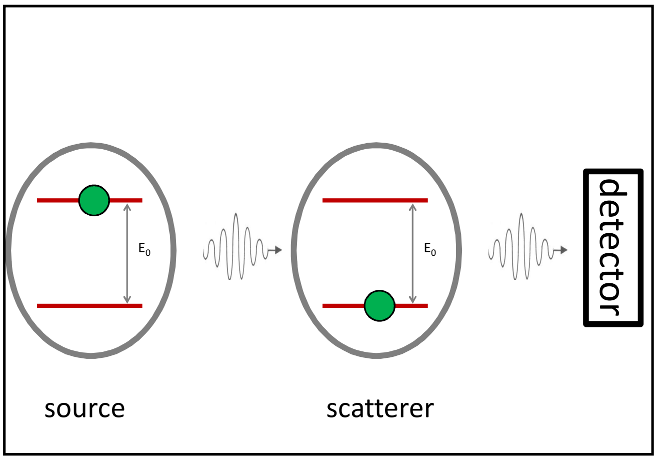
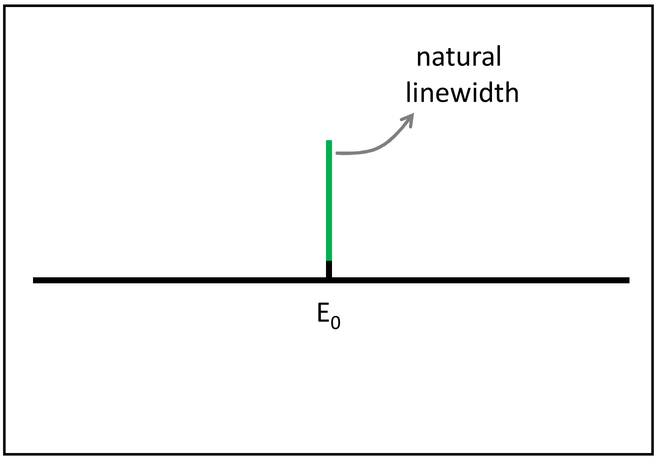
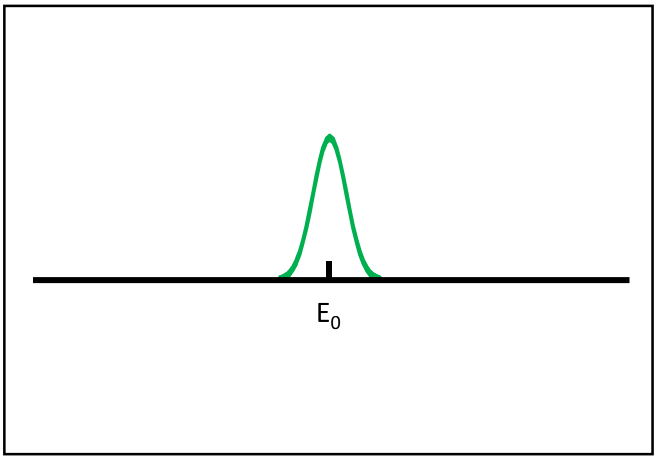
realizing nuclear resonant scattering

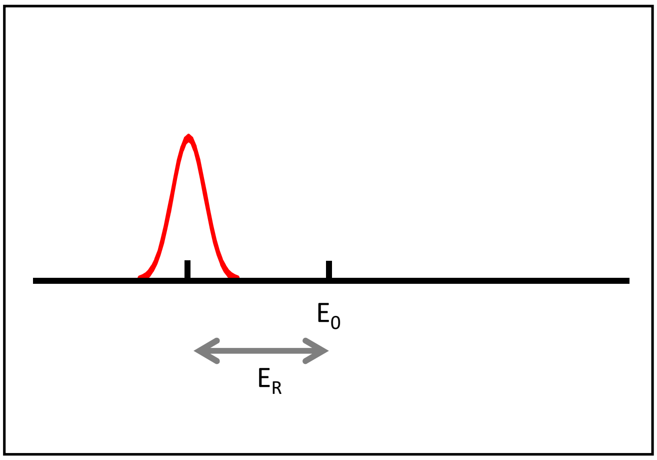
a.k.a. the Mössbauer effect

www. hyperfinecourse .org






E0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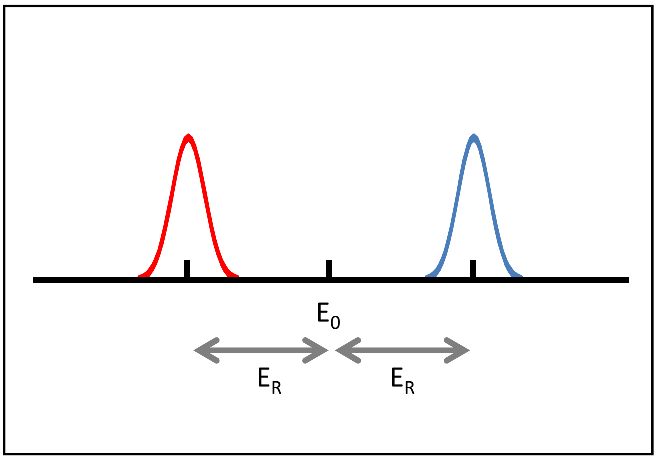
ER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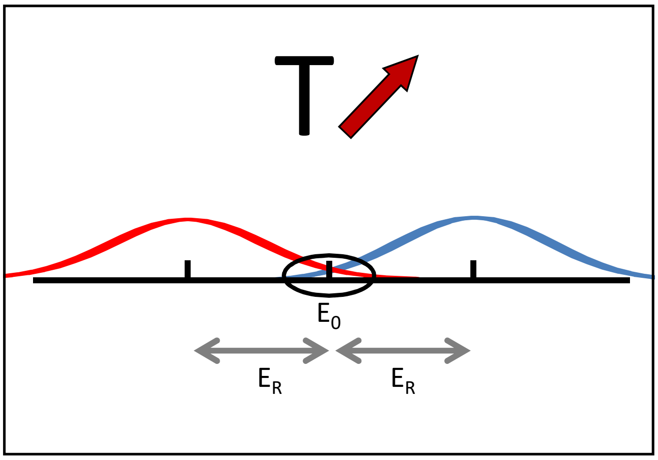
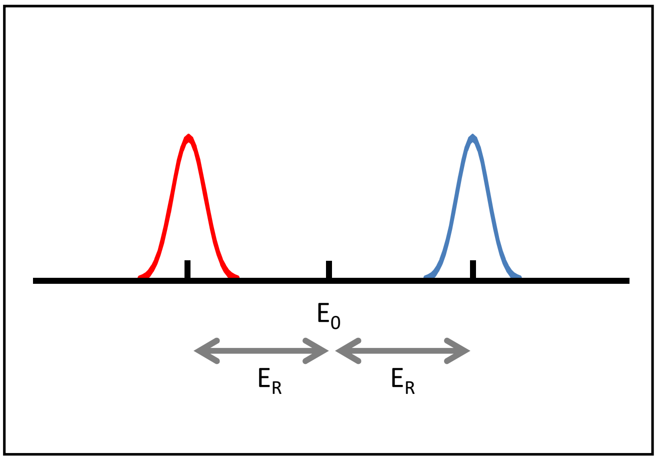
ER
ER





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

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

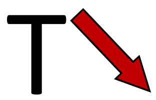
$$\underbrace{\Delta E}_{2E_R} = E_0\frac{v}{c}$$

$$\frac{E_0^2}{Mc^2} = E_0\frac{v}{c}$$

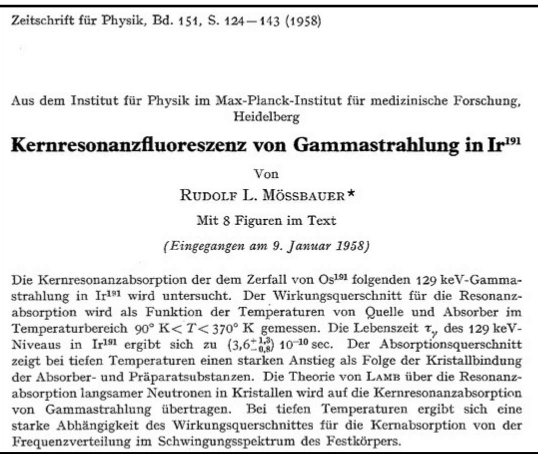
$$v = \frac{E_0}{Mc}$$

M = 100 amu
E_0 = 100 keV

v = 319 m/s



increased resonant scattering ??



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 Ir^{191}

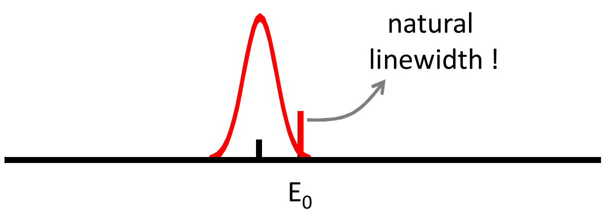
Von

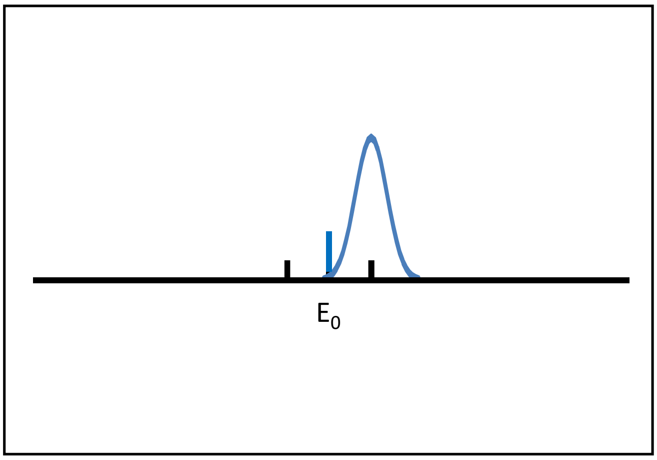
RUDOLF L. MÖSSBAUER *

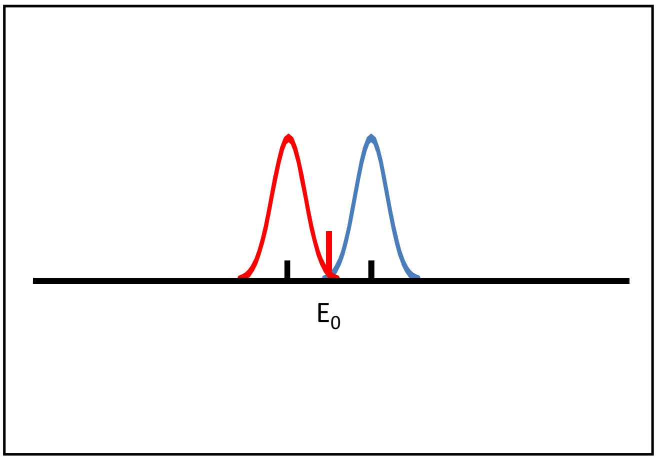
Mit 8 Figuren im Text

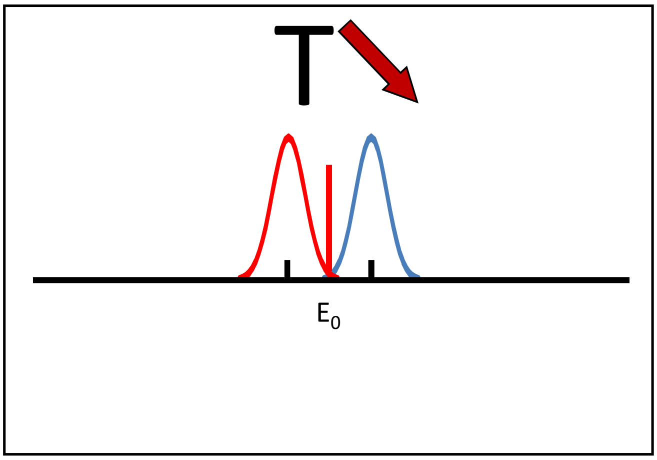
(Eingegangen am 9. Januar 1958)

Die Kernresonanzabsorption der dem Zerfall von Os^{191} folgenden 129 keV-Gammastrahlung in Ir^{191} 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 Ir^{191} ergibt sich zu $(3{,}6^{+1,3}_{-0,8})\,10^{-10}$ 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.




E_0


E_0


T
E_0

why ?

traditional explanation :

"the (massive) crystal aborbs the recoil"

rare example of a better explanation :

Physica B 293 (2000) 155–163

PHYSICA B

www.elsevier.com/locate/physb

Physical discussion of the Mössbauer effect

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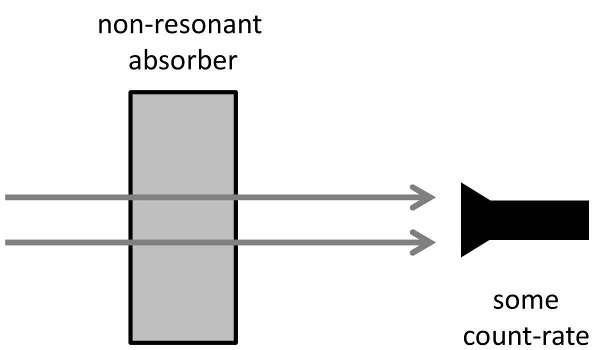
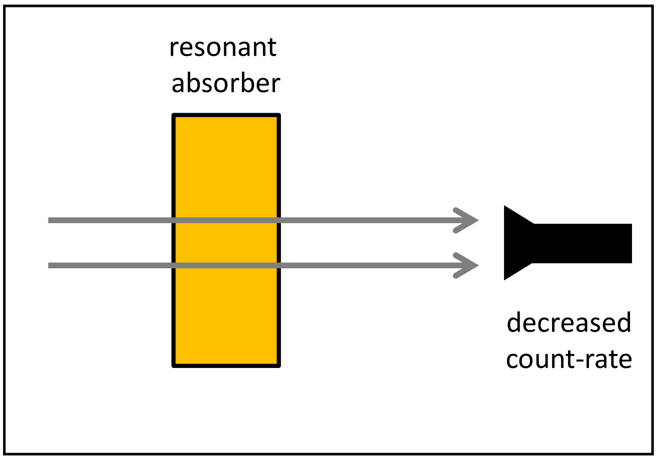
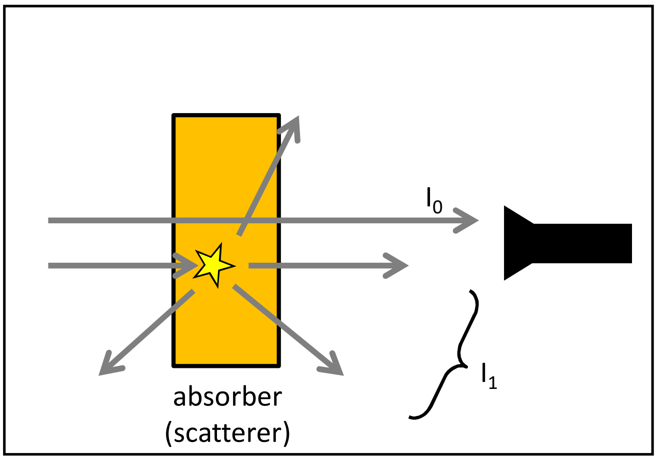
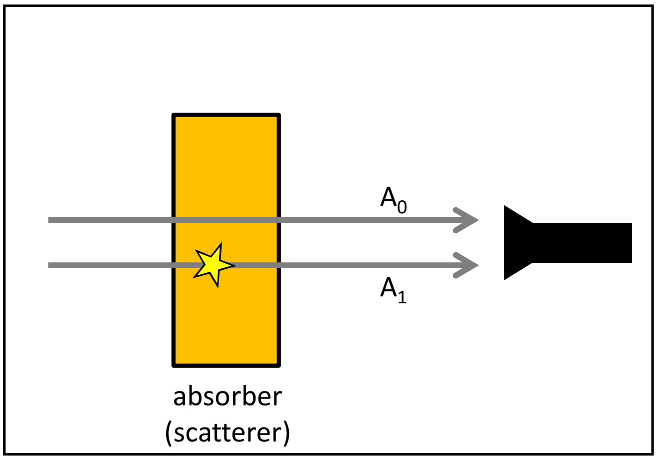
Abstract

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.

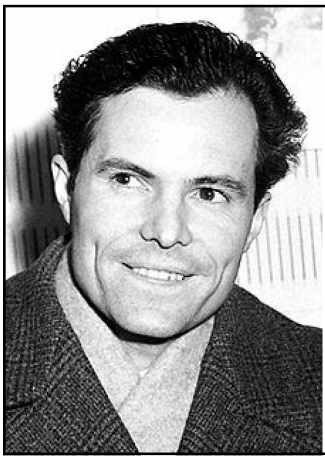



resonant
absorber
decreased
count-rate


I_0
I_1
absorber
(scatterer)


A_0
A_1
absorber
(scatterer)

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



Rudolf Mössbauer
(1929-2011)

Nobel Prize 1961