$E0$ decay of the 3788-keV 0^+ level of ^{30}Si†

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The branching ratio of the 0^+ state of ^{30}Si at 3788 keV for decay by e^+-e^- pair emission to the 0^+ ground state is measured to be $(2.7 \pm 0.4) \times 10^{-3}$. Combining this branching ratio with the previously measured lifetime of the state leads to an $E0$ matrix element of (0.054 ± 0.009) single particle units.

[NUCLEAR STRUCTURE ^{30}Si; measured branching ratio $E0$ decay 3788-keV level; deduced $E0$ matrix element.]

The ^{30}Si 3788-keV 0^+ level decays by an $E2$ transition to the ^{30}Si 2236-keV 2^+ first-excited state with a mean life of 15.6 ± 1.3 ps.[1] In our continuing program[2-4] for the determination of $E0$ matrix elements in light- and medium-weight nuclei, we have observed the e^+-e^- internal pairs corresponding to the $0^+ \to 0^+$ ground-state transition of the 3788-keV level. A water cooled target consisting of 1.5-mg/cm^2 $^{30}SiO_2$ evaporated onto a 13-mg/cm^2 Ag foil was bombarded by 0.5–1 μA of 7.0-MeV protons from the Brookhaven National Laboratory (BNL) MP tandem Van de Graaff facility and $e^\pm$ pairs were observed with the BNL magnetic-lens intermediate-image pair spectrometer.[5] The transition energy region between 3290 and 4070 keV was examined with 3% resolution. Two peaks were observed corresponding to the ground-state decay of the 2^+ 3498-keV level[6] as well as the 3788-keV $E0$ transition. It was also expected that this $E0$ peak contained a contribution from the unresolved $M1$ ground-state decay of the 1^+ 3770-keV level.[6] The relative intensities of the 3498- and 3788-keV peaks were determined by a least-squares fit of a function composed of two peaks of predetermined shape superimposed on a quadratic background as illustrated in Fig. 1. The relative intensities were in the ratio $(19.6 \pm 1.5):(35.1 \pm 2.3)$.

In order to interpret this result it is necessary to determine the intensity of the 3498-keV transition relative to the intensity of formation of the 3788-keV level and also to determine the contribution of the $M1$ 3770-keV transition to the 3788-keV peak. This information was provided by Ge(Li) spectra of the γ rays emitted under the same experimental conditions. Spectra were taken at 0, 30, 60, and 90° to the beam and the relative intensities of the appropriate lines were extracted for each spectrum and corrected for detection efficiency. The angular variation of the intensities was then obtained to yield the relative intensities and angular distributions. The $0^+ \to 2^+$ 1552-keV transition, which represents the formation of the 3788-keV level, was found to be 0.69 as intense as the 3498-keV transition while the 3770-keV transition was 0.39 times as intense. The theoretically and accurately known internal pair emission co-

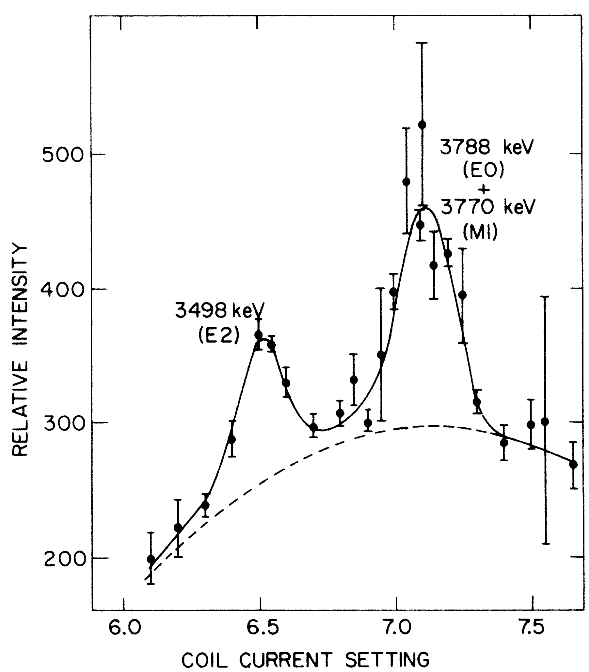

FIG. 1. Pair spectrum of electromagnetic transitions in ^{30}Si in the range 3.3 to 4.1 MeV. Note suppressed zeros. Ground-state transitions from the 3498-, 3770-, and 3788-keV levels of ^{30}Si are expected in this region. The resolution of 3% is not sufficient to resolve the latter two peaks. The solid curve is a least-squares fit to the data assuming two peaks (of predetermined shape and position) superimposed on a background represented by a quadratic. The background resulting from the fit is given by the dashed curve.

TABLE I. Experimental results relevant to the calculation of the ^{30}Si $E0$ branching ratio.

Transition (keV)	$J_i \rightarrow J_f$	Relative intensity Ge(Li)	pair spect.[b]	Angular distribution[a] a_2(%)	a_4(%)	Pair spect. eff. ($\times 10^6$) c	d
1552	$0^+ \rightarrow 2^+$	5397 ± 138	···	0	0	···	···
3498	$2^+ \rightarrow 0^+$	7834 ± 163	19.6 ± 1.5	$+23 \pm 3$	$+4 \pm 5$	65	73
3770	$1^+ \rightarrow 0^+$	3044 ± 136	6.0 ± 0.5	-13 ± 7	0	62	58
3788	$0^+ \rightarrow 0^+$	···	29.1 ± 2.4	0	0	58×10^3	58×10^3

[a] Legendre polynominal expansion coefficients from $W(\theta) = I_\gamma[1 + a_2 P_2(\cos\theta) + a_4 P_4(\cos\theta)]$. Those coefficients with zero entries are theoretically identically zero.

[b] The separation of the intensities of the 3770- and 3788-keV transitions (sum: 35.1 ± 2.3) was accomplished using the relative 3770- and 3498-keV Ge(Li) intensities and the pair spectrometer efficiencies.

[c] The pair spectrometer efficiency for emission of pairs by unaligned nuclei.

[d] The pair spectrometer efficiency corrected for alignment using the given a_2 and a_4 coefficients. The relative uncertainties are estimated as 5%.

efficients of the 3498-, 3770-, and 3788-keV transitions can be used to predict[1,7] the relative efficiency for detecting internal pairs for these $E2$, $M1$, and $E0$ transitions. After correcting for the alignment of the 2^+ and 1^+ states as determined by the γ-ray angular distributions[2] we find that the contribution to the 3788-keV peak from the 3770-keV transition is 17% and the $E0$ branching ratio of the 3788-keV level is $(2.7 \pm 0.4) \times 10^{-3}$. The relevant experimental factors are summarized in Table I.

The Wilkinson[8] single-particle unit strength for this $E0$ transition corresponds to a partial lifetime of 0.315 ns. The branching ratio of $(2.7 \pm 0.4) \times 10^{-3}$ when combined with the mean life of (15.6 ± 1.3) ps[1] yields a partial $E0$ lifetime of (5.8 ± 1.0) ns which corresponds to (0.054 ± 0.009) single-particle units. This is an $E0$ matrix element of medium strength as compared to other known[9] $E0$ matrix elements in $A \leq 48$ nuclei.

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