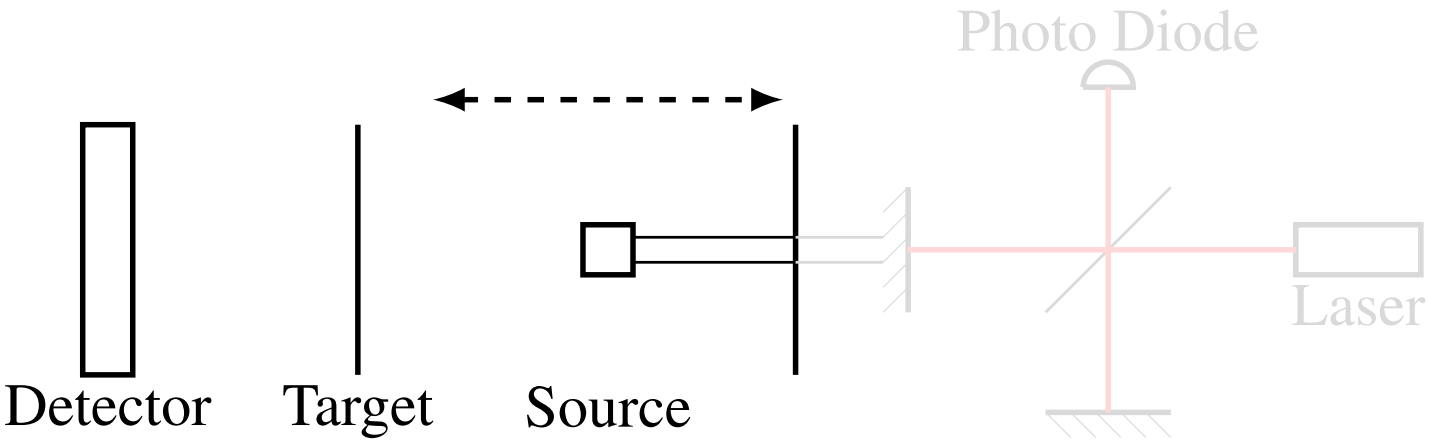
# Experiment Apparatus.



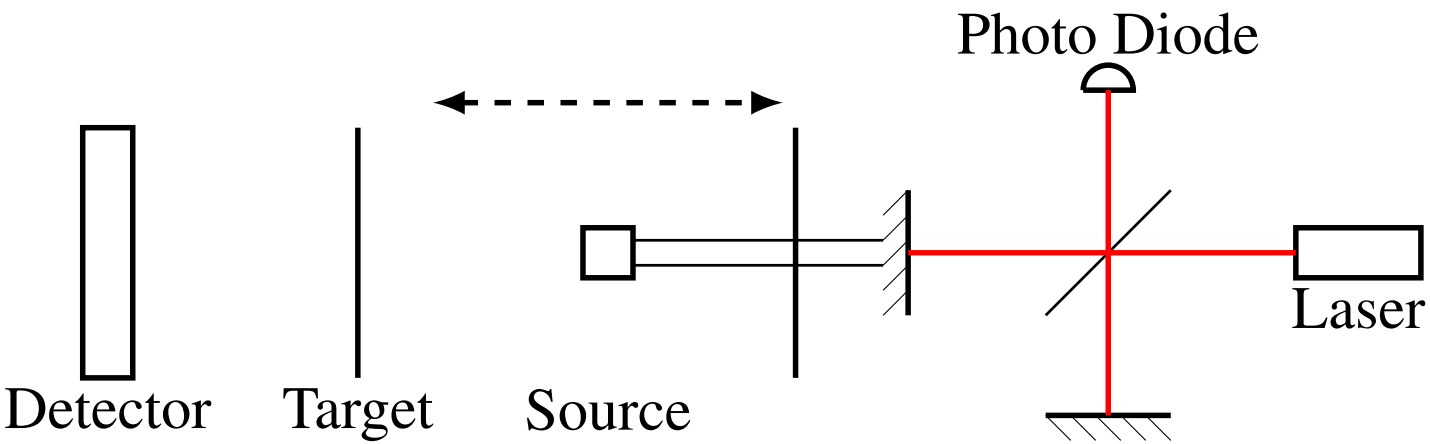
# Experiment Apparatus.



# Experiment Apparatus.



# Experiment Apparatus.



# Effects and samples.

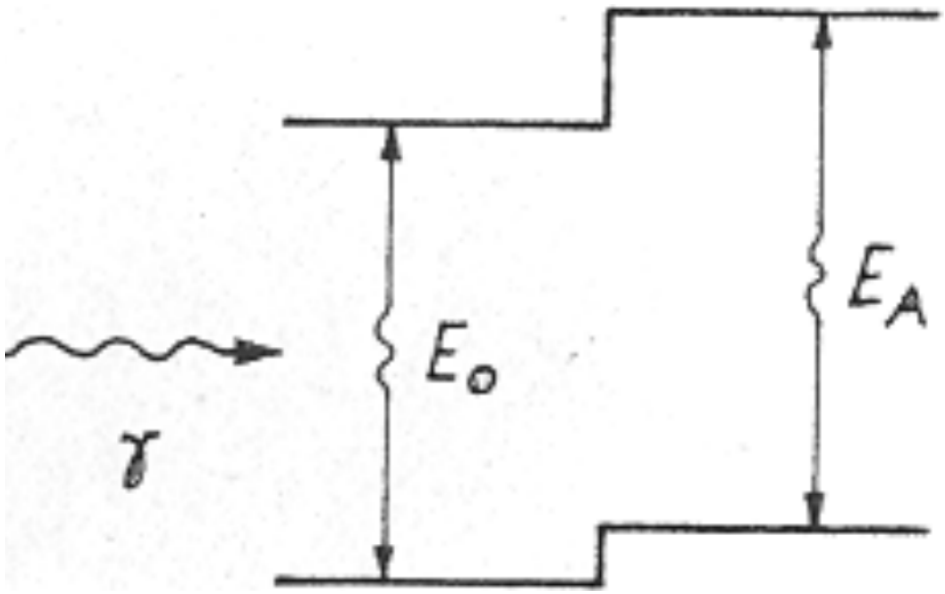
## Effects

- Isomer Shift.
- Zeeman effect.

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

- Quadrapole.
- Temperature Shift.

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



# Effects and samples.

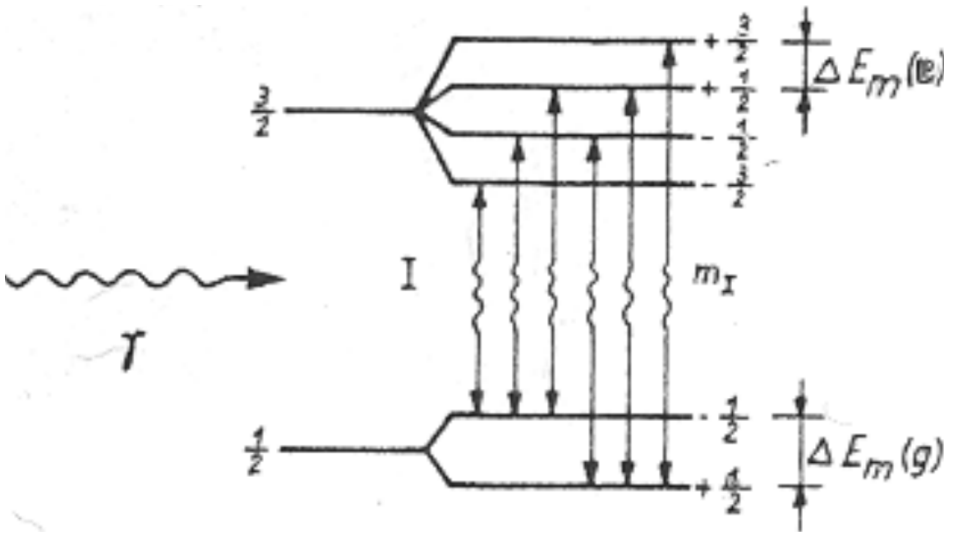
## Effects

- Isomer Shift.
- Zeeman effect.

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

- Quadrapole.
- Temperature Shift.

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



# Effects and samples.

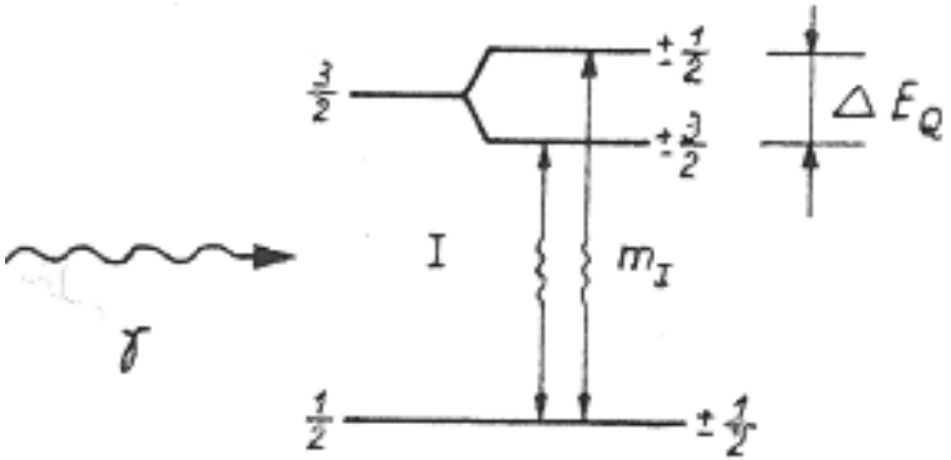
## Effects

- Isomer Shift.
- Zeeman effect.

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

- Quadrapole.
- Temperature Shift.

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



# Effects and samples.

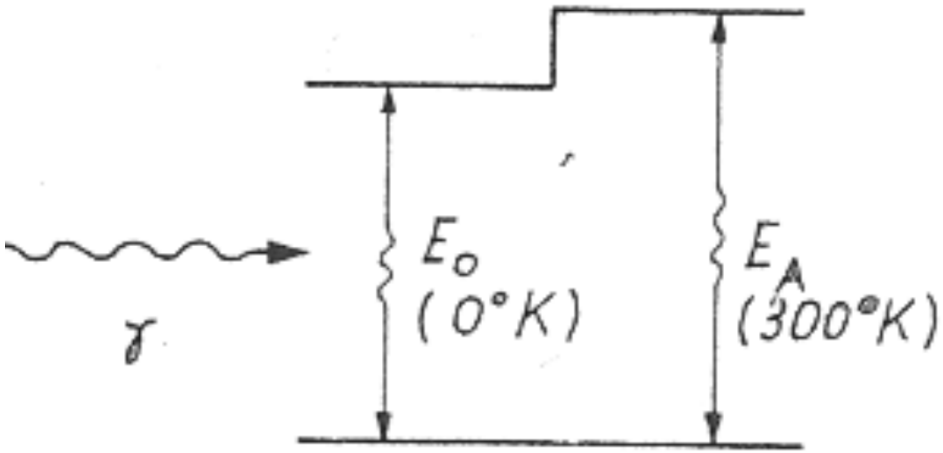
## Effects

- Isomer Shift.
- Zeeman effect.

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

- Quadrapole.
- Temperature Shift.

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



# Effects and samples.

## Effects

- Isomer Shift.
- Zeeman effect.

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

- Quadrapole.
- Temperature Shift.

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

## Samples

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

# Effects and samples.

## Effects

- Isomer Shift.
- Zeeman effect.

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

- Quadrapole.
- Temperature Shift.

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

## Samples

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

# Effects and samples.

## Effects

- Isomer Shift.
- Zeeman effect.

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

- Quadrapole.
- Temperature Shift.

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

## Samples

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

# Effects and samples.

## Effects

- Isomer Shift.
- Zeeman effect.

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

- Quadrapole.
- Temperature Shift.

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

## Samples

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

# Effects and samples.

## Effects

- Isomer Shift.
- Zeeman effect.

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

- Quadrapole.
- Temperature Shift.

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

## Samples

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

# Effects and samples.

## Effects

- Isomer Shift.
- Zeeman effect.

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

- Quadrapole.
- Temperature Shift.

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

## Samples

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

# Finding out the Maximum Doppler Shift.

Velocity distribution
at Galactic Longitude $\gamma = 50°$

vt-find.png

# Finding out the Maximum Doppler Shift.

(Maximum relative velocities)
Contour plot of velocity distribution

# Finding out the Maximum Doppler Shift.

| (Maximum relative velocities)<br>Contour plot of velocity distribution | (Transform into Absolute velocity)<br>Rotation curve of the Milky Way |
| --- | --- |
| ../milkyway/data/gal_1_contour.png | ../milkyway/data/gal_1_rot- |

# Conclusion.

- Measured the 21cm spectrum for different longitude in the galactic plane.
- Calculated the rotation curve of the Galaxy from 21cm spectrum.
- Saw the signature of dark matter.

# Conclusion.

- Measured the 21cm spectrum for different longitude in the galactic plane.
- Calculated the rotation curve of the Galaxy from 21cm spectrum.
- Saw the signature of dark matter.

# Conclusion.

- Measured the 21cm spectrum for different longitude in the galactic plane.
- Calculated the rotation curve of the Galaxy from 21cm spectrum.
- Saw the signature of dark matter.