Experiment N-16
The Mössbauer Effect

The detection of the Mössbauer effect consists of the measurement of the absorption of gamma rays as a function of the relative velocity of the source and the absorber (consult references for physics details). In this case the source contains excited Fe^{57} mounted on a small piece of brass. One source is magnetic, the other non-magnetic. The source mounts in a milled slot just behind the absorber. These sources should be handled as little as possible and should always be returned to a shielded container when not in use.

The absorber is a thin disc of nonmagnetic Fe^{57} which is free to rotate about a tilted axis. This disc is driven through a belt drive by a variable speed motor. The speed can be reset quantitatively by observing the voltage across the armature leads. The component of the source-absorber velocity along the gamma trajectory is obtained from the angle of incline and the calibration of the voltmeter with respect to the timed rotation of the disc. The detector is a crystal of NaI is fitted with a photomultiplier tube to view the scintillation light. For details on the detection of photons, see references for experiment N-0. The high voltage supplied to the photomultiplier should be set between +500 and +1000 volts.

At the base of the photomultiplier housing is a transistor amplifier supplied by a -24 V, D.C. power supply. The output of the phototube goes to an oscilloscope and a pulse height analyzer. The scope should be used to check that the transistor amplifier is not saturated.

The source emits gammas of 122 KeV, 14 KeV, and 6 KeV. Only the 14 KeV gammas show appreciable resonance absorption. The pulse height analyzer should be used to identify (and count) the 14 KeV photopeak. The peak does not stand out very clearly from the background of Compton pulses coming from the 122 KeV gammas because of the broadening due to fluctuations in the rather small number of photoelectrons made at the cathode of the photomultiplier. It is possible to see it however by displaying the output of the photomultiplier amplifier on a fast oscilloscope using the internal trigger. Note that if the 14 KeV pulses are to be visible, many of the 122 KeV pulses will be saturating the amplifier. To verify that you are indeed counting 14 KeV gammas, measure the resonance absorption of photons from the nonmagnetic source by comparing the counting rate for the stationary absorber with the rate observed while the absorber is moving at some appreciable velocity. The former rate should be about 15% less than the latter.

Objects of the Experiment:

1. Measure the pulse height spectrum for either the magnetic or nonmagnetic source without the absorber. Understand and explain the features of this spectrum.

2. With the pulse height analyzer set to count on the 14 KeV peak, trace out the counting rate versus velocity curve for nonmagnetic and magnetic sources.

3. Try to get a measurement of the width of the 14 KeV excited state from the resonance line width. This is most easily done with the zero-velocity line observed with the non-magnetic source.

4. Determine the atomic magnetic field in the source material from a measurement of the line spacings observed with the magnetic source.

5. With source and absorber (Fe foil) in magnetic fields, demonstrate the polarization of the resonance radiation.

References:

1. Frauenfleder, *The Mössbauer Effect.* An elementary introduction to the subject, plus reprints of important papers.

2. Mössbauer, Annual Reviews of Nuclear Science, Vol. 12 (1962). A recent review of the field. Other references can be found in the bibliography.

3. H. Lustig, "The Mössbauer Effect", American Journal of Physics, Vol. 29, p. 1 (1961).

4. A. J. Bearden et al., American Journal of Physics, Vol. 32, p. 109 (1964).