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PROGRESS REPORT *on nuclear Physics*

January, 1966 - December, 1966

Submitted by

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I. Introduction

The Atomic Energy Commission contract AT(11-1)-1468, for which this report is presented helps to support a program of nuclear physics research at the University of Arizona. This program utilizes a 2 MV Van de Graaff generator and associated facilities of the University. In addition, construction of a building to house a 6 MV Van de Graaff is underway. In the following sections, progress during the past year is reported, and a proposal for operation during the coming year is presented.

II. Progress Report, January 1, 1966 - December 31, 1966.

A. Mean Life of the 1.74-MeV state in B^{10} .

Included in the progress report of last year was a reprint of a paper describing the measurement of the mean life of the 1.74-MeV state in B^{10} . Since the appearance of that paper, Cohen and Kurath⁽¹⁾ have calculated this quantity, and their result is 1/35 of our measured value. In addition, Fisher, Hannah and Paul⁽²⁾ have described an attempt to measure this mean life and concluded that it was too short to be measured by the Doppler-shift attenuation method. In our measurements, the $B^{11}(\text{He}^3, \alpha)B^{10}$ reaction was used to produce B^{10} nuclei in the 1.74-MeV state. Coincidences between α -particles to the 1.74-MeV state and γ -rays from that state were measured in order to obtain Doppler shifts. It is difficult to resolve the groups of α -particles to the 1.74-MeV state and to the 2.15-MeV state in B^{10} . Since the long-lived 2.15-MeV state cascades through the 1.74-MeV state, if α -particles to those two states are not completely resolved, our measurements

¹S. Cohen and D. Kurath, Nucl. Phys. 73, 1 (1965).

²Fisher, Hannah and Paul, Phys. Rev. Letters, 16, 850 (1966).

of the Doppler shift of γ -rays from the 1.74-MeV state could lead to incorrect values for the mean life of that state. Because of considerable interest, both theoretical and experimental, in the mean life of this state, we have expended a great deal of effort in its remeasurement. In the new measurements, γ -rays from the 1.74 MeV state were detected with a large germanium crystal. The resolution of this detector was such that Doppler shifted γ -rays emitted from the 1.74-MeV state could be resolved from those which were part of a cascade from the long-lived 2.15-MeV state and which were not Doppler-shifted. Thus, difficulties resulting from our inability to resolve α -particle groups to these two states are circumvented.

These measurements are now essentially complete, and although the analysis of data is still underway, it appears that our original measurement was incorrect. However, the preliminary analysis indicates that the mean life is in fact long enough to be measured by the Doppler-shift method, and is about 10 times as long as the prediction of Cohen and Kurath. The completion of the analysis of these data, and their publication are now being pursued vigorously.

B. Doppler-Shift Measurements in Si^{29} .

Excited states of Si^{29} have been produced by the reaction $\text{Si}^{28}(\text{d},\text{p})\text{Si}^{29}$. The direction of recoil of Si^{29} nuclei in excited states was determined by detecting protons in a surface barrier detector, and energies of γ -rays from the excited states emitted in and opposite to this direction were measured. The attenuated Doppler shifts so obtained are being compared to the calculated full Doppler shifts, and from these comparisons, and the slowing down power of the copper backing through which the Si^{29} nuclei recoiled, mean lives, or limits to mean lives will be obtained. Approximate values of measured Doppler shifts of γ -rays from states in Si^{29} are shown in Table I.

Table I

State	<u>Measured Doppler shift</u> <u>Calculated full Doppler shift</u>
1.28 MeV	0.5
2.03 MeV	0.4
3.06 MeV	1
3.6 MeV	0

C. Doppler Shifts in F^{20}

Measurements similar to those described in Section B are being performed on excited states in F^{20} produced by the reaction $F^{19}(d,p)F^{20}$. These experiments are now in progress; preliminary results have been obtained for levels with energies of 0.65, 0.99, 1.06 and 2.05 MeV. In these measurements, γ -rays have been detected with a large germanium crystal, and it is interesting to note that γ -rays from the 0.99 and 1.06 MeV levels are easily resolved, so that information about both levels can be obtained.

D. Polarized Ion Source for 6 MV Van de Graaff.

Although the construction of this ion source is not being financed by the present contract, a brief progress report is included because it figures in future plans for the laboratory and has occupied a substantial fraction of the present total effort. The source is of conventional design, and will be similar in philosophy to the commercial ORTEC source. We plan to use strong field ionization for both protons and deuterons, and therefore need an adiabatic fast passage unit for each. By operating exclusively at low magnetic fields, we can use low frequency rf in the adiabatic fast passage region, and use the same power supply for dissociation. We plan to

have three main beams: 100% polarized protons, deuterons with the $m = 0$ state depopulated (corresponding to mixed vector and tensor polarization), and a pure vector-polarized deuteron beam. By techniques to be described in detail in future publications, these can all be achieved at frequencies around 30 Mc/sec, which simplifies the space and power requirements, a vital consideration in the Van de Graaff dome.

At present a prototype ionizer has been constructed. Its electrical characteristics are very good, although measurement of its ionization efficiency has not been satisfactorily accomplished. The deflecting magnets are built and three of the five vacuum cases for the complete source are awaiting testing. A tentative design for the titanium sublimation heaters we propose as vacuum pumps in the source has been arrived at, and tests on pumping speed and lifetimes are underway. The main components yet to be built are the dissociator and the fast passage unit. Both are of standard design and should cause little difficulty. We optimistically expect assembly to begin by July, realistically by early October.

E. 'Plunger' Measurements

A technique has been described by Alexander and Allen⁽³⁾ with which mean lives which are too long to be measured by the Doppler-shift attenuation method can be studied. We have built the appropriate apparatus and are now attempting to measure the mean life of the 0.72 MeV state in B^{10} . This mean life has been accurately determined by other methods, and its measurement will allow us to check our technique.

³Alexander and Allen, Can. J. of Phys. 43, 1563 (1965).

F. New Facilities

Work commenced on the building to house the 6 MV Van de Graaff on about the 1st of November, 1966. This is more than six months later than we had hoped, and the delay was due to a number of things. The low bid on the building was over \$600,000, more than twice as much as originally anticipated. The president of the University has managed to provide the additional funds, so that instead of the \$300,000.00 mentioned in our progress report for 1965-66, the State of Arizona is providing over \$600,000 for construction of the Van de Graaff building. As mentioned above, construction is now underway and we expect the building to be ready for installation of the new machine by the summer of 1967. The machine itself will be ready for delivery in April, 1967, and the large 90° bending magnet is at present in storage in Tucson. A 5" gun mount which will support this magnet and allow it to be rotated so as to direct the beam into one of the two experimental areas has been allocated from the U.S.S. Tucson.

G. Personnel

Faculty members directly participating in the nuclear physics program are D. J. Donahue, J. D. McCullen and L. C. McIntyre. Dr. McIntyre joined the staff in September. He received a Ph.D. degree from Wisconsin in 1964 and spent two years as an instructor at Princeton.

Five graduate students worked in the program, although only four were paid from this contract.

H. Publications: December 1965 - December 1966.

1. With direct support from this contract.

Mean Lives of Excited States in ^{14}N , J. A. Lonergan and D. J. Donahue,
Nuc. Phys. 74, 318 (1965).

Angular Distributions of α -particles from the Reaction $^{11}\text{B}(^3\text{He},\alpha)^{10}\text{B}$,
J. A. Lonergan and D. J. Donahue, Nuc. Phys. 88, 465 (1966).

2. Other publications of members of nuclear physics group: December 1965 -
December 1966.

Mean Lives of Some States in Atomic Hydrogen, A. S. Goodman and D. J. Donahue,
Phys. Rev. 141, 1 (1966).

Photonuclear Cross Sections with Monoenergetic Neutron-Capture Gamma Rays,
R. R. Hurst and D. J. Donahue, accepted by Nucl. Phys.

Magnetic Moments of Sc^{43} and Sc^{47} , R. G. Cornwell, W. Happer, J. D. McCullen,
Phys. Rev. 141, 1106 (1966).

Spin and Moments of Titanium 45 , R. G. Cornwell, J. D. McCullen, Phys. Rev.
148, 1157 (1966).

Decay of Ag^{103} , A. D. Jackson, Jr., J. S. Evans, R. A. Naumann, and J. D.
McCullen, Phys. Rev. 151, 956 (1966).

The (p,d) and (p,t) Reactions on the Zn Isotopes at 17.5 MeV, L. C. McIntyre,
Phys. Rev. 152, 1013 (1966).

Tensor Polarization in d- α scattering, L. C. McIntyre and W. Haeberli,
accepted by Nucl. Phys.

Phase Shift analysis of d- α scattering, L. C. McIntyre and W. Haeberli,
accepted by Nucl. Phys.