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Two-Dimensional Mössbauer Spectra

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Abstract. To decrease the spectra measurement time in Mössbauer spectroscopy a new data acquisition system was proposed, which allows to collect data as a two-dimensional distribution.

Key words: data acquisition, signal processor, two-dimensional Mössbauer spectrum.

1. Introduction

In spite of all advances in electronics, the design of Mössbauer spectrometers has not advanced principally. The usual arrangement [1] for collecting a Mössbauer spectrum is shown in Figure 1(a). The main disadvantage of this arrangement is the occurrence of pulse overlapping at high count rates, it is when the next pulse "sits on the tail" of a previous one. In this case a single channel analyzer (SCA) registers the noise pulses and misses the pulses from needed quanta, which will shift out of the working window. Pulse overlapping disturbs the amplitude spectrum, reduces the signal/noise ratio in the Mössbauer spectrum, limits the maximal count rate of the data acquisition system, and, finally, increases the duration of experiment. Another disadvantage of the conventional arrangement is the difficulty in setting the SCA window if the amplitude spectrum has the well-known "exponential decay" shape using CEMS or resonance detectors.

Therefore, a data acquisition system, which is free of these disadvantages, was created.

2. Proposed data acquisition system

The scheme of the proposed data acquisition system is shown in Figure 1(b). It consists of a fast analog-to-digital converter (ADC) AD9224 chip, signal processor (SP) ADSP-21061 chip, and random access memory (RAM).

The ADC digitizes the signals from the detector with a sampling rate of up to 40 million times per second. The signal processor determines the local maximum

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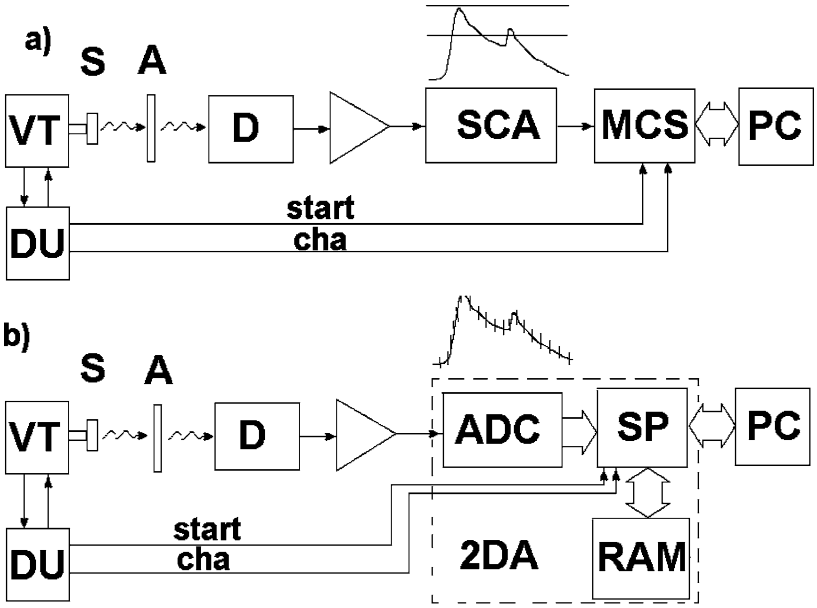

Figure 1. (a) Conventional scheme, where: S – source; A – absorber; VT – velocity transducer; DU – driving unit; D – detector; SCA – single channel analyzer; MCS – multichannel scaler; PC – personal computer. (b) Proposed scheme, where: ADC – fast analog-to-digital converter; SP – signal processor; RAM – random access memory; 2DA – "Two-dimensional analyzer".

and local minimum values, and calculates the correct amplitude for each pulse. Thus, pulse overlapping is eliminated. The operation of the SP is synchronized with the driving system by the signals START and "channel advance" CHA. Using the pulse amplitude in a digital form and the current velocity channel number SP forms a two-dimensional (2D) distribution of pulses in the RAM, where the Y-axis corresponds to the velocity scale, and the X-axis corresponds to the amplitude of pulses from the detector.

3. Experimental results

Examples of two-dimensional Mössbauer spectra are shown in Figures 2 and 3.

Cross-sections parallel to the velocity–counts-plane give Mössbauer spectra, which correspond to different amplitudes of input pulses. Cross-sections parallel to the energy–counts-plane give amplitude spectra, which correspond to different values of the Doppler velocity.

Figure 2 presents a two-dimensional Mössbauer spectrum of an iron foil measured with a proportional counter. There are 6 dips on the 14.4 keV billow and there are 6 small peaks on the 6.3 keV X-rays billow. This example illustrates, that with the new instrumentation absorption and emission spectra are acquired simultaneously.

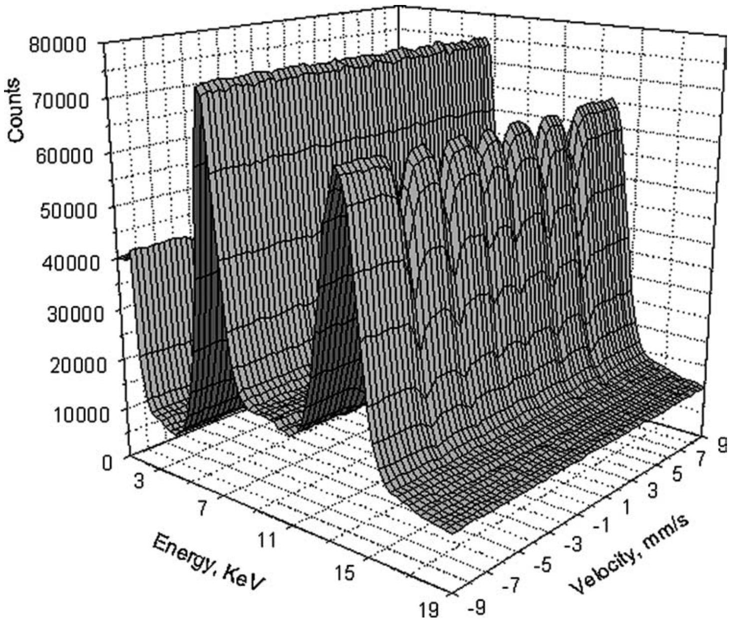

Figure 2. Two-dimensional Mössbauer spectrum of an iron foil, measured with a proportional counter.

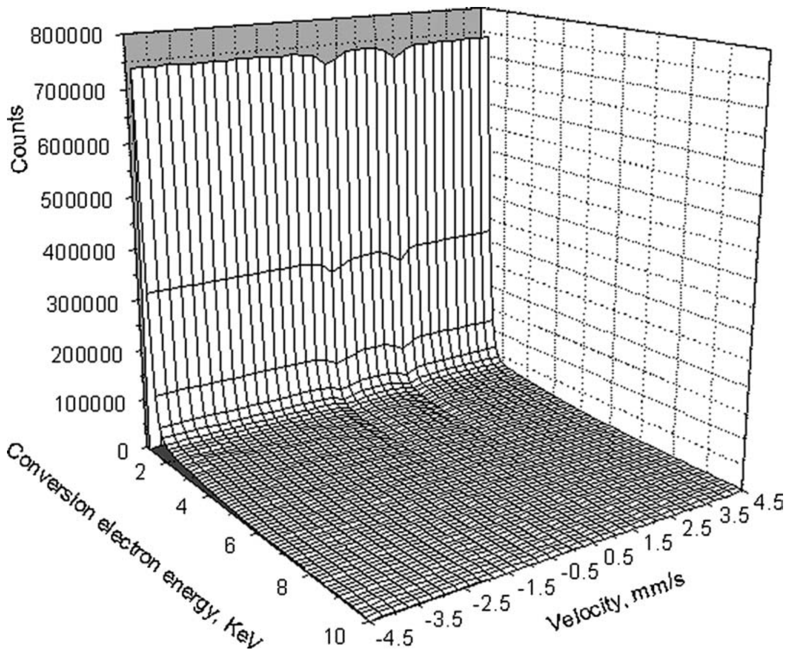

Figure 3. Two-dimensional Mössbauer spectrum of $FeC_2O_4 \cdot 2H_2O$, measured with a resonance scintillation detector.

Figure 3 presents a two-dimensional Mössbauer spectrum of a $FeC_2O_4{\cdot}2H_2O$ sample measured with a resonance scintillation detector [2]. It consists of a set of absorption Mössbauer spectra with different signal/noise ratios. The optimal energy "window" can be chosen *after* the experiment. But from the precision point of view, the best procedure would be to fit each partial Mössbauer spectrum independently, and to calculate the weighted averages of the spectral parameters. This technique reduces the estimated standard deviation by a factor of 1.4 and more, or reduces the data acquisition time by a factor of 2.0 and more.

4. Conclusions

The proposed setup allows to collect more information about the sample in one experiment, and, finally, saves data acquisition time.

The use of a fast ADC together with a modern digital signal processor significantly increases the count rate of Mössbauer spectrometer due to the elimination of pulse overlapping.

The application of a two-dimensional data acquisition system allows to chose the optimal energy "window" in the amplitude spectrum *after* the experiment, and to measure gamma-quanta absorption and X-rays emission spectra simultaneously in the same transmission experiment. In the case of low count rates the proposed scheme also saves data acquisition time, because amplitude and Mössbauer spectra are collected simultaneously.

In the case of CEMS measurements a single experiment gives a number of Mössbauer spectra, which correspond to different surface layers of the sample.

References

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