Comment on “Intruder Configurations in the $A = 33$ Isobars: ^{33}Mg and ^{33}Al ”

Herewith, we comment on a recent β -decay study of ^{33}Mg [1] and question the proposed ground-state configuration in light of our spin and magnetic-moment measurement [2]. The argument in Ref. [1] for assigning a positive parity to the ground state of ^{33}Mg is entirely based on assuming detection of all the decay strength. On the other hand, the negative magnetic moment is a key result from our work that, in our view, can only be accommodated with a negative-parity interpretation.

We apply the deformed shell model, considering the prolate shape of ^{33}Mg , supported by reaction data [3,4]. Calculated magnetic moments along the Fermi level for 21 neutrons [5] are presented in Table I, to be compared with the measured values: $\mu = -0.7456(5)\mu_N$ and $I = 3/2$ [2]. The moment associated with the negative-parity $3/2$ [321] orbital has the correct sign. Closest to the experiment, however, is the value of the $I = K + 1$ state with a single-particle occupation of the $1/2$ [330] orbital. Indeed, at a moderate deformation $\beta = 0.3$, the decoupling parameter is well below -1 , thus making $3/2^-$ the lowest state in that rotational band. The moment of the positive-parity $3/2$ [202] configuration is positive due to the dominant $\nu d_{3/2}$ component in the wave function. The decoupling parameter of the $1/2$ [200] state is close to zero for $\beta > 0.3$, and therefore, the lowest level of this band has a spin $I = K = 1/2$. At $\beta = 0.45$, this orbital represents the Fermi level for $N = 19$, and the corresponding magnetic moment is in good agreement with the experimental value for ^{31}Mg : $\mu = -0.88355(15)\mu_N$ [6].

The authors of Ref. [1] propose coupling of a $d_{3/2}$ neutron, characterized by a positive Schmidt value, with two unpaired neutrons in the pf shell in order to explain the negative magnetic moment of ^{33}Mg . Such three-quasiparticle configuration, involving two different orbits, has never been observed as a ground state, and certainly not in ^{31}Mg [6], where the two pf neutrons are coupled to $J = 0$. On the other hand, the negative magnetic moment of ^{33}Mg is consistent with a negative-parity $3p$ - $2h$ configuration [2], which can become the ground state due to the reduced $N = 20$ shell gap, gain in pairing energy, and enhanced quadrupole collectivity when two neutron holes are opened in the sd shell [7].

The following points need to be considered with regard to any unobserved strength in the β decay of ^{33}Mg [1]. First, the large Q_β value of 13.4 MeV opens a wide window for γ decay up to the 5.5 MeV neutron-separation energy. With the highest reported level at 4.73 MeV, a gap of nearly 1 MeV is left for nonobserved states. In such cases, much of the γ intensity remains undetected, a problem known as Pandemonium [8]. Second, the ground-state branch depends on preceding experiments, as β -delayed neutrons have not been measured in their work. Finally, the possibility of isomeric states in ^{33}Al has to be considered.

TABLE I. Particle-plus-rotor magnetic moments using the potential from Ref. [5], $g_R = 0.35$, $g_\ell^\nu = 0$, and $g_s^\nu = 0.6g_s^{\nu,\text{free}}$.

I^π	s.p. orbital	β	μ (μ_N)	a
$3/2^-$	$1/2$ [330]	0.30	-0.76	-3.07
$3/2^+$	$3/2$ [202]	0.40	$+0.80$	
$3/2^-$	$3/2$ [321]	0.50	-0.32	
$1/2^+$	$1/2$ [200]	0.55	-0.94	0.21
$1/2^+$	$1/2$ [200]	0.45	-0.86	-0.02

Reaction experiments [3,4] show that the 484 keV level in ^{33}Mg has the same parity as the ground state. With less than 1.2% feeding to this level in the β decay of ^{33}Na [9], the ground-state branch of 20(10)% is most likely overestimated. Thus, a parity change between ^{33}Na and ^{33}Mg is not ruled out.

Our measurement [2], combined with further theoretical modeling, strongly suggests that the ground-state parity of ^{33}Mg is negative, in contradiction with the conclusions of Ref. [1]. We have discussed here possible sources of error, which could result in an overestimated ground-state branch in the decay of ^{33}Mg to ^{33}Al . Furthermore, even the questioned $\log ft$ value of 5.2 may not completely exclude a possible first-forbidden transition. Clearly, final solution of the ^{33}Mg parity would require additional experimental input.

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