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Radiation Laboratory

BERKELEY, CALIFORNIA

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Radiation Laboratory

Contract No. W-7405-eng-48

Progress Report No. 62

June 1---15, 1948

Berkeley, California

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UNIVERSITY OF CALIFORNIA, RADIATION LABORATORY

PROGRESS REPORT NO. 62 June 1 - 15, 1948

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1. 184-inch Cyclotron Program

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Modification of the meson magnetic deflector was made to minimize its disturbance upon the main beam of the cyclotron. In addition, work on the resolution of the alpha and deuteron beams was continued in connection with the meson experimental program.

2. 60-inch Cyclotron Program

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During the period June 1 to 15, 1948, the 60-inch cyclotron operated primarily on protons at the request of the University of Rochester. Efficiency of production was increased from 4 microamperes to 20 microamperes as the result of the use of dry cylindrical hydrogen in place of that obtained by electrolizing distilled water. This has also increased the average filament life from three to 75 hours with a peak performance of 95 hours, during which time the instrument was not shut off.

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3. Synchrotron Program

Continued investigation of the electron orbit has resulted in obtaining electron current to a probe located 315° from the injector. The probe current seems to be entirely adequate but it has not been possible to obtain any betatron beam. After investigating the operating pressure on other synchrotrons and betatrons of comparable size, it has been concluded that the betatron beam is being lost by gas scattering and that it will be necessary to reduce the average pressure in the vacuum chamber by a factor of 10.

The present high pressure is due to porosity leaks in the outer plastic wall, and all attempts to seal them have been unsuccessful. An improvement has been made recently, however, by drilling numerous small holes part way through the plastic wall and connecting them to mechanical pumps. The porous structure inside the outer vacuum chamber wall is thus used as a guard ring, resulting in a substantial improvement in vacuum chamber pressure. The present pressure is a factor of 6 lower than that obtainable during the last attempt to get a betatron beam, and it is believed that additional pump-outs of this type will complete the desired improvement.

A careful study of the exact location of the electron beam at several points around the orbit has been started. The results of this study to date indicate that some additional improvement must be made to obtain exactly circular orbits. The radio frequency system has been re-designed to eliminate the possibility of electron multiplication in the dee stems by moving the vacuum seal to the inside edge of the bushings. The parts for making this change are now being fabricated.

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4. Linear Accelerator Program

Van de Graaff. During the period May 31 to June 15, the Van de Graaff operated for 82 hours. The time between the last two breakdowns was over three weeks. One significant operational point was noted: It was found possible to operate with a full pulsed beam

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with the diffusion pump in the high voltage end turned off. This should not be construed as an indication that the differential pumping is not desirable, for the beam diameter was larger, and the Van de Graaff voltage vs. linear accelerator current implied an increased spread in the energy of the protons from the Van de Graaff. However, this does mean that pulsed operation is possible under conditions of column vacuum which would not permit more than a fraction of a second of d.c. beam operation.

Tests of the activated charcoal trap have been continued. The pressure above the trap located directly over the air-cooled diffusion pump was better than 10^{-6} mm. of Hg. for ten days of operation. During five days of this time the forced cooling was removed. Reactivation of the charcoal trap was attempted after the run, but was not satisfactory. Further tests are in progress.

Linear Accelerator. The linear accelerator was in operation at all times when the Van de Graaff beam was available. Experiments were continued for the measurement of the half lives of Al^{25} and Al^{26}, on proton-proton scattering by photographic plates and by counters, on excitation curves for carbon, and on the calibration of photographic plates. No operational difficulties with the machine were experienced.

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5. Experimental Physics

Film Program. During this period several meson runs were made. It appears, as a result of experiments with plates with 100 micron emulsion thickness, that it may be possible to account for the presence of light positive mesons on the basis of decay of the heavy ones. However, difficulty is experienced in applying the same considerations to the light negative mesons and further work is needed before the direct production of light mesons from nuclear events can be excluded.

Work on the excitation curves of the mesons continues. Approximately fifteen examples are now at hand for the decay of heavy positive mesons to light ones with the full range of the latter contained in the emulsion. The results obtained indicate a single range in agreement with the Bristol work.

Delayed Neutrons. Further work has been done on the energy spectrum of the neutrons from N^{17} using counter methods and cloud chamber.

Total Cross Section Measurements for High Energy Neutrons. Total cross section measurements, up to this date, using Bi fission detection and monitoring, have yielded values as follows:

KNABLE-DEJUREN CROSS SECTIONS
(June 18, 1948)

Nuclei	σ_t (barns)	R(cm)
H	.067 ± .005	1.03×10^{-13}
D	.087 ± .009	1.18
Be	.396 ± .004	2.51
C	.502 ± .004	2.83
O	.681 ± .011	3.29
Al	.993 ± .011	3.98
Cl	1.265 ± .014	4.49
Cu	2.00 ± .02	5.64
Sn	3.13 ± .025	7.06
Pb	4.38 ± .03	8.35

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Compounds	Density	σ_t
H_2O	.998	.815 ± .005
D_2O	1.104	.854 ± .009
C_5H_{12}	.627	3.315 ± .053
CCl_4	1.592	5.56 ± .055

These cross sections lie below those measured employing $C^{11}(n,2n)C^{12}$ detection.

Measurements of Elastic Scattering of High Energy Neutrons. In the brief period since the last report no new results have been obtained. Experiments are planned and under preparation for estimating the inelastically scattered contribution which could be detected, and also to carry the measurements to wider scattering angles. Thus far nothing over about 30° has been measured, since the central maximum for diffraction lies within this scattering angle for all nuclei studied.

n-p Scattering and Other Experiments. A considerable amount of time has been spent on the measurement of n-p scattering at zero scattering angle and 90 Mev energy. This measurement is now complete.

The causes of the background single counting in the coincidence apparatus used in the scattering experiments have been investigated without notable success.

A paper on the change of half life of Be^7 has been prepared for publication in the Physical Review.

6. Theoretical Physics

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Work continued on the calculation of n-p scattering at 45 and 90 Mev, on the estimates of star sizes in photographic plates bombarded by deuterons, on the yields of spallation reactions, and on the energy spectra of mesons. Progress has also continued on the problem of range straggling of high energy deuterons, cross sections for meson production by the cyclotron and synchrotron, and on questions associated with the design of the cyclodrome.

7. Isotope Separation Program

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JA Research on Isotope Separation. An argon ion beam of 2-3 ma has been intensity modulated by applying 1.5 mc rf voltage of 10 kv amplitude to the G slit. The M potential was held at 10-12 kv.

This beam was allowed to traverse nearly 360°, at ground potential, and then to pass thru a grid toward a plate with adjustable bias near M potential. When this plate was positively biased, the ions were reflected back out thru the grid and were caught by a collector plate at ground potential.

The current at the final collector was a function of the reflecting bias voltage, and amounted to 1-1.5 ma. It was modulated 70-80 percent with the frequency applied to the G slit. If the reflector bias was made negative no current came to the final collector. The hash amplitude on the final collector current was not over 10 percent of the peak value of the current.

After several successful attempts to reproduce this condition, work was begun,

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and is now in progress, on design and construction of a simple 360° calutron unit to make use of this possibility of beam modulation more efficiently than is possible with the original test unit.

Nier Spectrometer. The spectrometer has been in regular use on a classified problem. An electrometer circuit employing 100 percent inverse feedback has been applied, with a recording output, to this instrument. Fluctuations in the current measurement are of the order of 10^{-15} amperes and less.

Parts for the small deuterium spectrometer have been made, and the unit awaits assembly.

8. Chemistry

Part A

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Astatine Chemistry. A 184-inch cyclotron bombardment with the full energy alpha particle beam was made on bismuth in a search for long lived astatine isotopes. Since Seaborg's group has looked for alpha active astatines this bombardment was concerned only with possible K capture activities.

Since the bombardment was run at energies well above that necessary to cause fission in bismuth, the astatine produced must be separated from the fission products. The purification procedure made use of the previously observed facts that (1) Astatine distills in high vacuum readily from bismuth at its melting point. (2) Astatine carries completely with Te when treated with SO_2 in 3 M HCl. (3) Astatine does not carry with Te when reduced by sodium stannite. (4) Astatine does not carry with silver halides after Br_2 oxidation.

From these facts a procedure consisting of the following steps was evolved that should separate astatine from all other elements.

(1) Distillation
(2) Te product
(3) AgI by-product
(4) AgCl by-product
(5) Te by-product

Steps 2, 3, 4 and 5 were repeated once, and the final sample mounted as Te metal plus astatine and counted. In each step during the first cycle of purification large amounts of gamma activity were removed. However, in the second cycle the total activity stayed almost constant.

In preliminary runs using astatine 211 from the 60-inch cyclotron the procedure was tested and gave yields up to 80 percent for one cycle with good material balances.

The only activities observed in the final sample were the Po x-rays of 7 1/2 hr half-life from astatine 211 and a 7-8 hour half-life gamma ray with a half-thickness of approximately 10 gram/cm^2 of lead corresponding to astatine 210. No electrons were observed. From this we conclude that either the astatines lighter than 210 are alpha emitters or are K-capture isotopes that are too short or too long lived to be observed by our experiment.

Chemistry

Part B

RESTRICTED

Synthetic and Experimental Chemistry. Work has continued on the synthesis of a number of C^{14}-labeled compounds including stilbamidine, acetylcholine chloride, choline chloride, and a modified synthesis of methanol, ethanol, and propanol.

Tryptophan labeled in the β-position of the side chain with C^{14} has previously been prepared and the metabolism of the compound studied. The synthesis of tryptophan labeled with C^{14} in the 3-position of the indole nucleus is now being studied.

Biological Chemistry. Biochemical studies have continued in three fields: (1) the metabolism of C^{14}-labeled tryptophan, an essential amino acid, (2) the metabolism of C^{14}-labeled tyrosine and C^{14}-labeled dihydroxyphenylalanine (Dopa) and (3) the metabolism of C^{14}-labeled dibenzanthracene, a carcinogen.

The conversion of tryptophan to kynurenine, kynurenic acid, and nicotinic acid in mammals has been studied with the use of radioactive carbon. In these experiments dl-tryptophan-β-C^{14} was administered to rabbits, dogs, and rats. The kynurenine and kynurenic acid isolated from the urines were radioactive, and by degradation the label was found to be in the methylene group and the 3-position of the two compounds, respectively. The N-methylnicotinamide was not radioactive, indicating that it was produced from tryptophan by some method other than a ring-closure to a quinoline derivative followed by oxidation. From the data obtained, it was formulated that the kynurenine is formed from tryptophan by direct opening of the pyrrole ring, and the kynurenic acid by direct ring-closure from kynurenine.

Photosynthetic Chemistry. Experiments designed to test whether chlorophyll transfers non-labile hydrogen during photosynthesis are almost concluded. The experimental procedure consists in the suspension of Chlorella algae in D_2O followed by the exposure of a vessel to light for a time of such duration that the mole ratio of O_2 evolved as a result of photosynthesis to Chlorella present was 20:1. Identical runs were also made without light. The Chlorella was then isolated, purified, and analyzed for deuterium content. The procedure was applicable only to non-labile hydrogen, since exchange with hydrogens capable of transfer would proceed to the same extent regardless of the presence or absence of light and the isolation and purification of the chlorophyll would result in a loss of all exchangable deuterium by virtue of copious washing with ordinary water.

The result of the initial experiments showed more deuterium in chlorophyll from algae exposed to light than in those kept in the dark, but the ratio of deuterium incorporated was still only one-quarter of that expected. Later work confirmed earlier experiments and noted that in four to five hour reactions the ratio of deuterium incorporated in the chlorophyll in the light to the deuterium taken up in the dark was approximately 4. Some chlorophyll was apparently formed in the dark. This was further confirmed by the use of C^{14}. The ratio of the percent incorporation of C^{14} in the light-synthesized chlorophyll to the dark-synthesized chlorophyll indicates that the greater amount of deuterium in the light-synthesized chlorophyll could be accounted for by the formation of newly synthesized chlorophyll. The degradation of light and dark chlorophyll to smaller units (pheophorbide) which should still contain the active hydrogen and, therefore, give a higher analytical result, showed no preferential distribution of deuterium within the porphin ring (as compared to phytol).

Analytical methods of conversion of combusted H_2O-D_2O to hydrogen-deuterium were shown to be satisfactory. Control exchange experiments with pure chlorophyll in

90 percent acetone, 10 percent deuterium water showed the usual number of labile hydrogens. The results of the experiments are, therefore, negative in character and indicate that (a) chlorophyll may act as a sensitizer rather than as a hydrogen transport agent or (b) if it does not act as a hydrogen carrier then it (1) functions via an enolizable hydrogen, or (2) the fraction of chlorophyll that is fairly active is small compared to the amount of material, or (3) the path of hydrogen from water to chlorophyll proceeds via a large reservoir of non-exchangable hydrogen.

Studies on the initial products of photosynthesis as indicated by the products synthesized on the administration of radioactive carbon dioxide to green algae under a variety of conditions have continued.

Chemistry

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Part C. Sub-project 48B

Metals and High Temperature Thermodynamics. Work is in progress on the following problems:

1. Thermodynamics of CN and CH.
2. Vapor pressure of metals.
3. Thermodynamics of gaseous molybdenum and copper halides.
4. Gaseous oxides and hydroxides.
5. Absorption coefficients of species in sun.
6. Low melting metal alloys.
7. Refractory studies.
8. Construction of 4000° furnace.
9. Structure of solids.

Basic Chemistry. Solvent Extraction. The following problems are under investigation:

1. The aqueous chemistry of zirconium.
2. The formation of the uranyl-TTA chelate in aqueous solutions.
3. Complex ion formation of lanthanum.
4. Intermolecular forces in solvent extraction.

9. Medical Physics

RESTRICTED

Part A. Project 48A-I

Radioautographic studies with yttrium indicate that at 16 days after administration this element is deposited on the periosteal and endosteal surfaces of the shaft, on the surface of trabecular bone, and there is some evidence that a spotty distribution occurs within the cortical bone. Experiments with strontium, yttrium, and curium are being continued.

The 1, 4, and 16 day intramuscular studies with praseodymium have been completed. This element is handled in a manner similar to the other lanthanide rare earths. The 64 day vanadium intramuscular studies have been completed. Carrier-free radio-vanadium is eliminated from the body very readily. During this period, about 80 percent was excreted. Small amounts of activity remained in the skeleton and at the site of injection. The 16 and 32 day U^{230} intramuscular studies have been completed. Deposition of U^{230} is similar to that of U^{233} with the possible exception of lower bone deposition.

Further data is available concerning the effects of massive doses of parathormone on bone resorption in the rat. Twenty-four hours after administration of 5 units/gram, histological sections showed tremendous osteoclast activity and a marked reduction in trabecular bone. A comparison of the metabolism of carrier-free radio-calcium and radio-strontium, now completed, indicates the great similarity of these two elements, and supports the validity of using radio-strontium as a "stand-in" for calcium. Addition of aluminum hydroxide to the diet was found to sharply reduce the absorption of radio-phosphorus from the gut, and to increase the loss of phosphorus by rats on a phosphorus deficient diet. In this way, it increases the effectiveness of the diet in promoting bone resorption.

Radio-cadmium was separated from the silver target mentioned in the last report. Approximately 1.4 millicuries was obtained. A cadmium target was received which had been bombarded with alpha particles for the production of radio-tin. Investigations have been started to develop another method for isolation of radio-tin as the previously reported methods give very low yields. Work has continued on the identification of a sample of radioactive material received from Oak Ridge which was probably mislabeled.

Medical Physics

Part B. Project 48A-II [redacted]

Studies with the Direct Beam of the 184-inch Cyclotron. Rate of energy loss and range energy curves of the 380 Mev alpha particle beams have been studied. Further progress was made in the study of the scattering of the deuteron beam. Exposure of mammary carcinoma tumors of type A mice to the direct deuteron beam was continued.

Sodium Ion Exchange of Rabbits. The permeability of the cell walls of rabbits to sodium ions was tested in a set of experiments reported previously. One series of experiments is now finished and contrary to the preliminary findings we have to report that no statistically significant change occurred in the sodium ion space of rabbits measured one to three days after irradiation by doses of x-ray up to 800 r.

Trace Analysis by Induced Radioactivity. Analysis of tissue ash samples irradiated with neutrons was continued. The iron fraction was separated. A new set of samples is being prepared for the study of induced activity in blood and bone marrow samples of a patient with leukemia, polycythemia, anemia, and normal controls.

10. Health Physics and Chemistry RESTRICTED

Following is a list of the current projects under development and a statement as to the progress of each.

a. Beta-gamma lead-shielded gloved box: Complete and ready for full dress dummy runs: Waiting for Webb target assembly.

b. Yttrium box for Dr. Gofman: In process of design; bottle capping device being rebuilt.

c. Gofman hood: Being assembled in Donner.

d. Conway arc source: In process of design.

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e. "Cow": Spinner columns are ready for tracer runs; centrifilter trial runs are in process.

f. Protection box to enable milling hot targets safely: Design complete.

g. Protective housing for milling machine: In process of design.

h. Decontamination chamber: Design in process.

i. Synchrotron quartz tube: Being etched with HF.

j. Portable alpha counters: Worn-out canvas carrying bags replaced by aluminum containers on two counters.

k. Alpha "finger" probe: First model almost completed.

l. Impinging air sampler: Built and being tested.

m. Phosgene apparatus: "Warmed up" and ready for modification for air contamination studies.

n. Stripcoating: Hood and sink section in Room 205, ORL, coated with liquid rubber (Stabond) and plastic (liquid envelope) for test.

o. Beta-gamma shield testing table: Completed.

p. Miniature heat lamps for microchemical work in gloved boxes: 6 made.

q. Constant temperature bath for gloved boxes for microchemical work: Being drawn by the Drafting Department.

r. Centrifuges being prepared for radioactive work: 14 dismantled, numbered, sent to sandblasting and paint shop. 5 received from paint shop and reassembled.

s. Swivel jaw tongs: Handles redesigned.

t. Ghiorso "inert atmosphere" box: Being pressure-tested.

Additional effort has begun on development of anthracene scintillation counting, with applications in view to γ-counting for medical physics experiments, and high-energy neutron detection.

Numerous conferences have been held with the architects on laboratory design for the newly finished rooms in Bldg. 5 and for the new laboratory to be built below Bldg. 29. Also, much time has been spent supervising details in installations in the new laboratories.

Information Division
6-23-48/hw

June 1 - 15, 1948

APPROXIMATE DISTRIUBTION OF EFFORT

PROGRAM	SUBDIVISION	MAN-MONTHS EFFORT	COMMENTS
1. 184-inch Cyclotron	Operation	10.5	
2. 60-inch Cyclotron	---	---	Non-Project
3. Synchrotron	R.f. System	3.8	
	General	0.3	
	Injection	2.0	
	Miscellaneous Equipment	2.0	
	Magnet Tests and Operation	2.0	
	Vacuum Chamber	1.0	
4. Linear Accelerator	Linear Accelerator-General	5.0	
	Van de Graaff General	7.0	
	General, Development, etc.	0.5	
5. Experimental Physics	Cloud Chamber	5.0	
	Film Program	3.3	
	Ionization Chamber and Crystal Counter	0.8	
	Neutron-proton Scattering	2.0	
	Proton-proton Scattering	2.0	
	Neutron Diffraction	0.5	
	Delayed Neutrons	2.0	
	Meson Counting	1.0	
	Absolute Cross Section Measurements	1.0	
	Neutron Half Life	0.5	
	Bevatron Design Studies	0.5	
	General Physics Research	6.0	
	Magnetic Measuring Equipment	0.5	
	Bevatron Magnet	5.5	
6. Theoretical Physics	Synchrotron	0.3	
	Bevatron	1.5	
	Cyclotron	0.5	
	Linear Accelerator	0.3	
	General Physics Research	7.6	
7. Isotope Separation	JA Conversion	1.5	
	Nier Spectrometer	1.0	

PROGRAM	SUBDIVISION	MAN-MONTHS EFFORT	COMMENT
8. Chemistry. Part A	Chemistry of Transuranic Elements	5.0	
	Nuclear Properties of Transuranium Elements	3.5	
	Transmutations with the 184-inch Cyclotron	6.0	
	Transmutations with the 60-inch Cyclotron	1.0	
	Analytical and Service	14.5	
	Chemistry of Astatine	1.5	
Chemistry. Part B	Synthetic and Experimental Organic Chemistry	6.6	
	Biological Chemistry	4.8	
	Photosynethetic Chemistry	6.8	
Chemistry. Part C	Metals and High Temperature Thermodynamics	2.5	
	Basic Chemistry, including Metal Chelates	3.5	
	General	2.0	
9. Medical Physics. Part A	Evaluation of Metabolic Properties of Plutonium and Allied Materials in Animal and Man	13.0	
	Decontamination Studies	7.0	
	Radiochemistry	1.0	
	Radioautography	2.0	
Medical Physics. Part B (Project 48A-11)	Uranium Research	0.5	3.0 Consultant Man-Month
	Tumor Metabolism	0.3	0.5 "
	Special x-ray Studies, Radioactive Measurements, etc.	0.5	---
	Radioactive Carbon Studies	0.3	---
	Fundamental Medical Research	0.5	1.0 "
	Hematology	---	0.5 "
	Medical Work with 184-inch Cyclotron	0.5	0.5 "
10. Health Physics and Chemistry	Monitoring and Special Problems	6.0	
	Salvage, Decontamination, Disposal, etc.	3.4	
	Research and Development	8.0	

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