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ACQUISITION OF THE ANL 4-MeV
ELECTROSTATIC ACCELERATOR

Progress Report

Dwight R. Dixon
Principal Investigator

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ABSTRACT

The operation of the ANL 4-MeV accelerator for the reporting period September 1, 1975 through August 31, 1976 is described. Some improvements and modifications to the accelerator and associated equipment, as well as maintenance problems are reported.

Activities on the three research projects specified in contract AT(11-1)-1805 and a subsequent modification are summarized. Progress on the shift of research activities from the BYU 2-MeV accelerator to the 4-MeV accelerator is described.

ACCELERATOR OPERATION

Operation of the accelerator during the reporting period was generally satisfactory. All operation was under the previously established limits of three million volts on the terminal and 20 micro-amperes of proton beam current. No effort was made to exceed these figures.

The difficulties with shift of beam position reported earlier were not experienced to any appreciable extent. Beam steering units constructed earlier were installed to allow adjustments to compensate for slight beam shifts and minor misalignments of beam-transport magnets.

Failure of the roughing pump in the main vacuum system made it necessary to replace this unit. Frequent leaks in the cooling coils on the diffusion pump had to be repaired. Major problems with the analyzing magnet power supply caused several weeks of delay in the program. These problems were largely due to faulty maintenance information supplied by the manufacturer of the power supply.

FACILITY MODIFICATIONS AND IMPROVEMENTS

Vacuum System

The previously described control system for protecting the vacuum pumps and accelerator against equipment and utility failures operated well during most of the reporting period, but gradually developed

problems which were difficult to analyze and correct because of the complexity of the system. For this reason it was decided to replace it with a simplified control unit. Such a unit is now being designed.

A 250 liter per second ion pump has been installed in the beam line between the analyzing magnet and the switching magnet. This provides lower operating pressures in the beam-transport system.

Signal Cables

The cables previously installed to transmit signals to the gamma-ray analysis system in the 2-MeV Nuclear Laboratory were tested and found to be reasonably satisfactory for use with the proton-capture studies but inadequate for the more critical fission-product studies. Noise pickup broadened the peaks in the gamma-ray spectra enough to be objectionable in the complex spectra obtained in the latter work. For the long-lived isotopes it is, however, possible to carry the irradiated samples to the 2-MeV laboratory for counting and analysis.

The cables have also been used to transmit digital data from the gamma-ray analysis system in the 2-MeV laboratory to the IBM 7030 computer in the Eyring Science Center. This has resulted in considerable saving of time and expense in handling of data from the X-ray fluorescence project.

Beam-Transport System

A switching magnet, High Voltage Engineering Corporation Model MM,

providing nine output ports has been installed. With the associated 150 ampere power supply, it has mass-energy products ranging from 85 at 15° to 6.25 at 60°. One beam line has been installed at 0° for use with the X-ray fluorescence project and another at 30° for the fission-product and proton capture gamma-ray studies. Quadrupole magnets have been installed preceding the switching magnet and in the 30° line.

EXPERIMENTAL PROGRAMS

Work has continued on the experimental programs as specified by the contract and called out in Modification No. 1.

Fission-Product Studies

During the past year work has continued on measurement of fission products yields from Pu-239 as a function of neutron energy. A short description of the experiment was given in the previous report.¹ Thus far, neutrons generated by the Brigham Young University L-77 reactor and the 2-MeV Van de Graaff accelerator have been used.

Data have been accumulated using neutrons of energies of 160 keV, 300 keV and 500 keV as well as thermal neutrons from the reactor. Yields for more than 40 fission products have been determined from these data. Early phases of the fission-product work are described by Rich.² A report describing the work done thus far has recently been prepared by Jensen.³

Trace-element Analysis Using X-ray Fluorescence

The 2-MeV Van de Graaff accelerator has continued to serve as the source of protons. Research currently being carried out includes determination of sulfur speciation in industrial aerosols under a three year contract with the U.S. Energy Research and Development Administration and determination of the trace-element concentration of obsidian artifacts⁴ collected during archeological studies in Utah, Central and South America and of obsidian sources in these areas.

Sulfur studies are being conducted to clarify whether sulfur in the +4 oxidation state (SO_2 and SO_3^-) or in the +6 oxidation state (SO_4^{--}) is responsible for the toxic pulmonary effects observed in smelter workers.

The obsidian studies are being carried out in an attempt to correlate the trace-element content of obsidian artifacts with the trace-element content of obsidian sources and to postulate trade routes in Utah, Northern Campeche, Mexico and highland Guatemala.

A further phase of the X-ray work is concerned with the analysis of biological samples as reported by Mangelson, et al.⁵

Recent studies have indicated that the optimum proton energy for X-ray fluorescence studies is in the vicinity of 3 MeV. This higher energy provides greater sensitivity for some elements as well as simplified target preparation. To take advantage of these improvements, we expect to move this project to the Argonne accelerator in the very

near future. A new scattering chamber has been constructed and is being prepared for installation. We expect that the X-ray spectrometer and associated computer will be moved to the 4-MeV laboratory where most of the future activity on this project as well as the other two reported here will take place.

Study of Proton-capture Gamma Rays

Study of the $^{55}\text{Mn}(p,\gamma)^{56}\text{Fe}$ reaction was continued with protons from the Argonne accelerator. Excitation functions were taken in energy regions between one and two MeV. Several gamma-ray spectra were measured at an interesting resonance at 1.750 MeV and these spectra have been partially analyzed. Additional data must be taken on the manganese reaction before a paper can be prepared for publication.

A 50-mg sample of Ni-62 has been purchased for use in the proposed proton-capture experiment described in the previous report.

PERSONNEL

Time spent on the overall nuclear research projects have been about as reported in the report for the previous year with the following exceptions:

1. The principal investigator and two associate investigators were on campus and working on research for the academic year plus one two-month summer term.

2. Students involved in the research projects were (a) one student who finished a Master's Degree thesis on the fission-product studies, (b) one senior student supported half-time for one semester by Department of Physics funds, and (c) several students doing short-term projects on the Argonne accelerator for academic credit.

3. A full-time accelerator and laboratory technician was assigned to the trace-element analysis project. Financial support for this project was from the Salt River Project (an Arizona-based power company), U.S. Energy Research and Development Administration, and Brigham Young University.

4. Electronic technician support, as well as machinist and vacuum technician support was satisfactory.

PROJECTED ACTIVITIES

As this report is written, equipment is being set up in the Argonne accelerator laboratory for a run on the fission-studies project. The main effort at present is in aligning and adjusting the elements of the beam-transport system to increase the beam current at the experimental position. Initially neutrons from the lithium reaction will be used, but in the future a tritium target will be used to produce neutrons at 1-MeV energy. Funds are available for purchase of a tritium target and tritium monitor. In addition to extending the measurements to higher neutron energies, another objective of the projected set of runs is to locate a systematic error which exists in the absolute value of the cross sections measured previously.

Mechanical work is being done in preparation for mounting the new X-ray fluorescence scattering chamber in the target area. Within a few weeks preliminary experiments will be done to resolve any problems relating to the use of the Argonne accelerator on this project. When a satisfactory level of operation has been achieved, the computing and pulse-height analysis equipment will be moved to the new location.

In January, a student is expected to begin work on the manganese proton-capture gamma ray experiment for a Master's Degree thesis. When sufficient data has been collected for this project, work will begin on the nickel experiment.

REFERENCES

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