STRUCTURE OF $^{207}$Pb POPULATED IN $^{208}$Pb + $^{208}$Pb DEEP-INELASTIC COLLISIONS*

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The yrast structure of $^{207}$Pb above the 13/2$^+$ isomeric state has been investigated in deep-inelastic collisions of $^{208}$Pb and $^{208}$Pb at ATLAS, Argonne National Laboratory. New and previously observed transitions were measured using the Gammasphere detector array. The level scheme of $^{207}$Pb is presented up to $\sim$ 6 MeV, built using coincidence and $\gamma$-ray intensity analyses. Spin and parity assignments of states were made, based on angular distributions and comparisons to shell model calculations.

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1. Introduction

$^{207}$Pb is a one-neutron-hole nucleus with respect to the doubly-magic $^{208}$Pb core. The low-lying single-particle states of $^{207}$Pb are described by the $\nu p_{1/2}^{-1}$, $\nu f_{5/2}^{-1}$, $\nu p_{3/2}^{-1}$, and $\nu i_{13/2}^{-1}$ orbitals. The $13/2^+$ single-particle state is isomeric with a half-life of $t_{1/2} = 0.806(5)$ s [1]. Little is known concerning the structure of the yrast states above $13/2^+$, which require the core to be broken. It is expected that the $\nu i_{13/2}^{-1}$ state will couple to states within the $^{208}$Pb core to produce core-breaking states.

Schramm et al. were the first to suggest that a 2485 keV transition lies above the $13/2^+$ state in $^{207}$Pb [2]. The 2485 keV transition was placed connecting a $(19/2^-)$ state to the $13/2^+$ isomer, with the expectation that it is a collective E3 transition. Also placed at the time were six new transitions in coincidence with the 2485 keV $\gamma$ ray, with the spin and parity assignments of the corresponding depopulated states based purely on shell model calculations. The level scheme up to $I^\pi = (29/2^+)$ was suggested.

2. Experiment and results

The experiment was conducted at the ATLAS facility at Argonne National Laboratory, USA. A 75 mg/cm$^2$ thick target of $^{208}$Pb was bombarded with a 1446 MeV beam of $^{208}$Pb. $\gamma$ rays following deep-inelastic collisions were detected by the Gammasphere detector array. Experimental details of this reaction are elaborated in [3].

The $\gamma$-ray spectrum gated on the known 2485 keV $^{207}$Pb transition is shown in Fig. 1. All previously identified $\gamma$-ray transitions are present in the gated spectrum. In addition, several new $\gamma$ rays are visible, including two at 412 and 569 keV. The focus of the work presented here is the level scheme up to $\sim 6$ MeV; thus, a number of the new transitions observed are not discussed. Angular distribution spectra were produced with a single gate on

![Fig. 1. Spectrum gated on the 2485 keV $^{207}$Pb transition, showing transitions above the $13/2^+$ isomeric state. Indicated are, transitions previously seen [2] and a number of new transitions identified in this work.](image-url)
2485 keV, except for the 2485 keV angular distribution spectra which were ungated. Subsequent angular distributions were fitted with the function of the standard form \( W(\theta) = A_0 \{ 1 + A_2 P_2(\cos \theta) \} \), where \( \theta \) is the angle of the \( \gamma \) ray relative to the beam, \( A_i \) are the angular distribution coefficients, and \( P_i \) are the Legendre polynomials. From measurements of intense transitions in \(^{208}\)Pb with known multipolarities, we expect stretched transitions to have: \( A_2 \sim 0.36 \) for an octupole, \( A_2 \sim 0.22 \) for a quadrupole, and \( A_2 < 0 \) for a dipole \([4]\).

Angular distributions are shown in Fig. 2, along with the fitted \( A_2 \) coefficient values and deduced multiplicities. Spins and parities of the states were assigned based on the \( \gamma \)-ray multiplicities. Parities of the \( 23/2^-(\text{−}) \) and \( 29/2^{(+)} \) states were ascertained from the shell model calculations. The deduced level scheme up to \( \sim 6 \) MeV, shown in Fig. 3, is in agreement with the previous work of Schramm et al. \([2]\). A 57 keV \( \gamma \) ray is inferred from coincidence relationships.

![Angular distributions of transitions in \(^{207}\)Pb above the \( 13/2^+ \) isomeric state. Deduced multiplicities are indicated, D denotes dipoles.](image)

Two shell model calculations were performed using the KHH7B and KHM3Y interactions, descriptions of which can be found in \([4]\). The KHH7B calculation used in this work differs from the prescription in \([4]\), in that \( t = 1 \) proton and neutron mixing is considered. Figure 3 compares the calculations to the experiment, displaying a good agreement. The differences between the calculations become apparent when looking to the octupole state, \( 19/2^- \). Variations in the octupole state can be explained by the number of \( \Delta j = \Delta l = 3 \) pairs in each calculation, as discussed in \([4]\).
3. Conclusion

The level scheme of $^{207}$Pb up to $\sim 6$ MeV is presented, and is in agreement with the previous work by Schramm et al. [2]. An additional excited state and three $\gamma$ rays were identified. Our spin and parity assignments are based on angular distribution measurements. Future work will detail the extension of the $^{207}$Pb level scheme to $\sim 10$ MeV.

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