LA-9388-MS

UC-34c
Issued: June 1982

LA--9388-MS

DE82 019189

The Effect of Acceleration on the Decay Rate of ^{198}Au

A Preliminary Report

D. H. Whitaker

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Los Alamos Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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ABSTRACT

Experimental evidence obtained at the Los Alamos National Laboratory during 1980 suggests that the decay rate of ^{198}Au may be influenced to a measurable extent by acceleration of the bulk material. In the experiments, a sample of ^{198}Au was subjected to a sustained acceleration of approximately 196 000 g's, and its decay rate was compared with that of a control sample that remained at rest. The decay probability of the accelerated sample was observed to exceed that of the control sample by 7.48 standard deviations. This was the maximum value resulting from comparison of the accelerated sample data and the control sample data. Although not conclusive, these preliminary data are certainly suggestive that a direct coupling may exist between gravitation (acceleration) and nuclear processes (radioactive decay).

I. INTRODUCTION

During the last 6 months of 1980, a series of six experiments was performed at the Los Alamos National Laboratory to determine if the decay rate of a radioactive material could be affected to a measurable extent by subjecting the material to a very high acceleration. The material chosen for the experiments was ^{198}Au, a gamma-beta emitter with a half-life of 2.69 days[1] and a predominant gamma-energy peak of 0.411 MeV. Acceleration of the bulk sample material was achieved using a Beckman model L3-50 ultracentrifuge. Counting data were obtained by using a sodium-iodide crystal scintillator and a multichannel pulse-height analyzer.

Recognized sources of error, which were either minimized or eliminated, included background gamma radiation, electrical noise in the counting instrumentation, procedural errors, instrumentation drift, uncertainties of counting geometry, dead-time in the pulse-height analyzer, errors in time measurements, contamination of the gold samples before irradiation, uncertainties resulting from the mechanical deformation of the gold because of the high centrifugal forces, and the degradation of the counting statistics resulting from natural decay of the gold during the time period of the experiments.

As stated earlier, a series of six experiments was performed representing an iterative process by which improvements and refinements were made in equipment and procedures following each experiment until ultimately in December 1980 the final experiment was performed that represented the best effort with then-available resources. It should be noted that although the experimental approach and procedures differed in all six experiments, the data obtained in every instance suggest that the decay rate of ^{198}Au is greater when the material is under acceleration than when it is at rest. However, until the final experiment was performed, the error sources mentioned earlier had effects (either singly or in combination) on the data that render them unreliable. For this reason, only the results of the best-effort experiment are presented in this report.

II. EXPERIMENTAL METHOD

The experimental method used in the best-effort experiment, including preparation procedure, operational procedure, and data analysis, is presented in sequential fashion.

A. Preparation Procedure

1. Two gold samples were fabricated from foil stock. The samples were discs and were 1.27 cm in diameter and approximately 0.001 cm thick.

2. Both samples were cleaned and degreased by dipping them in methylethylketone (MEK) followed by an agitated rinse in nanograde freon. All subsequent handling of the samples was accomplished using clean tweezers.

3. Both samples were placed in separate wells of the fixed-angle centrifuge rotor and were exposed to 1 h of approximately 196 000-g's acceleration. The purpose of this was to deform both samples in the same manner so that subsequent handling and placement in the centrifuge and counting chamber would be consistent.

4. A special fixture was fabricated and installed in the counting chamber. Its purpose was to insure that the counting geometry of both samples was closely controlled and as nearly identical as possible during all counting intervals.

5. One sample, designated the test sample, was placed into a clean polyethylene tube for temporary storage. The other sample, the control unit, was neutron-activated in the Solution High-Energy Burst Assembly (SHEBA) reactor located at the Pajarito Site (TA-18).

6. The sodium-iodine crystal scintillator, photomultiplier tube, amplifiers, power supplies, and pulse-height analyzer were all functional-checked and system-balanced. The reliability, accuracy, and precision of the entire counting instrumentation system were verified by placing the irradiated control sample into the counting chamber for a total time period of 41 h, during which the total count data of the gamma spectrum were taken at random intervals and recorded over a 200-channel bandwidth. All counting intervals were 4 min in duration with additional time required following the actual counting interval for the 200-channel count integration and data recording. The 0.411-MeV gamma ray was the peak channel. All the counts within 100 channels on either side of the peak were also counted and integrated. The data obtained during this system test resulted in a measured decay probability of ^{198}Au that was within 0.16% of the accepted value, which is 0.010712/h ($\pm$ 2 x 10^{-6}/h).

7. The ultracentrifuge was given a final functional check and the counting instrumentation circuits were monitored for noise originating from the centrifuge. No noise was detected.

8. Both the control and test samples were neutron-activated by positioning them on the side of the SHEBA reactor vessel.

B. Operational Procedure

1. The gold sample designated as the test unit was placed in the counting chamber and counted for eight consecutive 4-min time intervals. The counting method was identical to that described in Sec. II.A. This counting was done to establish a count rate of the sample before acceleration.

2. The test sample was removed from the counting chamber and placed into the ultracentrifuge and exposed to an acceleration of approximately 196 000 g's for predetermined time intervals. These time intervals, hereafter referred to as "spin intervals," were not constant but were varied depending on conditions such as time of day.

3. Intermittently during the spin intervals, the control sample was placed into the counting chamber and counted for 4-min time periods. The purpose of this was to establish base-line data for the control sample under static conditions and to monitor the counting system for proper functioning. Background gamma radiation also was monitored intermittently during the spin intervals. The background count remained essentially constant at 295 counts per minute during the entire 71-h time period of the experiment. The background count was subtracted from all data as they were recorded.

All counting (including test sample counting) was accomplished by monitoring the peak (0.411-MeV) channel on the pulse-height analyzer and integrating the counts on 100 channels on either side of the peak channel. In addition to the total number of counts thus obtained, the peak channel number, the low channel number (peak minus 100 channels), and the high channel number (peak plus 100 channels), and their individual counts were recorded. This enabled us to detect and account for the effects of amplifier gain-drift.

4. At the end of a given spin interval, the test sample was removed from the centrifuge and placed in the counting chamber; great care was taken to insure that no damage or deformation of the sample resulted from handling and that the placement of the test sample into the counting chamber was identical to that of the previously counted control sample.

5. The test sample was counted for two or more 4-min time intervals.

6. Steps II.B.2. through II.B.5. were repeated until the experiment was concluded. During the 71-h total time duration of the experiment, a total of 39 data points were obtained for the control sample, and a total of 31 data points were obtained for the test sample. In addition, the test sample was exposed to approximately 196 000 g's for an accumulated time of approximately 21 h.

C. Data Analysis

Analysis of the data was made a relatively complicated task by three major issues.

- Theory is mute concerning whether a measurable effect on the decay rate exists at the acceleration levels attained during the experiments. Therefore, there is no substantiated theoretical insight into the implications of the data.

- The absence of similar experimental work by other investigators precludes the comparison of results.
- The manner in which the experiment was performed resulted in data analysis difficulties. For example, during the approximately 70-h duration of the experiment, the test sample was under acceleration for approximately 21 h and was at rest for approximately 49 h. Assuming that acceleration did affect the decay rate of the ^{198}Au, then a complete analysis must account for the composite decay rate implicit in the overall data. Because all count data were obtained under static conditions, a straightforward, real-time comparison between accelerated decay and static decay is not possible.

In an attempt to glean maximum information from the experiment, the data were analyzed using two different methods. The first method used standard linear regression techniques by which the decay probabilities of the control sample data and test sample data were calculated and compared. In this analysis, no effort was made to account for "at-rest" time in the test sample data. In the second method, an attempt was made to extract the data reflecting accelerated conditions from those of the "at-rest" conditions in the test sample data. Linear regression techniques were also employed in this method.

The count data are tabulated in Table I.

III. RESULTS

The major results of the experiment are the following.

1. The decay probability (λ) of the test sample appears to be greater than that of the control sample.

2. The amount of difference between the two decay probabilities is a specific function of the method used to analyze the test sample data.

These results are synopsized in Table II. As can be seen from the table, the apparent increase in λ varies from 0.77% when the test sample data are analyzed by the first method to 2.6% when they are analyzed by the second method.

IV. CONCLUSION

The experiment produced suggestive but inconclusive evidence that acceleration may affect the decay rate of ^{198}Au to a measurable degree. If indeed

TABLE I

EXPERIMENTAL DATA

CONTROL SAMPLE Elapsed Time (h)	CONTROL SAMPLE Total Counts (200 Channels)	TEST SAMPLE Elapsed Time (h)	TEST SAMPLE Total Counts (200 Channels)
0	588912	0	566454
0.233	588311	0.100	563348
0.333	589220	0.200	562876
0.433	585769	0.300	563205
0.533	585267	0.400	560477
0.633	585956	0.516	562119
0.733	583613	0.633	560683
0.833	583040	0.766	559538
0.933	583542	15.732	474566
1.033	582007	15.848	474874
18.400	479853	25.431	433405
18.533	480519	25.547	432758
19.249	477097	25.663	432235
20.265	476640	40.463	367587
21.248	471986	40.563	369149
22.431	465125	40.663	367610
23.181	462699	42.829	357505
24.231	455940	42.929	357912
24.364	455307	43.029	356883
25.147	451378	43.129	355680
26.147	444365	43.295	354898
43.030	374068	46.195	344497
43.146	374658	46.300	344734
43.246	372889	50.683	327014
43.346	371875	50.800	326522
44.096	369864	50.900	326011
48.729	358850	63.000	287269
48.845	348356	63.116	285654
48.961	348883	69.950	265053
49.777	345403	70.05	264021
51.060	340370	70.15	263379
52.126	336452		
65.542	291571		
65.658	290578		
66.791	288462		
66.907	288109		
68.973	281253		
70.639	275954		
71.972	271628		

TABLE II

RESULT SYNOPSIS

ANALYSIS METHOD	Measured Decay Probability (λ) (per hour)		Standard Deviation (σ) (per hour)		REMARKS
	Control Sample (λ_c)	Test Sample (λ_t)	Control Sample	Test Sample	
1	0.010695	0.010778	3.73×10^{-5}	3.68×10^{-5}	λ_t is a composite of both static and accelerated decay.
2	0.010695	0.010972	3.73×10^{-5}	3.68×10^{-5}	λ_t reflects only the decay while ^{198}Au was under acceleration.

such an effect does exist, the implications are profound. Because of this, and the relative simplicity and inexpensive nature of the experiment, it is believed that further investigations along this line of inquiry should be pursued.

V. ACKNOWLEDGMENTS

The author gratefully acknowledges the contributions made to the overall experimental effort by the following individuals.

W. Bradley — J. Koelling
W. Chamberlin — R. Leep
W. Davey — R. Malenfant
D. Enger — R. Pederson
G. Hansen — J. Straight
W. Kirk — C. Swannack

The author also wishes to thank B. Krohn, M. Nieto, and D. Strottman for the helpful theoretical discussions.

VI. REFERENCE

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