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THE POSSIBILITY OF WEAK ALPHA BRANCHING IN RADIUM D

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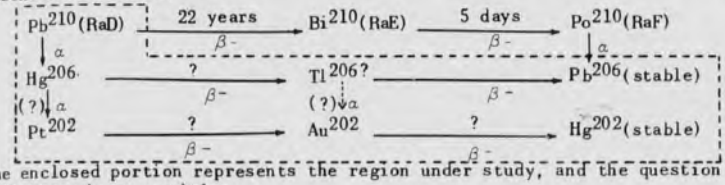
Up to now, naturally occurring radium D has not been known to emit alpha-particles. However, work in the chemistry department at the University of Arkansas has indicated that such a weak alpha branch may exist in the decay of radium D -- in fact, preliminary study supports such a hypothesis. Nuclear shell theory also supports an argument for the enhanced stability of the alpha-decay daughter, Hg^{206}, leading to a measurable lifetime. The general decay scheme may be represented as follows:



The enclosed portion represents the region under study, and the question marks indicate unknown entities.

The solution to this problem lies in the preparation of sufficient amounts of Hg^{206}. The present method is to isolate mercury from the radium D present in aged radon needles. The activity husbanded in this way is quite small, and while it is sufficient for some experiments, it is too small for others. Larger amounts of Hg^{206} might be produced by second-order neutron capture in highly enriched Hg^{204}, using the highest neutron flux facility available, such as the MTR reactor at Oak Ridge or at Arco, Idaho. If we should fail to detect this reaction, we should be able to set an upper limit for the product $\sigma_2 \lambda_2$ where σ_2 is the cross section for reaction $Hg^{205}(n,\gamma)Hg^{206}$, and λ_2 is the decay constant of Hg^{206}.

One approach to the investigation of Hg^{206} will be to examine its possible beta-decay daughter, 4.3-minute Tl^{206}: Gross decay of a mercury fraction which was chemically separated from radium D by a sulfide separation, which does not provide an adequate decontamination factor from polonium or bismuth, exhibited a curve whose period of maximum growth occurred at 250 hours. This would rule out the possibility that Hg^{206} decays to 4.3-minute Tl^{206}, but leaves the possibility that it may decay to some unknown isomeric level in Tl^{206}, or that it may decay by alpha emission. The neutron absorption cross-section of Tl^{205} has been reported[1] as 0.77 barns by the pile-oscillator technique while the activation cross section of 4.3-minute Tl^{206} has been reported as only 0.10 barn. The difference is attributed to the existence of one or more long-lived isomeric levels in Tl^{206}, which is activated simultaneously. Shell structure predicts the existence of many low-lying high-spin states in odd-odd Tl^{206}, which has 81 protons and 125 neutrons, just one proton and one neutron short of a closed shell. The unknown isomeric level cannot be shortlived, for it either would feed the 4.3-minute state and contribute to its activation cross section, or it would independently beta-decay. The latter would hardly have escaped notice in the past. Moreover, it is doubtful that an ordinary lifetime (hours, days, or months) would have gone undetected. Thus, we predict that the isomeric level has a half-life either very long or similar to that of Tl^{204} (about 3 years).

Another possibility is that Hg^{206} may be beta-stable, and decays by alpha emission. In early studies a 70-hour daughter of Hg^{206} has shown up. Further work is planned to establish the identity of the 70-hour activity, which might be due to unknown Pt^{202} decaying to a possible short-lived Au^{202} daughter.

That Tl^{206} might undergo orbital electron capture to Hg^{206} is also within the realm of speculation. We plan to test this idea by studying the ratio of X-ray-decay/beta-decay of aged (2 to 5 years) and young samples of long-irradiated

[1] "Neutron Cross-Sections," U.S. Atomic Energy Commission Report AECU-2040.

elemental thallium. Should this ratio prove to be different between the young and the old samples, it would indicate that the beta-decay and orbital electron-capture arise from states of different lifetime, and perhaps from different nuclides. The next step would be to irradiate isotopically enriched thallium in an attempt to identify these states.

We have established a reliable procedure for chemically isolating and decontaminating the radium-D decay products involved to study their radiation characteristics. Our new technique, which supplants the unsatisfactory sulfide method mentioned earlier, is based on the following principles: (1) that $Pb(NO_3)_2$ is insoluble in fuming nitric acid; (2) that bismuth and polonium do not extract into isoamyl acetate from a dilute nitric acid aqueous phase; and (3) that mercury can be stripped from the isoamyl acetate layer by 1M ammonium chloride aqueous solution. Thus, a carrier-free technique, easily adaptable for the isolation of any of these elements, is at hand for the separation, carrier-free, or radium-D, -E, and -F. The radiations emitted by Hg^{206} will first be investigated, using the following counting techniques: (1) gross alpha and beta decay in a windowless flow counter; (2) hard beta-decay through absorbers; and (3) gamma decay and energy by scintillation spectrometry.