MASS OF THE ISOTOPE Pu^{239}

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A measurement of the mass of the plutonium isotope was done in a mass spectrometer[1] with a resolving power of 60,000 – 80,000. To determine the mass of the plutonium isotope we used doublets obtained with the help of organic compounds of different composition. These compounds consisted of the elements H, C^{12}, and O^{16}, whose masses had been measured earlier rather carefully.[1] By determining the isotope's mass by direct comparison with the mass of the organic compounds it was possible to avoid a series of intermediate measurements and thus significantly improve accuracy. We used two organic compounds to produce the doublet pair. In the first case we used alizarin ($C_{14}H_8O_4$, M = 240) giving fragments at mass 239. The second line of the doublet was formed by fragments of the organic compound perylene ($C_{20}H_{12}$, M = 252) having the composition $C_{19}H_{11}$. Ion formation occurred in an arc ion source whose basic discharge was maintained in helium. Pairs of plutonium and organic compounds moved into the discharge by the evaporation of these substances in crucibles of special construction.

The differences ΔM of the masses of the doublets and the corresponding value of mass of the isotope Pu^{239} are shown in the table. The final

Doublet	ΔM, mmu	Mass, Pu^{239}, mu
Pu^{239}—$C_{14}H_7O_4$	18.448±0.082	239.128922±92
$C_{19}H_{11}$—Pu^{239}	33.447±0.067	239.128695±74
		average:
		239.128784±165

mass value of the isotope Pu^{239} was calculated taking into account the "weight" of the measurements. For comparison we point out that the value of the Pu^{239} mass obtained from nuclear reactions[2] (there were no mass-spectrometer measurements available up to that time) was 239.126999 ± 150.* The mass of Pu^{239} calculated from data on nuclear reactions with corrections for the more accurate value of isotope Pb^{208},[3] was 239.128025 ± 155.* The disparity between the value of the mass of the isotope Pu^{239} we obtained and the value obtained from calculations on nuclear reaction data is equal to 0.759 amu. This somewhat exceeds double the magnitude of total error of both measurements. It is interesting to note the following fact. The difference between our value and the value obtained by calculation from nuclear reaction data for the isotope U^{238} is equal to 1.035 + 0.120 mmu,[4] and for the isotope Pu^{239} is equal to 0.759 ± 240 mmu. In addition, the deviation for the difference of the masses of Pu^{239} and U^{238} calculated by our data from the corresponding value according to nuclear reaction data is 0.166 ± 0.250 mmu, that is, it is within the limits of experimental error. In our case, the masses of the isotopes Pu^{239} and U^{238} were measured quite independently, but the nuclear measurements are connected by a continuous chain of Q values. Therefore, we may assume that the error ~1 mmu was a result of inaccurate values in the Q values that connect the reference isotope Pb^{208} with the isotopes Pu^{239} and U^{238}. This assumption is confirmed by the fact (see references 3 and 4) that deviations of difference values between our values and the nuclear values increase the farther one gets from the standard Pb^{208}, both on the side of an increase in A, and on the side of a decrease in A.

*Error actually equal to ± 1000μ mu.

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[2] J. R. Huizenga, Physica **21**, 410 (1955).

[3] Demirkanov, Gutkin, Dorokhov, J. Exptl. Theoret. Phys. (U.S.S.R.) **35**, 917 (1958), Soviet Phys. JETP **8**, 639 (1959).

[4] Demirkhanov, Gutkin, Dorokhov, Dokl. Akad. Nauk SSSR **124**, 301 (1959), Soviet Phys. Doklady **4**, 105 (1959).

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SOME CHARACTERISTICS OF THE ANNIHILATION OF AN ANTIPROTON IN THE DEUTERON

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As Pontecorvo has already noted,[1] aside from the usual annihilation of the antiproton in one of the nucleons of the deuterium nucleus, the so-called