**AMES
LABORATORY
IOWA STATE
COLLEGE**

PHYSICS. QUARTERLY SUMMARY RESEARCH REPORT
JANUARY, FEBRUARY, AND MARCH, 1955

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

-1-
U N C L A S S I F I E D

ISC-608

U N I T E D S T A T E S A T O M I C E N E R G Y C O M M I S S I O N

QUARTERLY SUMMARY RESEARCH REPORT IN PHYSICS

For January, February, and March, 1955

by

Ames Laboratory Staff

July 5, 1955

Ames Laboratory
at
Iowa State College
F. H. Spedding, Director
Contract W-7405 eng-82

U N C L A S S I F I E D

This report is distributed according to the category Physics and Mathematics as listed in M-3679, April 15, 1955.

TABLE OF CONTENTS

PHYSICSPageExperimental Physics

1. Nuclear Studies.	5
1.1 Continuous Flow Chamber Experiments.	5
1.2 Beta-Spectra of Some Short-Lived Nuclides.	6
2. Solid State Studies.	7
2.1 Electrical Properties of Magnesium Silicide (Mg_2Si)	7
2.2 Hall Effect Magnetic Field Gradient Meter.	7
2.3 Electrical Properties of Thin Sodium Films	8
APPENDIX I: LIST OF REPORTS FROM THE AMES LABORATORY.	9
1. Reports for Cooperating Laboratories.	9
2. Papers Published in Scientific Journals	10

QUARTERLY SUMMARY RESEARCH REPORT IN PHYSICS

For the Period January, February, and March, 1955

This report is prepared from material
submitted by the group leaders of
the Laboratory

Previous quarterly research reports in this series are:

ISC-35
ISC-41
ISC-56
ISC-69
ISC-74
ISC-76
ISC-79
ISC-113
ISC-130
ISC-133
ISC-137
ISC-171
ISC-193
ISC-220
ISC-246
ISC-283
ISC-301
ISC-338
ISC-395
ISC-422
ISC-451
ISC-508
ISC-533
ISC-577

PHYSICS

Under the direction of F. H. Spedding, G. W. Fox, G. C. Danielson, D. E. Hudson, E. N. Jensen, J. M. Keller, J. K. Knipp, S. Legvold, G. H. Miller and D. J. Zaffarano

Experimental Physics1. Nuclear Studies1.1 Continuous Flow Chamber Experiments (G. H. Miller)*

The experiment dealing with the ionization yield for protons in argon has been completed. The results are presented in Table 1. Several points are significant; first, the average energy per ion pair was found to be 26.5 ev., which is in good agreement with the value 26.4 ev. for high energy alpha particles; second, the energy intercept of a curve of ionization versus energy is only of the order of one kev, where the experimental uncertainty is about this great. These two points together indicate that the ionization defect for protons in argon is very small, if not zero. It appears that this is certainly a successful method of investigation for problems dealing with ionization yields for low velocity ions in various gases.

Table 1

Ionization Yield of Protons in Argon

Proton Energy kev	Ionization Yield coul./proton x 10^{16}	Average Energy Per Ion Pair ev.
25	1.455 $\pm$.026	27.52 $\pm$.49
50	2.879 $\pm$.044	27.82 $\pm$.43
100	5.957 $\pm$.114	26.89 $\pm$.51
150	8.923 $\pm$.145	26.93 $\pm$.44
200	12.04 $\pm$.18	26.61 $\pm$.40
250	15.26 $\pm$.25	26.25 $\pm$.43

*Names indicate group leaders in charge of work.

1.2 Beta-Spectra of Some Short-Lived Nuclides (D. J. Zaffarano)

The determination of the energy endpoints of the beta radiation spectra from the parent nuclides of "mirror" pairs was undertaken utilizing an improved scintillation spectrometer as the means of detection. The Iowa State College 67 Mev synchrotron was used to create the short-lived parent nuclei, and a short pneumatic tube was used to transport the samples rapidly to the counting position.

The scintillation spectrometer was an improved version of the one reported in ISC-359¹ and subsequently by Hunt.² The detector consisted of two photomultiplier tubes and anthracene crystals arranged to give nearly complete solid angle response to the particles from the thin (40 mg/cm²) samples used.

The Cs¹³⁷ internal conversion electron peak was analyzed. The resolution of the peak was 15.9% with a valley to peak ratio of 0.29. The P³², Y⁹⁰, and Cl³⁴ spectra, which have reported endpoint energies of 1.70, 2.24, and 4.47 Mev respectively, were examined to test the accuracy of the scintillation spectrometer and recording equipment. A calibration pulse height versus energy ratio was established by adjusting the Kurie plot from the recorded P³² negatron spectrum to have an endpoint energy of 1.70 Mev. The calibration ratio was then applied to the Y⁹⁰ negatron spectrum and the Cl³⁴ positron spectrum to determine their endpoint energies. The endpoint energies agreed with magnetic spectrometer values. This and additional spectral calibrations established that positron endpoints could be determined accurately with this equipment.

The positron endpoint energies obtained, and the respective "ft" values for the transitions are listed in Table 2.

Table 2

Endpoint kinetic energies, half-lives, and
"ft" values for some "mirror" transitions

Nucleus	E _{max} (Mev)	t 1/2 (sec)	ft (sec)
Si ²⁷	3.82±0.04	4.47±0.05	4520±310
P ²⁹	3.82±0.04	4.46±0.05	4350±310
S ³¹	4.42±0.03	2.55±0.02	4640±250
Ca ³⁹	5.58±0.04	0.97±0.02	4830±230

¹ W. A. Hunt, W. Rhinehart, J. Weber, and D. J. Zaffarano, Ames Laboratory Report ISC-359 (1953); Rev. Sci. Inst. 25, 268 (1954).

² W. A. Hunt, Radioactive Disintegration Spectra of Some Short-lived Nuclides, Unpublished Ph.D. Thesis, Ames, Iowa, Iowa State College Library (1954).

2. Solid State Studies

2.1 Electrical Properties of Magnesium Silicide (Mg₂Si) (G. C. Danielson)

Single crystals of magnesium silicide (Mg₂Si) have been grown and the electrical properties have been investigated in some detail. The crystals were spectroscopically pure except for the impurities copper and silver which were present in concentrations of approximately 0.01 atomic per cent.

The electrical resistivity (ρ) and the Hall coefficient (R) have been measured over the temperature range 62°K to 1037°K. The Hall mobility ($\mu = R/\rho$) between 300°K and 482°K varied as $T^{-3/2}$ and suggested, therefore, that thermal scattering predominated over impurity scattering at all temperatures above 300°K. The analysis of the data for the intrinsic behavior above 482°K was based upon this assumption that the empirical formula,

$$\mu_H = 0.84 (10^6) T^{-3/2} \text{ cm}^2/\text{volt-sec.},$$

which was determined from data between 300°K and 482°K, was also valid for all temperatures above 482°K.

With this assumption regarding the temperature dependence of the mobility of the electrons, the energy gap between the filled and empty bands was found to be 0.48 ev. An electron to hole mobility ratio of 1.3 gave best agreement with the data. If m is the free electron mass, the effective mass of the electrons in Mg₂Si is then 1.8 m and the effective mass of the holes is 2.0 m .

2.2 Hall Effect Magnetic Field Gradient Meter (G. C. Danielson)

Substantial improvements have been made in the design of a Hall effect magnetic field gradient meter. The general usefulness of the device, however, has not been determined.

Adjustable phase shifting networks have been added to the secondaries of the subtraction transformers. It has now been possible to adjust the phase angle between the two Hall voltages to 180.00 ± 0.17 degrees. This adjustment reduced considerably the field dependence of the difference voltage in a uniform field.

The background signal has been largely eliminated by the use of subtraction transformers with electrostatically shielded windings.

In magnetic field gradient measurements for high energy accelerators, the quantity of particular interest is the relative gradient $n' = (dH/dx)/H$. A voltage divider arrangement has been added to the Hall effect gradient meter so that this ratio can be read directly.

The most successful method of attaching the Hall probes has been a microsoldering technique based on a method developed by W. H. Mitchell.³ The five mil copper wire leads were tinned with ordinary solder and pressed against the surface of the germanium. A 1000 μ fd capacitor charged to 50 volts and discharged through each junction produced sufficient heat to melt the solder. Lactic acid was used as a flux. Previously the discharge was frequently accompanied by a spark and the germanium sample was broken. This difficulty has been eliminated by keeping the wire firmly against the germanium by means of mechanical holders and guides. It was possible to position the probes to within 0.2 mm of any desired position.

2.3 Electrical Properties of Thin Sodium Films (G. C. Danielson)

A completely new glass system for the deposition of thin sodium films has been designed and satisfactory sodium films have been produced. It is now possible to produce stable low resistance films (less than 5 ohms) by either evaporation of sodium from a tungsten filament or by effusion of sodium vapor from an oven.

³ W. H. Mitchell, J. Sci. Inst. 31, 147 (1954).