MEASUREMENT OF THE g-FACTOR OF THE 3^- OCTOPOLE VIBRATIONAL STATE IN ^{208}Pb‡

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The nuclear g-factor of the collective 3^- level at 2615 keV in ^{208}Pb has been measured by the perturbed angular correlation technique. The result of $g(3^-) = 0.58 \pm 0.14$ confirms the strongly collective character of the state.

The first excited state of the doubly magic nucleus ^{208}Pb is believed to be an octupole vibrational state built on the 0^+ ground state. The large experimentally observed E3 transition rate [1] to the ground state and the relatively low energy support the description of this state as a collective excitation. The microscopic descriptions of the 3^- state in terms of particle-hole excitations contain a large number of terms all with small amplitudes due to the collective nature of this state. The contribution from the spins to the magnetic moment approximately cancels, since the spins are randomly oriented. We therefore only have a contribution from the orbital motion of the protons. Since the fraction of proton components is about Z/A we also expect the g-factor to be of the order of Z/A. The most detailed calculation of this state has been made by Gillet et al. [2]. Using their wavefunction we calculate the g-factor to be 0.52 [3]. The calculation of Lombard [4] yields $g = 0.5$.

Recently Grodzins and Pramila [5] reported a measurement of this g-factor using the internal field of Pb in an iron lattice. They obtained 0.08 ± 0.07 in disagreement with the above predictions.

In an attempt to clear up this disagreement we undertook a measurement of $g(3^-)$ using an external magnetic field. The integral-reverse-field method of the perturbed γ-γ angular correlation technique was used. The apparatus was identical to that described in ref. 6, except that a 30.5 kgauss electromagnet was used. Because of the very small change in the coincidence counting rate upon the reversal of the magnetic field expected in this case, special care was taken to eliminate any effect of the stray magnetic field on the gain of the photomultiplier tubes. The observed gain shift in the photomultipliers was reduced to less than 5 parts in 10^5.

The radioactive source as ^{228}Th in an HCl solution contained in a small polyethylene sack. The 583-2615 keV γ-γ cascade was used. The low energy was selected with a window at the photopeak of the 583 keV line and in the high energy channel an integral discriminator was set at 1.3 MeV. The true coincidence couting rate was 120 s^{-1} with a "true to random" ratio of 20. As a check on instrumental asymmetry $R(\theta) = [W(\theta,+B) - W(\theta,-B)]/[W(\theta,+B) + W(\theta -B)]$ was also determined for the random background of the time spectrum derived from the time-to-amplitude converter. A 1 μs conversion range was chosen in order to collect the same statistics in true and random coincidences. The results are summarized in table 1.

The lifetime of the 3^- state has been measured with the γ-γ coincidence technique [7] giving $\tau_m = 47 \pm 15$ ps. This value is in poor agreement with the much more accurate results for the lifetime obtained from $B(E3, 0^+ \rightarrow 3^-)$ measurements by Coulomb excitation and inelastic scattering. The results for $B(E3, 0^+ \rightarrow 3^-)$ by several authors are compiled in ref. 1. A weighted average for the lifetime of this level is $\tau_m = 21 \pm 1$ ps. With this lifetime, our result for $\omega\tau$ yields $g(3^-) = +0.58 \pm 0.14$ in good agreement with the theoretical predictions quoted above.

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Table 1
Summary of results

$R(\theta) = [W(\theta, +B) - W(\theta, -B)]/[W(\theta, +B) + W(\theta, -B)]$. The angular correlation coefficients A_2 and A_4 are not corrected for geometry.

$R(135^{\circ})$	$R(225^{\circ})$	R(randoms)
$(3.45 \pm 1.20) \times 10^{-4}$	$-(4.25 \pm 1.48) \times 10^{-4}$	$(-0.31 \pm 0.95) \times 10^{-4}$

$A_2 = +0.144 \pm 0.003$, $A_4 = +0.005 \pm 0.005$, $\omega\tau = (1.80 \pm 0.45) \times 10^{-3}$ rad.

The value reported by Grodzins and Pramila [5] for this g-factor was based on $\tau_m = 47 \pm 15$ ps. Using our weighted average value for the lifetime, their value is modified to $g(3^-) = 0.17 \pm 0.15$. Grodzins and Parmila obtained their value for g assuming an internal hyperfine field of 262 kG at the site of the Pb nucleus in Fe. This internal field was derived from the precession of the 1064 - 570 keV γ-γ cascade in ^{207}Pb which is preceded by the electron capture decay of ^{207}Bi. The levels of ^{208}Pb on the other hand are populated by the beta decay of ^{208}Tl which in turn is fed by the α-particle decay of ^{212}Bi. The discrepancy between the internal field and external field measurements of $g(3^-)$ may indicate that the ^{208}Tl atoms are no longer in lattice position following the recoil due to the preceding α-particle emission. The above interpretation of the discrepancy between the measurements of $g(3^-)$ points to a possible source of systematic error for recoil implantation measurements of g-factors of excited states.

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The value of $D_C^{l=0,1,2}$ given in line 13 of column one on page 373 should be 108.6 MeV instead of 106.7 MeV. This changes the values given in the second and third columns of the second row of table 1 to 58.4 and 34.1, respectively, and D for the HT potential with 40% suppression in odd-parity states to 46.4 MeV for the case $M_\Lambda^*/M_\Lambda = 0.9$. This does not affect the content of the paper.

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