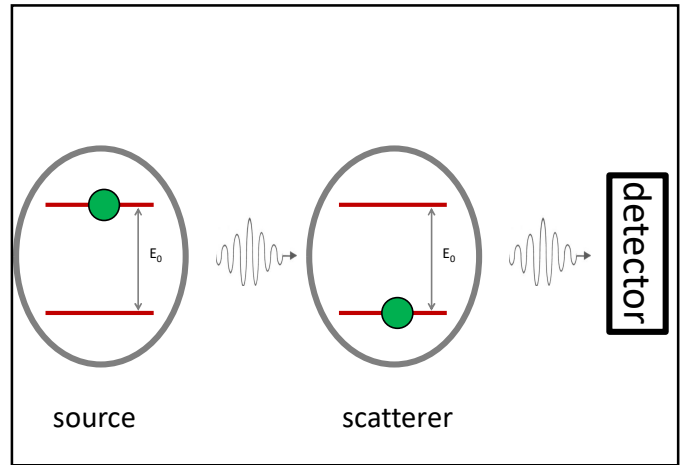
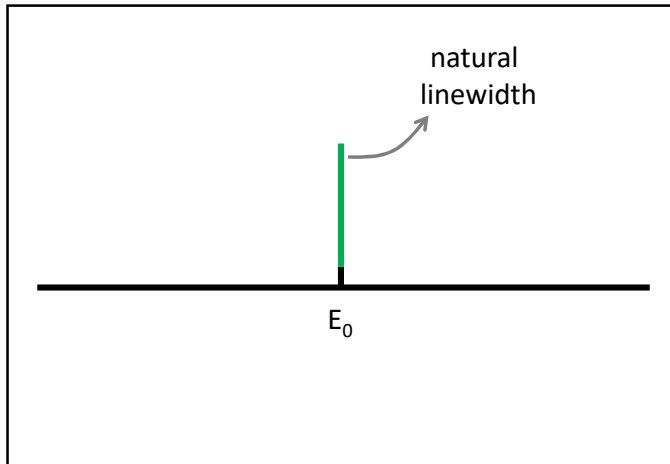


realizing nuclear
resonant scattering
a.k.a. the Mössbauer effect
www.hyperfinecourse.org

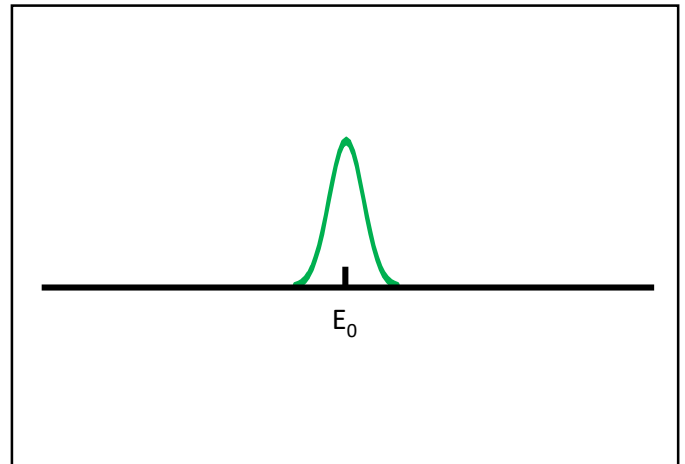
1



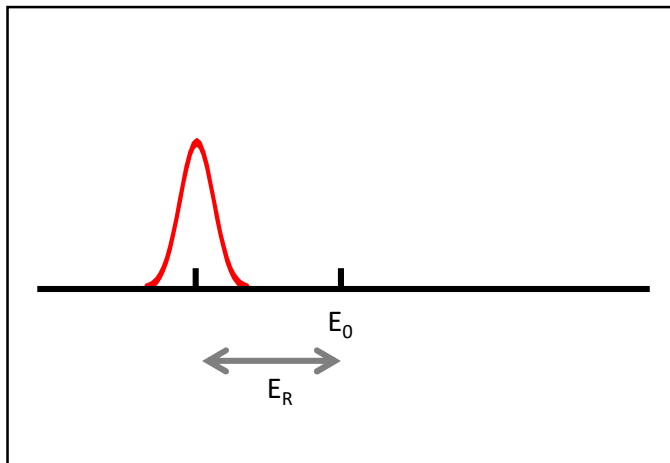
2



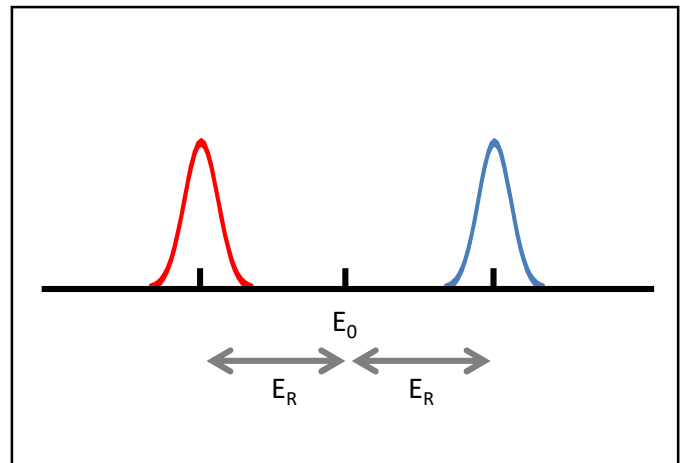
3



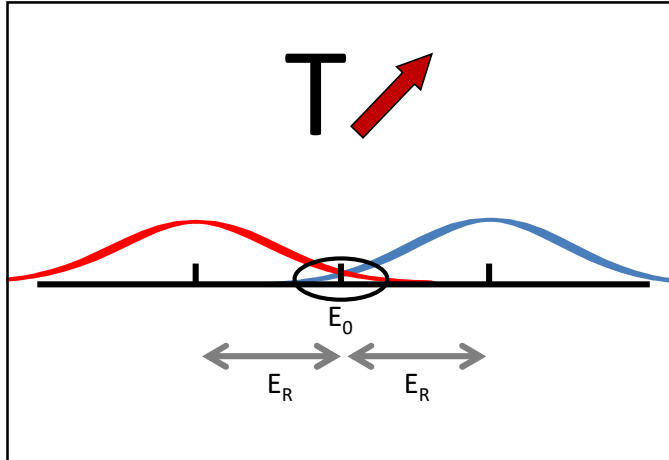
4



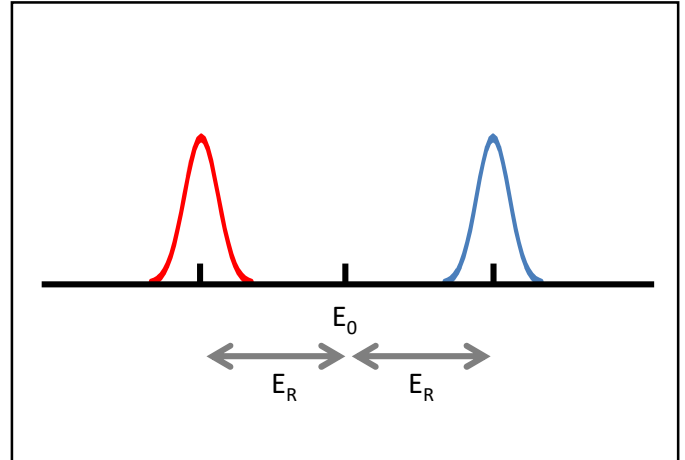
5



6



7



8

$$\nu_{obs} = \nu_{rest} \left(1 + \frac{v}{c} \right)$$

$$\Delta\nu = \nu_{rest} \frac{v}{c}$$

$$\frac{\Delta E}{2E_R} = E_0 \frac{v}{c}$$

$$\frac{E_0^2}{Mc^2} = E_0 \frac{v}{c} \quad M = 100 \text{ amu}$$

$$v = \frac{E_0}{Mc} \quad E_0 = 100 \text{ keV}$$

$$v = 319 \text{ m/s}$$

9

increased resonant scattering ??

10

Zeitschrift für Physik, Bd. 151, S. 124–143 (1958)

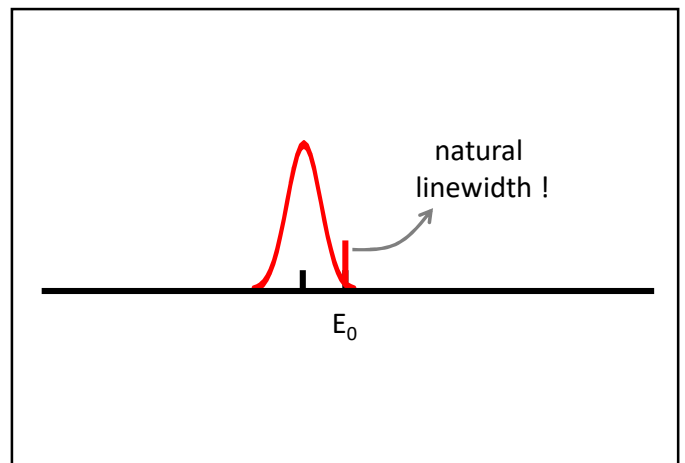
Aus dem Institut für Physik im Max-Planck-Institut für medizinische Forschung,
Heidelberg

Kernresonanzfluoreszenz von Gammastrahlung in Ir¹⁹¹

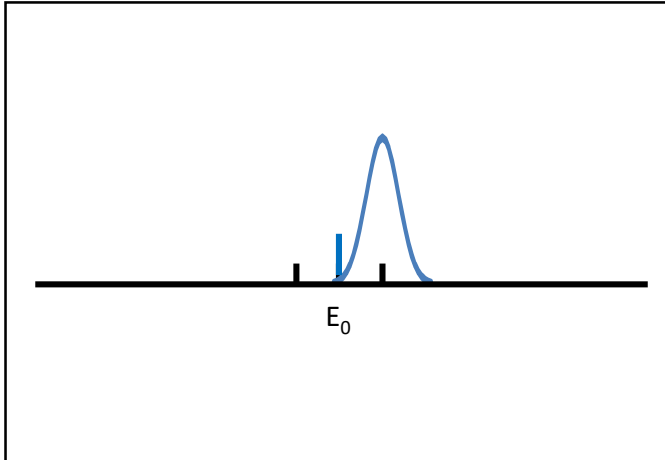
Von
RUDOLF L. MÖSSBAUER*
 Mit 8 Figuren im Text
 (Eingegangen am 9. Januar 1958)

Die Kernresonanzabsorption der dem Zerfall von Os¹⁹¹ folgenden 129 keV-Gammastrahlung in Ir¹⁹¹ wird untersucht. Der Wirkungsquerschnitt für die Resonanzabsorption wird als Funktion der Temperaturen von Quelle und Absorber im Temperaturbereich 90° K < T < 370° K gemessen. Die Lebenszeit τ_γ des 129 keV-Niveaus in Ir¹⁹¹ ergibt sich zu $(3,6^{+1,3}_{-1,2}) \cdot 10^{-10}$ sec. Der Absorptionsquerschnitt zeigt bei tiefen Temperaturen einen starken Anstieg als Folge der Kristallbindung der Absorber- und Präparatsubstanzen. Die Theorie von LAMB über die Resonanzabsorption langsamer Neutronen in Kristallen wird auf die Kernresonanzabsorption von Gammastrahlung übertragen. Bei tiefen Temperaturen ergibt sich eine starke Abhängigkeit des Wirkungsquerschnittes für die Kernabsorption von der Frequenzverteilung im Schwingungsspektrum des Festkörpers.

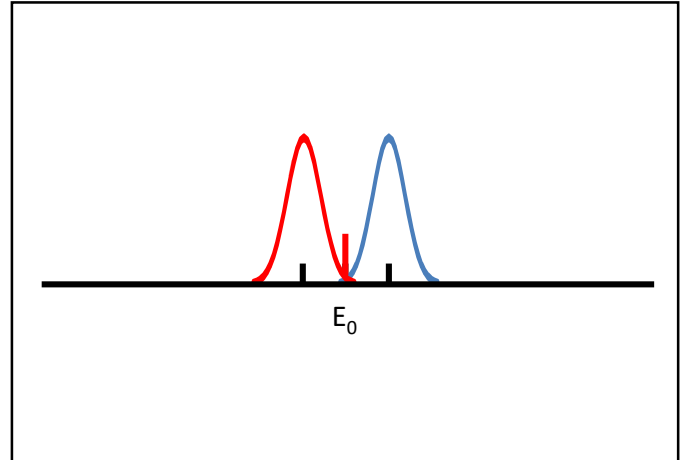
11



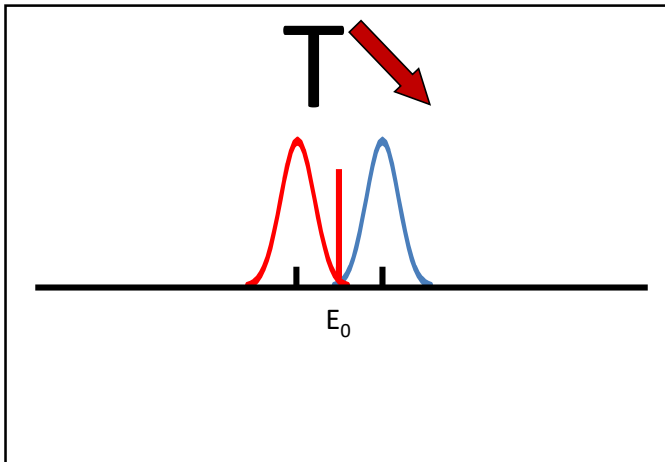
12



13



14



15

why ?

traditional explanation :

“the (massive) crystal absorbs the recoil”

16

rare example of a better explanation :

PHYSICA B

Physica B 293 (2000) 155–163

Physical discussion of the Mössbauer effect

R. Giovanelli^a, A. Orefice^{b,*}

^aUniversità di Parma, Via Volturno, 39, 43100 Parma, Italy

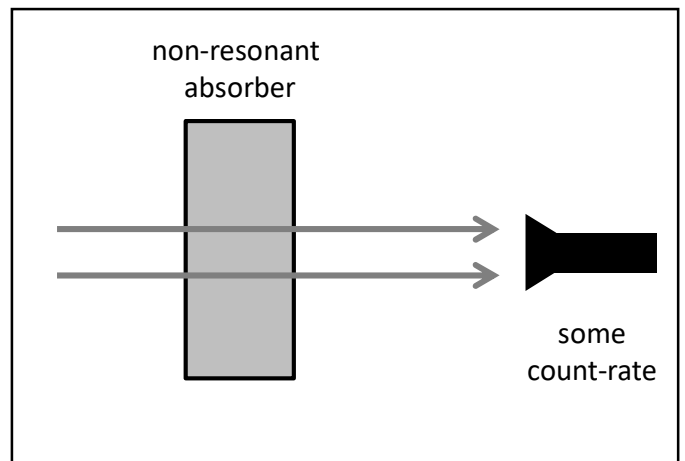
^bUniversità di Milano, Via Celoria, 2, 20133 Milano, Italy

Received 20 September 1999

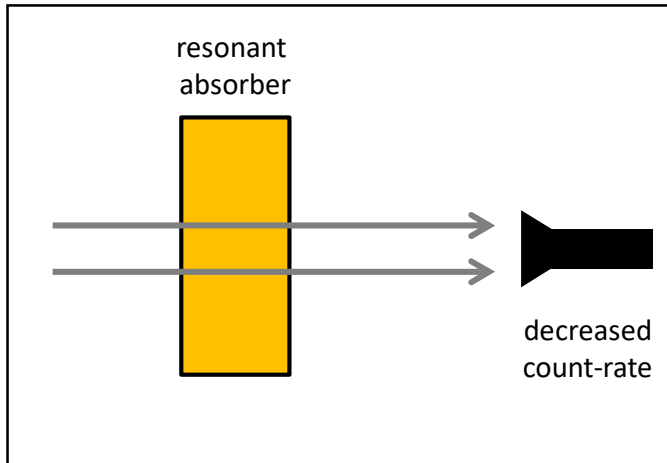
Abstract

In order to interpret the peculiarities of the Mössbauer effect, both an approach based on the wave nature of the emitted (or absorbed) γ radiation and an approach based on its corpuscular nature are currently employed in the specialized literature. However, while the former appears to be contradicted by the experimental evidence and by the uncertainty principle, the latter appears to hit the target, provided one takes into account the zero-point momentum reservoir of the mechanical oscillators forming the crystal lattice. Such a reservoir, indeed, appears to lend itself to the interpretation of all kinds of microscopic elastic phenomena in solids. © 2000 Elsevier Science B.V. All rights reserved.

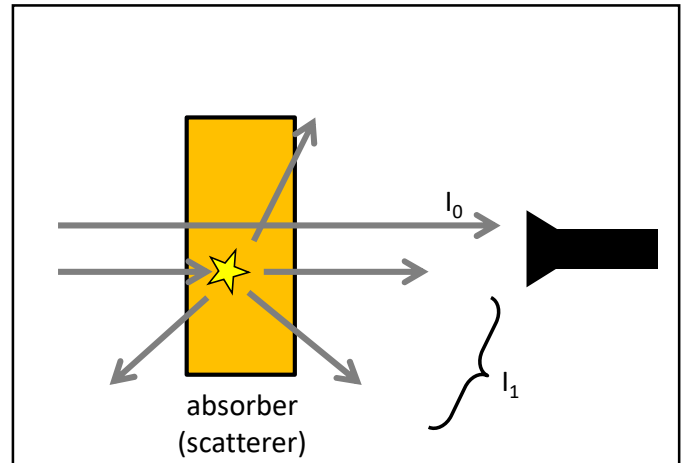
17



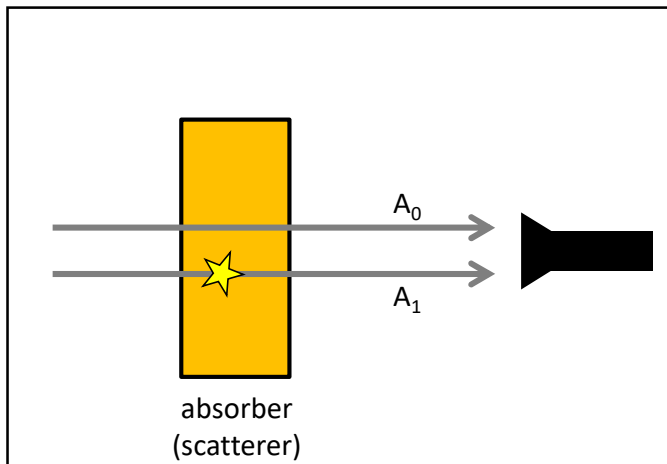
18



19



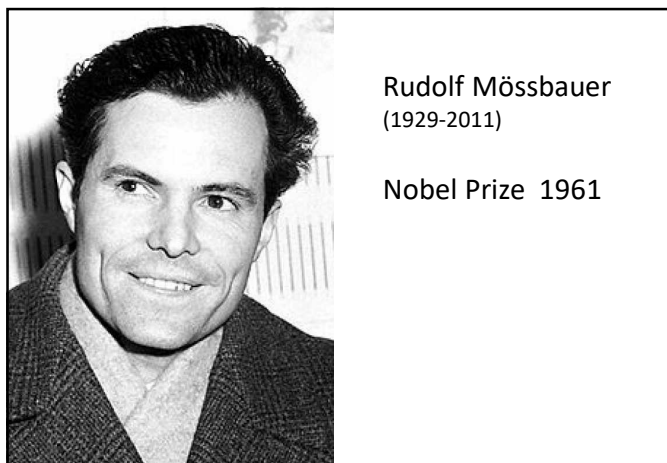
20



21

$$\begin{aligned}
 I &= |A_0 + A_1|^2 \\
 &= |A_0|^2 + |A_1|^2 + A_0^* A_1 + A_0 A_1^* \\
 &= I_0 + I_1 + 2 |A_0| |A_1| \underbrace{\cos(\theta_0 - \theta_1)}_{\pi} \\
 &= I_0 + I_1 - 2 |A_0| |A_1| \\
 &\approx I_0 - 2 |A_0| |A_1|
 \end{aligned}$$

22



Rudolf Mössbauer
(1929-2011)

Nobel Prize 1961

23