TWO-PROTON MULTIPLETS IN ^{210}Po*

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Received 21 June 1971

The ^{209}Bi(α, t)^{210}Po reaction at 45 MeV has been used to study ^{210}Po. Many new levels have been observed and proton configurations are suggested for the lowest three multiplets.

According to the shell model, the nuclear structure of ^{210}Po can be described in terms of two interacting protons outside of the doubly-magic ^{208}Pb core. This relatively simple two-nucleon structure is amenable to detailed calculation and results from shell-model calculations are available [1,2].

To provide experimental data for comparison with theory, we have studied ^{210}Po using the ^{209}Bi(α, t)^{210}Po proton transfer reaction. A self-supporting bismuth target with a thickness of approximately 600 μg/cm^2 was bombarded with 45 MeV α particles; the emitted tritons were analysed by a magnetic spectrograph and detected with Ilford emulsions. Partial angular distributions have been recorded in 2.5° steps from 0° to 20°.

The (α, t) reaction adds a proton to the ^{209}Bi ground state which consists of an $h_{9/2}$ proton plus the ^{208}Pb core. The added proton will be captured into an unfilled shell-model orbital and will couple with the $h_{9/2}$ proton; each two-proton

* Supported in part by the US Atomic Energy Commission.

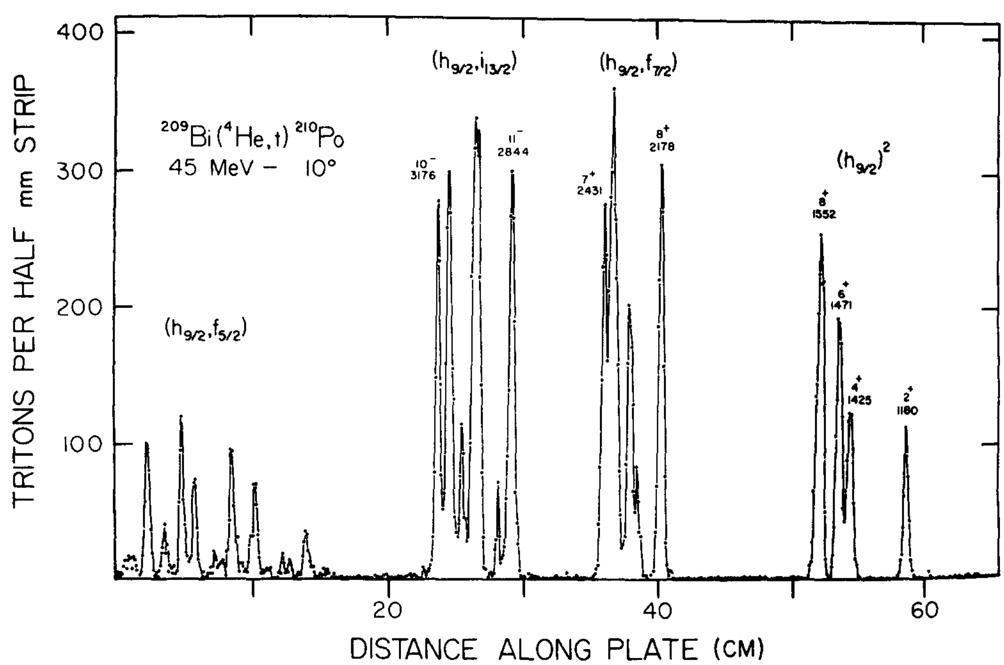

Fig. 1. Spectrum from the ^{209}Bi(α, t) ^{210}Po reaction at 45 MeV. The 0^+ ground state is not shown and is off the figure to the right.

Table 1.
Suggested spins, obtained from the assumption that within a multiplet the intensities are proportional to $2J+1$, and measured excitation energies. The configurations are suggested by comparison of the observed level structure with shell-model calculations. Parities are assigned consistent with the assumed configuration. Energies are believed correct to within ± 6 keV.

Excitation energy (keV)	Suggested J^{π}	Suggested configuration
0	0^+	
1180	2^+	
1425	4^+	$(h_{9/2})^2$
1471	6^+	
1552	8^+	
2178	8^+	
2286	1^+	
2319	6^+	
2377 2396 2405	$3^+, 4^+, 5^+$	$(h_{9/2}, f_{7/2})$
2431	7^+	
2844 2910	$11^-, (2^-)$	
3001 (3006) (3014) 3019	$8^-, 6^-, 5^-, (3^-)$	$(h_{9/2}, i_{13/2})$
3067	(4^-)	
(3125) 3130	$9^-, 7^-$	
3176	10^-	

configuration will consist of a multiplet of states. In the 82-126 shell, the proton orbitals are $1h_{9/2}$, $2f_{7/2}$, $1i_{13/2}$, $2f_{5/2}$, $3p_{3/2}$ and $3p_{1/2}$.

The triton spectrum in fig. 1, which has a resolution of approximately 30 keV, shows that the levels, as expected, are grouped into multiplets. The suggested configuration assignments are based on the close agreement between the observed multiplet structure and theoretical calculations [1,2]. Of all of the "two-nucleon" spectra, the spectrum of ^{210}Po probably comes closest to fulfilling simple shell-model expectations.

The levels in the three lowest multiplets are predicted by the calculations to be nearly pure configurations (in amplitude squared > 93% except for the 0^+ ground state [2]) with little or no mixing; to good approximation intensities within a multiplet should therefore be proportional to

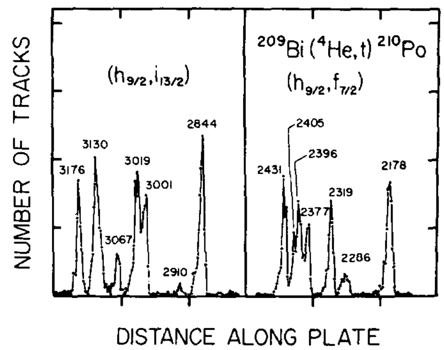

Fig. 2. Two of the multiplets in the ^{209}Bi$(\alpha, t)^{210}$Po spectrum shown with improved resolution (10-15 keV).

$2J+1$. Table 1 lists measured excitation energies and suggested spins. No spins have been measured in this work; the suggested values follow from the assumption that within a multiplet the relative intensities are proportional to $2J+1$.

The multiplet lowest in energy is $(h_{9/2})^2$. Five states are allowed from this coupling: 0^+, 2^+, 4^+, 6^+, and 8^+. The 0^+ ground-state member of the multiplet is off fig. 1 to the right. The spins, parities, and energies of the 2^+, 4^+, and 6^+ states have been measured previously from

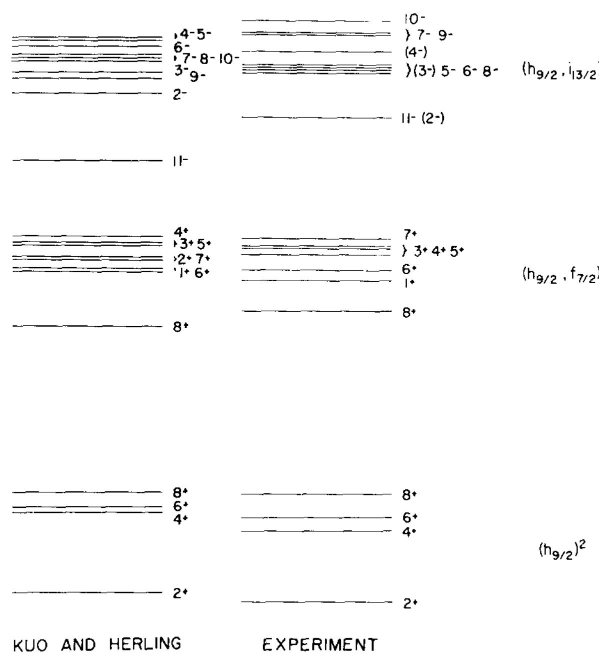

Fig. 3. A comparison of the experimental levels of ^{210}Po with the theoretical results of Kuo and Herling (ref. [2]).

the decay of ^{210}At [3] and from the γ-decay of levels in ^{210}Po populated by the ^{208}Pb(α, 2n)^{210}Po reaction [4].

The ($h_{9/2}$, $f_{7/2}$) multiplet, which should contain eight levels, is shown with better resolution (15 keV) in fig. 2. Seven levels are resolved. The improved resolution in fig. 2 was obtained by using two of the three magnetic spectrographs ancillary to the University of Michigan sector-focused cyclotron [5]; the spectrum in fig. 1 was measured with one spectrograph. The assignment of spins (see table 1) favored exclusion, though not strongly, of the 2^+ state.

Ten levels with spins ranging from 2^- to 11^- are expected in the ($h_{9/2}$, $i_{13/2}$) multiplet. The relative intensities suggest that the strongest group at 2844 keV contains the 11^- state; this tentative assignment is supported by the observation [4] of a 1292 keV γ-ray following the ^{208}Pb(α, 2n)^{210}Po reaction that probably connects the 11^- state to the 8^+ state in the $(h_{9/2})^2$ multiplet. The level at 2910 keV seems too weak to be a member of the multiplet. Inclusion of both the 11^- and 2^- states in the group at 2844 keV fails to quite account for all of its intensity; it may contain a third state which is weak, similar in strength to the level at 2910 keV.

Fig. 3 is a comparison of the experimental results with the calculation of Kuo and Herling [2]. Their shell-model calculation used reaction matrix elements deduced from the Hamada-Johnston potential and included core polarization effects. The overall agreement is quite good.

References

[1] Y. E. Kim and J. O. Rasmussen, Nucl. Phys. 47 (1963) 184.
[2] T. T. S. Kuo and G. H. Herling, private communication.
[3] S. G. Prussin and J. M. Hollander. Nucl. Phys. A110 (1968) 176.
[4] T. Yamazaki and G. T. Ewan, Phys. Letters 24B (1967) 278.
[5] W. C. Parkinson et al., Nucl. Instr. 18 (1962) 93.

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