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Comments and Addenda

The Comments and Addenda section is for short communications which are not of such urgency as to justify publication in **Physical Review Letters** *and are not appropriate for regular Articles. It includes only the following types of communications: (1) comments on papers previously published in* **The Physical Review** *or* **Physical Review Letters***; (2) addenda to papers previously published in* **The Physical Review** *or* **Physical Review Letters***, in which the additional information can be presented without the need for writing a complete article. Manuscripts intended for this section should be accompanied by a brief abstract for information-retrieval purposes. Accepted manuscripts will follow the same publication schedule as articles in this journal, and galleys will be sent to authors.*

Level Scheme of ^{144}Sm Determined by the (γ, γ') Reaction

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The 8.998-MeV resonance level excited by the (γ, γ') reaction, which was previously assigned to ^{150}Sm, is shown to belong to ^{144}Sm. The level scheme of ^{144}Sm is given and the reevaluated level parameters of the 8.998-MeV resonance are presented.

Resonance fluorescence of the 8.998-MeV level in natural samarium excited by nickel capture γ radiation[1] was tentatively assigned[2] to ^{144}Sm, since this is the only stable samarium isotope having the (γ, n) threshold above 9 MeV, and observation of resonance fluorescence of an unbound level was considered unlikely. This resonance level was later remeasured using Ge(Li) detectors, and transitions to lower levels were observed. Several transitions populated levels corresponding to known low-lying levels of ^{150}Sm, and the resonance level was therefore assigned[3,4] to an unbound level in this isotope. It was pointed out,[5] however, that the measured ground-state transition width found for this level, together with the level spacing for ^{150}Sm at 9 MeV, resulted in an unusually high value of the strength function, showing that this level was of an unusual nature. Based on this assignment of the 8.998-MeV level an apparent strong correlation between the (d,p) and (γ, γ') reduced reaction widths leading to the same final states in ^{150}Sm was reported.[6]

Recent experimental data, however, indicate that the original assignment of the resonant level to ^{144}Sm is after all the correct one. The decay scheme of the 8.998-MeV resonance level in Sm as obtained in the present work, is shown in Fig. 1 together with other experimental and calculated results for ^{144}Sm. Most of the levels shown in the figure seemed to correspond to levels in ^{150}Sm as published in *Nuclear Data Sheets* of 1964. However, more recently published decay schemes[7] with more accurate energies show that only four of the levels in Fig. 1 correspond to known levels in ^{150}Sm. Even this matching of four levels could well be fortuitous, since ^{150}Sm has a high density of levels in the energy range 1.5 to 3 MeV, with an average level spacing of 40 keV and an experimental energy resolution of ±10 keV. Moreover, one of these matching levels, namely at 1.652 MeV, has been reported[7,8] to have a 4^+ spin and hence is not likely to be populated from the 8.998-MeV resonance level which has spin 1. Also, no levels below 1.65 MeV were populated from the 8.998-MeV level, although ^{150}Sm has 14 levels below this energy, of which 9 are known to have spins of 0^+ or 2^+.[7,8] This makes it extremely unlikely that the resonance level is in fact in ^{150}Sm, since the E^3 intensity dependence favors the population of lower-lying levels. If we assume a Porter-Thomas distribution of the reduced transition widths from the 8.998-MeV level to levels of appropriate spin and parity, the probability of not observing transitions to the nine adjacent lowest-lying levels is less than 10^{-3}.

^{144}Sm, with its 82-neutron shell, is the only sa-

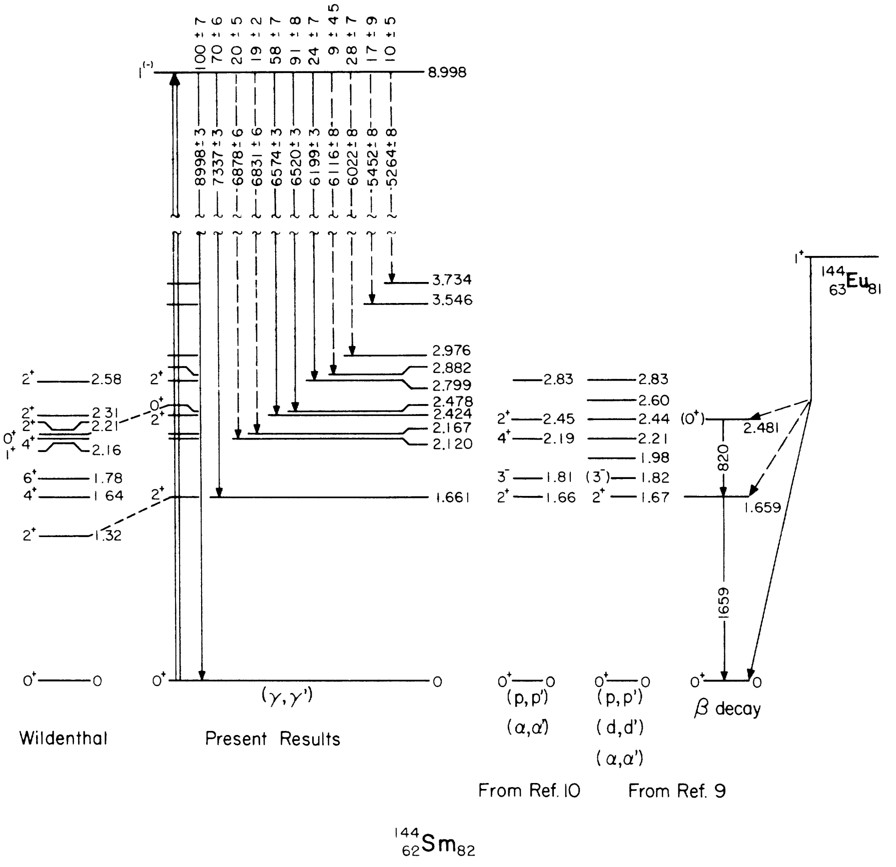

FIG. 1. The level scheme of ^{144}Sm as obtained by the various experimental methods, compared with the theoretical shell calculations of Wildenthal cited in Ref. 10 (some of the calculated levels of spin 3^+ or higher – not relevant to this work – have been deleted). The level energies are given in MeV, and transition energies in keV. The transition intensities from the 8.998-MeV level are as obtained with the nickel source temperature at 670°K. The transition intensities as obtained with the nickel temperature at 320°K are different and transitions marked by broken arrows were not observed.

marium isotope having the first excited 2^+ state at an energy of 1.659 MeV,[9] in good agreement with the lowest excited level populated from the 8.998-MeV level; all the other stable isotopes of samarium have many levels below 1.65 MeV. The assignment of ^{144}Sm is reinforced by the recent (p, p') and (α, α') results of Barker and Hiebert.[10] They obtained a definite spin assignment of 2^+ for the 2.45-MeV level, while the 2.48-MeV level was previously shown from β decay[9] to be 0^+, and they concluded that there are probably two different levels at this energy. The doublet of 2.424-MeV 2^+ and 2.478-MeV 0^+ levels in our results are in excellent agreement with the above findings. The same authors mention that the 2.83-MeV level is probably a multiplet, and it has actually shown up in our results as three different levels. Furthermore, inspection of the results of the (p, p') experiments (see Fig. 4 of Ref. 10) reveals two peaks at channel number of about 1800 and 1850. These were probably assigned by the authors to background, since corresponding lines did not appear in the (α, α') reaction. However, these peaks correspond to the levels at energies of 3.546 and 3.734 MeV found in the present experiment.

There is fairly good agreement between our results and Wildenthal's calculations[11] for the ^{144}Sm nucleus. (In order to simplify Fig. 1, some levels of spin 3^+ or higher not relevant to the present results have been deleted.) Up to 2.800 MeV there is an almost one-to-one correspondence between our results and the 0^+, 1^+, and 2^+ levels calculated by Wildenthal. It can therefore be taken as confirmed that the level scheme derived from the 8.998-MeV resonance describes the ^{144}Sm nucleus, and provides important new data concerning the levels of low spin in this nucleus.

The parameters of the 8.998-MeV level have been reevaluated and the data listed in Table I of Ref. 5 for ^{150}Sm should be replaced by the following data for ^{144}Sm: $\Gamma = 0.27 \pm 0.08$ eV; $\Gamma_0 = 0.063 \pm 0.013$ eV; level spacing $D = 110$ eV; reduced transition strength $K_{E1} = 28.6 \times 10^3$ eV MeV^{-4} and $K_{M1} = 786 \times 10^3$ eV MeV^{-4}; the strength parameter $c = 5.67 \times 10^{-5}$. This value of c is within a factor of 3 of the value 2.2×10^{-5} derived by Axel[12] by extrapolation of the giant electric dipole resonance and is now in good agreement with the other values presented in the above-mentioned table.

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Possible Statistical-Model Explanation for the ^{26}Mg(p, t)^{24}Mg Reaction at $E_p = 26$ MeV*

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A simplified Hauser-Feshbach treatment of angular distributions of the ^{26}Mg(p,t)^{24}Mg reaction populating levels in ^{24}Mg up to 7.59-MeV excitation energy yields good agreement with the data for several of the states above the 1.37-MeV 2^+ level. In particular, it is not necessary to invoke a direct two-step process to explain the magnitude and shape of the 3^+ level at 5.22 MeV excitation as suggested by Shepard, Kraushaar, and Baer.

Angular distributions from the ^{26}Mg(p, t)^{24}Mg reaction to the first 10 levels in ^{24}Mg have been measured recently by Shepard, Kraushaar, and Baer (SKB)[1] at bombarding energies of 25.4, 26.8, and 27.3 MeV. SKB present arguments against statistical contributions being important for the weakly excited states and suggest the need for two-step processes to explain the data. However, no calculations have been performed to prove this point more rigorously. In the present note it is shown that a simplified Hauser-Feshbach treatment of the data gives good agreement for several of the weakly excited states above the 2^+ (1.37 MeV) state.

For calculation of the angular distributions, the usual form of the average cross section in the statistical model[2] was used with the simplification given by Eberhard *et al.*,[3] where the sum over all exit channels into which the compound nucleus can decay is replaced by an explicit expression obtained from the Fermi-gas model. In this approximation, Eq. (19) of Ref. 3, the parameters appearing in the sum over exit channels are the density of spin-zero states in the compound nucleus ($\rho = \Gamma_0/D_0$) and an average value of the spin-distribution parameter (σ) for the various residual nuclei reached by the decay of the compound nucleus. The compound nucleus was assumed to decay predominantly by neutron, proton, and α-particle emission, and the calculated values[4] for these parameters were $\rho = 1570$ and $\sigma = 3.2$, in qualitative agreement with the work of Gilbert and Cameron[5] and Gadioli and Zetta.[6] These values were kept fixed throughout the analysis.

The proton and triton optical potentials given by SKB[1] were used to find the entrance and exit channel transmission coefficients, respectively. All the potential parameters were kept fixed and in