Project No. 225

Progress Report No. 1

November 1, 1952, through December 31, 1952

In May, 1952, steps were taken to establish a Nuclear Spectroscopy Laboratory at the Georgia Tech Experiment Station. These steps resulted in the formal establishment on November 1, 1952, of Station Project No. 225 in Nuclear Spectroscopy and Instrumentation. This report covers the activities in this project from its initial stages through December 31, 1952, and also describes its future plans.

I. OBJECTIVES

The general objectives of this project are outlined in the proposal submitted on August 11, 1952, by G. P. Robinson. These objectives are as follows:

1. To study decay schemes of natural and artificially produced radioactive isotopes including half lifes, angular correlations, energy levels, etc.

2. To fit experimental results with theory and add to the literature of the field.

3. To develop new techniques of instrumentation such as the use of (1) detectors with increased sensitivity and resolution and (2) electronic equipment for faster and better analysis of nuclear radiations.

In connection with these general objectives, Dr. C. H. Braden of the Georgia Tech School of Physics has suggested a specific problem, the theoretical and experimental study of the Double Compton Scattering. Since this problem is quite new there is little competition in the field.

The problem, although it promises positive results, will involve experiments that require a very modest amount of equipment.

Since the Double Compton Scattering study fits in very nicely with the long-range program of this project, it has been decided that efforts should be concentrated here in the near future. The plan of attack is discussed in this report.

II. PROGRESS TO DATE AND FUTURE PLANS

The early efforts in this program were expended in literature surveys and cataloging, and in the design, construction, and purchase of laboratory equipment. Funds were made available for the purchase of a scalar, a pulse-height analyzer, and scintillation equipment, including photomultiplier tubes and NaI crystals. The electronics laboratory and machine shop cooperated in constructing a high-voltage power supply, a pulse generator, a triple-coincidence circuit, a dry box, and numerous small items.

1. A Germanium Alpha Particle Detector:

The literature survey showed an interesting possibility of developing an alpha particle detector using an n-p junction Germanium diode. An experimental model of the detector was constructed from a Germanium crystal (obtained from the Bell Telephone Laboratories) which initially proved to be quite satisfactory. A life test, however, showed that exposure to the moisture in the atmosphere was detrimental. Since then only one additional crystal has been obtained, and it was damaged in handling before any useful information could be gathered. Efforts have been made to obtain additional crystals to continue this study.

The n-p junction diodes used for these tests were 0.50-mm square and 1-cm long. Polonium alpha particles bombarded the crystal perpendicular to the length of the crystal and parallel to the barrier. It was found that a light shield was not necessary.

The crystal was biased approximately 1 volt negatively; the pulses were fed into an A-1 linear amplifier and then to a scalar. After the gain of the amplifier and the capacity of the n-p barrier (70-mm fd) were measured, the quantum yield of the crystal was found to be approximately one. (One quantum or 3 ev of incident energy produced one electron-hole pair in the crystal.) This can be compared with a gas ionization chamber which requires approximately ten quanta or 30 ev of incident energy to produce one ion pair.

The efficiency of the detector proved to be extremely good; however, since the capacity of the barrier was so large, the voltage of the output pulse was too small to make a practical counter. Further theoretical studies showed that the capacity of the barrier should have been approximately 3-mm fd. An additional crystal was measured and this was found to be the case; however, this crystal was damaged in handling.

2. Double Compton Scattering:

The work accomplished on the Double Compton Scattering problem has been in a literature survey and in organizing the necessary equipment for the experiment. A discussion of the experimental procedure, equipment, and pertinent results of the literature survey are given here.

In 1934 Heitler and Nordheim[1] predicted that one or more further quanta were produced in addition to the normal scattered quantum in the Compton process. P. E. Cavanaugh[2] at Harwell used Co^{60} gamma rays incident on a thin metallic foil to produce the Double Compton Scattering. Approximations were made as to the angular distribution of the Compton photons, Bremsstrahlung, etc., which resulted in a cross section of 1/300 of the primary Compton effect as compared to the theoretically expected value of 1/137. An assumption was also made that this double effect occurred only when the incident quantum energies were much greater than M_oC^2. Heitler[3] now shows that this last assumption was not correct.

The proposed experiment is to study the primary and secondary Compton quanta from gamma rays from Cesium 137 incident on an anthracene crystal. The energy of the Compton electron in this crystal will be measured and the time of the event will be fed to a coincidence circuit. Two scintillation detectors will be spaced around this scattering crystal to detect the scattered quanta. The energy of these scattered quanta will be measured, and the time of these events will also be fed to the coincidence circuit. When these three events occur in time coincidence the energy in each event is recorded, as is the angular location of the two gamma detectors. From these data the angular distributions and cross sections may be determined.

The actual measurements will be accomplished as follows: the pulses from the Compton electron events in the anthracene crystal and the pul[illegible] from the two NaI crystals from the scattered quanta will each be amplified by their respective A-1 amplifiers. A new pulse formed by the leading edge of the three primary pulses will be fed into a triple-coincidence circuit which will trigger a synchroscope only when these three pulses are in time coincidence. The three primary pulses, which are proportional to the energy of the events that cause them, will be fed to the vertical deflection system of the synchroscope. Each pulse will be separated from the other in time by suitable time-delay cables. The result will be that a photograph of the synchroscope will show the three pulses that occurred in time coincidence and will give a measure of the energy in each event. By correlating these energy measurements with various positions of the detectors, all of the desired information will be obtained.

It is anticipated that in the next quarter all of the necessary equipment will be purchased or constructed for this experiment. Theoretical studies will continue to assure that no experimental information will be overlooked when the actual experiments are started.

1. W. Heitler and L. Nordheim, Physica 1, 1059 (1934).
2. P. E. Cavanaugh, P. R. 87, 1131 (1952).
3. W. Heitler, The Quantum Theory of Radiation (Oxford University Press, London, 1936).

Respectfully submitted,

Approved:

G. P. Robinson
Project Director