MEASUREMENT OF THE MOSSBAUER EFFECT IN Fe^{57} *WITH A SCATTERING GEOMETRY BY RECORDING* 14.4-keV *RADIATION*

A. N. ARTEM'EV, V. V. SKLYAREVSKIĬ, G. V. SMIRNOV and E. P. STEPANOV

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Various methods are compared of measuring the Mossbauer effect in Fe^{57} with a scattering geometry. It is shown that a sufficiently large effect can be obtained with thick unenriched samples.

In some work with application of the Mossbauer effect the magnitude of the observed effect is very important. This magnitude is determined to a considerable extent by the choice of the method of recording.

Frauenfelder was the first to measure the Mossbauer effect in Fe^{57} with a scattering geometry at an angle of 90° by recording the 6.3-keV characteristic radiation of Fe^{57}.[1] He indicated in his work that this method of recording is preferable on account of the large conversion coefficient of the transition under consideration ($\alpha = 9$).[2]

We were confronted with the problem of obtaining a maximum effect in iron, in unenriched and preferably thick samples. Under these conditions the recording of the characteristic radiation in the scattering geometry offered no advantage over the usual transmission method. The magnitude of the effect did not exceed 2.5 per cent.

Recording of the scattered 14.4-keV radiation made it possible to increase the effect by a factor of almost ten. The central portion of the Mossbauer spectrum of transformer iron (0.1 mm thick) in Fig. 1 can serve as an illustration of this.

This large increase of the effect can be explained by the following circumstances. The measured effect is

$$\varepsilon = (N_v - N_\infty)/N_\infty,$$

where N_v is the count at the velocity corresponding to the investigated point of the spectrum, and N_∞ is the count at a velocity at which there is no resonance absorption. In measurements with the scattering geometry N_∞ consists of three components:
1) the external (including the natural) background;
2) the background from the source due to the direct passage of gamma rays from the source to the detector, as well as due to the scattering of gamma rays by the components of the setup (the collimator, the substrate and holder of the scatterer, etc.);
3) the background due to nonresonant scattering of gamma rays from the source by the investigated sample.

It is obvious that while the first two components can be minimized by sensible construction of the setup, the third component is inherently connected with the investigated sample and cannot be changed. In measurements on thick samples of natural iron (containing 2.17 per cent Fe^{57}) the background due to nonresonant processes in the scatterer can be very large and consists almost entirely of the characteristic radiation of iron. As a result, in measurements in which x-ray radiation is recorded, N_∞ is large and the effect is small. If, on the other hand, one records scattered 14.4-keV radiation, then the background in this case is due only to Rayleigh scattering (as well as to Compton scattering of harder gamma rays) and its intensity is small.

On the other hand, the intensity of the K radiation of iron which follows resonance absorption is determined not only by the conversion coefficient but also by the value of the fluorescence yield for which for iron is ~0.4.[3] Thus in resonance scattering the ratio of the number of quanta of the

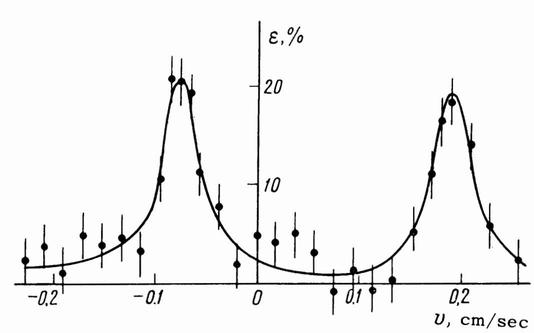

FIG. 1. The central portion of the Mossbauer spectrum of natural iron oxide (of 100 mg/cm² thickness) measured in the scattering geometry at an angle of 90°, recording 14.4.-keV gamma rays.

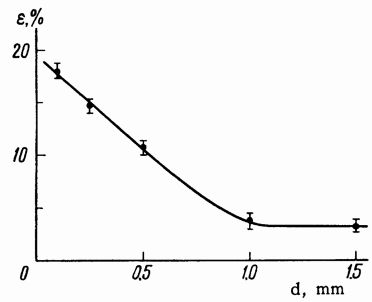

FIG. 2. Dependence of the magnitude of the effect in natural iron on the thickness of the scatterer.

characteristic radiation to the number of scattered 14.4-keV quanta is ~3.6, and the decrease in the useful count on going over from recording x rays to recording 14.4-keV gamma rays is not so appreciable.

Control measurements with enriched samples showed that recording of the characteristic radiation is only convenient for large enrichment percentages. Even for samples with 20 per cent Fe^{57} both methods of measurement yield close values of the effect (120 per cent when recording the characteristic radiation and 150 per cent when recording at 14.4 keV).

Measurements of the dependence of the magnitude of the effect on the thickness of the scatterer, the results of which are shown on Fig. 2, show that the method which we applied is suitable for investigating the Mossbauer effect on samples of arbitrary thickness. The decrease in the effect observed on the graph in the 0—1 mm range of thicknesses is due to an increase in the background due to the scattering of 122-keV gamma radiation.

In conclusion, it should be noted that the magnitude of the observed effect is very closely connected with the quality of the gamma-ray detector. We used a scintillation gamma counter with a 0.3-mm NaI crystal which had a resolution of about 60 per cent for the 14.4-keV peak. Improvement of the resolution of the detector leads to a decrease in the background count and to an increase of the effect. Resonance counters and semiconductor detectors are in this connection of undoubted interest for similar measurements, particularly in the light of possible technical applications of the Mossbauer effect.

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[1] H. Frauenfelder, D. R. F. Cochran, D. E. Nagle, and R. D. Taylor, Nuovo Cimento 19, 183 (1961).

[2] A. H. Muir, K. J. Ando, and H. M. Coogan, Mossbauer Effect Data Index, North American Aviation Science Center, 1965.

[3] Beta and Gamma Spectroscopy, K. Siegbahn, ed., North Holland, 1956.

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