nies, P. Van Assche, and J. Vervier (North-Holland, Amsterdam, 1966), p. 379.

[9] The FORTRAN-IV version of the DW code JULIE was used in all DW calculations. R. H. Bassel, R. M. Drisko, and G. R. Satchler, Oak Ridge National Laboratory Report No. ORNL-3240, 1962 (unpublished); Oak Ridge Memorandum to the Users of the Code JULIE, 1966 (unpublished).

[10] G. Bencze and J. Zimanyi, Phys. Letters 9, 246 (1964); P. J. A. Buttle and L. J. B. Goldfarb, Proc. Phys. Soc. (London) 83, 701 (1964); J. K. Dickens, R. M. Drisko, F. G. Perey, and G. R. Satchler, Phys. Letters 15, 337 (1965).

[11] F. G. Perey and D. S. Saxon, Phys. Letters 10, 107 (1964).

[12] N. Austern, Phys. Rev. 137, B752 (1965); F. G. Perey, in *Proceedings of the Rutherford Jubilee International Conference, Manchester, 1961,* edited by J. B. Birks (Heywood and Company, Ltd., London, 1962), p. 125.

[13] A. M. Green, Phys. Letters 24B, 384 (1967).

[14] J. C. Hiebert, E. Newman, and R. H. Bassel, Phys. Rev. 154, 898 (1967).

PHYSICAL REVIEW C VOLUME 5, NUMBER 2 FEBRUARY 1972

g Factor of the $\frac{19}{2}^-$ Isomeric State in ^{43}Sc[†]

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(Received 17 August 1971)

The g factor of the $\frac{19}{2}^-$ state in ^{43}Sc is discussed within the framework of the conventional shell model. An inert ^{40}Ca core is assumed. The effective interaction derived for this mass region by Kuo and Brown is used. It is shown that the g factor can be well explained with a small configuration mixing. The g factor of the 6^+ state in ^{42}Ca is also discussed.

The explanation of the measured magnetic dipole moments provides a useful probe in the study of nuclear structure. With the j-j coupling shell model, the various features of the deviations of magnetic dipole moments from the Schmidt values were interpreted by configuration mixing for almost the whole region of nuclei.[1] Freed and Kisslinger[2] carried out the calculations using the same method, but within the framework of the pairing model. For the magnetic dipole moments of $p_{1/2}$-shell nuclei, the importance of the tensor force which causes the configuration mixing is emphasized in the explanation of the small deviations from the Schmidt values.[3] However, these calculations were restricted to the magnetic dipole moments of the ground state of odd-mass nuclei, where the mixed seniority-three configurations were assumed to be the initial nucleon of the seniority-one configuration coupled to the other two nucleons of the same kind having equal orbital angular momenta and $J=1$. The deviations from the Schmidt values of the magnetic dipole moments of high-spin excited states have been studied in the ^{208}Pb region[4] and $A=88$ region.[5] The anomalous $g^{\rm eff}$ factor of about 1.10 has been deduced under the assumption of the renormalized single-particle operator $\vec{\mu}=g_l^{\rm eff}\vec{l}+g_s^{\rm eff}\vec{s}$.

In addition, the g factor of the $\frac{19}{2}^-$ isomeric state in ^{43}Sc has recently been measured to be 0.331 ± 0.002 by both the time-differential, perturbed-angular-distribution, and the stroboscopic-resonance methods.[6] The configuration of this $\frac{19}{2}^-$ state was proposed to be an $f_{7/2}$ proton coupled to the 6^+ state in ^{42}Ca. A g factor for the $f_{7/2}$ proton was deduced from the measured value combined with the experimental value for the g factor of the 6^+ state in ^{42}Ca under the assumption of the additivity of g factors. However, there are two experimental values for the 6^+ state[5,7] which do not agree with each other. Nevertheless, the g factors of the $f_{7/2}$ proton deduced from both values were close to, or even larger than, the Schmidt value. By adopting the more recent datum in Ref. 5, Nakai *et al.*[6] have shown that the single-particle value, using the orbital g factor of the proton $g(\text{proton})=1.1$, agrees with the experimental value of the g factor of the $\frac{19}{2}^-$ state in ^{43}Sc. They also concluded that the anomaly of this magnitude (~10%) of g(proton) may indicate the same effect as those reported by Yamazaki *et al.* in the ^{208}Pb[4] and ^{90}Zr[5] region.

In the present work it is shown that the measured value of the g factor of the $\frac{19}{2}^-$ state in ^{43}Sc can be explained without the adoption of an anomalous g(proton) factor by a small mixing of another configuration. The calculations under discussion are carried out within the framework of the conventional shell model. An inert ^{40}Ca core is assumed. For the $\frac{19}{2}^-$ state in ^{43}Sc, the $1p_{3/2}$ and $1p_{1/2}$ orbits are irrelevant to the basis vectors, while the effect of the $0g_{9/2}$ orbit is quite small, so that its contribution to the g factor is negligible. The basis vectors are thus $|(\nu f_{7/2})^2_6(\pi f_{7/2})\rangle_{19/2}$ and $|(\nu f_{7/2}f_{5/2})_6(\pi f_{7/2})\rangle_{19/2}$. For the single-particle energy and the effective interaction, the results given for this mass region by Kuo and Brown[8] are used. Then the wave function of the $\frac{19}{2}^-$ state obtained by diagonalizing the two-by-two interaction matrix is

$$0.9910|(\nu f_{7/2})^2_6(\pi f_{7/2})\rangle_{19/2}+0.1337|(\nu f_{7/2}f_{5/2})_6(\pi f_{7/2})\rangle_{19/2}\,. \qquad (1)$$

TABLE I. The g factor of the $\frac{19}{2}^-$ state in ^{43}Sc.

	g(neutron)	g(proton)	g(total)
Case I	−0.48	1.66	0.31
Case II	−0.55	1.66	0.26
Expt.			0.331 ± 0.002

In Table I, the calculated g factors are shown and compared with the experimental data.[6] The individual contributions from both neutron and proton are also listed. Case I exhibits the value calculated with the configuration mixing, while case II is the value estimated from the pure state $|(\nu f_{7/2})^2_6(\pi f_{7/2})\rangle_{19/2}$. Though the mixing of the configuration $|(\nu f_{7/2}f_{5/2})_6(\pi f_{7/2})\rangle_{19/2}$ is less than 2%, its contribution to the g factor is quite significant. In analyzing the experimental data, Nakai *et al.*[6] have utilized the measured value for the g factor of the 6^+ state in ^{42}Ca. In the present calculation, the wave function of the 6^+ state is given as

$$0.9918|(\nu f_{7/2})^2\rangle_6+0.1274|(\nu f_{7/2}f_{5/2})\rangle_6\,, \qquad (2)$$

which produces the same g-factor value of −0.48 as that from the contribution of two neutrons in the $\frac{19}{2}^-$ state in ^{43}Sc. If the active $0g_{9/2}$ orbit is included in the basis-vector spaces, the wave function is then

$$0.9890|(\nu f_{7/2})^2\rangle_6+0.1320|(\nu f_{7/2}f_{5/2})\rangle_6-0.0662|(\nu g_{9/2})^2\rangle_6\,, \qquad (3)$$

and the g-factor value still remains unchanged. Our calculated g factor is close to the measured value, $-0.50^{+0.02}_{-0.03}$ (Ref. 5), but in disagreement with the other experimental value, -0.42 ± 0.03 (Ref. 7). Nevertheless, the correction from the single-particle value −0.55 is in the right direction.

In the present calculation, the adoption of 6.5 MeV as the splitting of the single-particle energy between $0f_{5/2}$ and $0f_{7/2}$ is questionable. For the low-lying levels in ^{41}Sc, a $\frac{5}{2}^-$ state at 3.19-MeV excitation energy has been identified and three other states below 6-MeV excitation energy may be the $\frac{5}{2}^-$ states.[9] Also, the spectroscopic factor of $l=3$ is widely distributed among these levels. In Fig. 1, the dependence of the g factor of the $\frac{19}{2}^-$ state in ^{43}Sc on the value of $\epsilon_{f_{5/2}}-\epsilon_{f_{7/2}}$ is shown, while that of the 6^+ state in ^{42}Ca is shown in Fig.

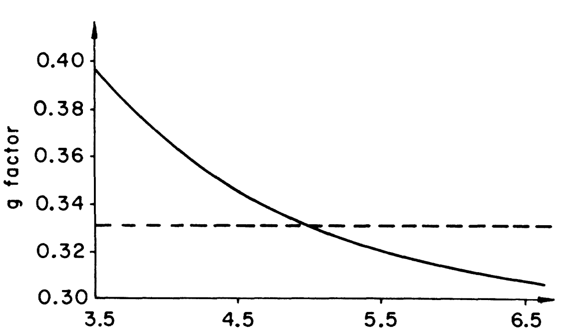

FIG. 1. Dependence of the g factor of the $\frac{19}{2}^-$ state in ^{43}Sc on the value of $\epsilon_{f_{5/2}}-\epsilon_{f_{7/2}}$ value. The solid line is the calculated value. The dashed line is the experimental value of Ref. 6.

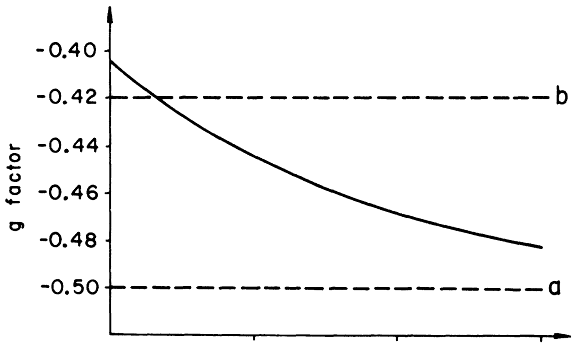

FIG. 2. Dependence of the g factor of the 6^+ state in ^{42}Ca on the value of $\epsilon_{f_{5/2}}-\epsilon_{f_{7/2}}$ value. The solid line is the calculated value. The dashed lines a and b are the experimental values in Refs. 5 and 7.

2. Both the g factors of the $\frac{19}{2}^-$ state in ^{43}Sc and that of the 6^+ state in ^{42}Ca decrease with an increase in the value of $\epsilon_{f_{5/2}} - \epsilon_{f_{7/2}}$. As shown in Fig. 1, the g factor from the value $\epsilon_{f_{5/2}} - \epsilon_{f_{7/2}} = 5.0$ MeV agrees with the experimental data for that of the $\frac{19}{2}^-$ state in ^{43}Sc. Also, this value of $\epsilon_{f_{5/2}} - \epsilon_{f_{7/2}}$ gives the g factor of the 6^+ state in ^{42}Ca to be -0.46, which corresponds to the average of the two measured values.[5,7]

Nakai *et al.*[6] indicated that the single-particle value using the orbital g factor of the proton $g_l(\text{proton}) = 1.1$ agrees with the experimental value. In view of the large deviation from the Schmidt value of the magnetic dipole moment of the ^{43}Sc ground state,[10] which is expected to be composed mainly of the configuration $|(\nu f_{7/2})^2{}_0(\pi f_{7/2})\rangle_{7/2}$, a small change of the g_l(proton) is not enough to explain the measured value. In addition, the correction for the deviation from the single-particle value is of the opposite sign if one chooses g_l(proton) > 1.

In conclusion, the configuration-mixing calculation is an attempt to calculate microscopically the deviation of the g factor of the $\frac{19}{2}^-$ state in ^{43}Sc from the single-particle value. In view of our calculated g factor of the 6^+ state in ^{42}Ca, it is worthwhile to extend the calculation to the g factor of the 8^+ states in $A = 88$ and 208 regions, where both neutron and proton do not belong to the closed shells in the sense of L-S coupling.

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†Work supported by the National Science Council of the Republic of China.

[1] H. Noya, A. Arima, and H. Horie, Progr. Theoret. Phys. (Kyoto) Suppl. 8, 33 (1958).

[2] N. Freed and L. S. Kisslinger, Nucl. Phys. 25, 611 (1961).

[3] S. T. Hsieh, Phys. Rev. C 3, 1220 (1971).

[4] T. Yamazaki, T. Nomura, U. Katou, T. Inamura, A. Hashizume, and Y. Tendou, Phys. Rev. Letters 24, 317 (1970); T. Yamazaki, T. Nomura, S. Nagamiya, and T. Katou, Phys. Rev. Letters 25, 547 (1970).

[5] S. Nagamiya, T. Katou, T. Nomura, and T. Yamazaki, Phys. Letters 33B, 574 (1970).

[6] K. Nakai, B. Skaali, N. J. Sigurd Hansen, and B. Herskind, Phys. Rev. Letters 27, 155 (1971).

[7] R. A. Ricci, in *Proceedings of the International School of Physics "Enrico Fermi," Nuclear Structure and Nuclear Reactions, Course XL*, edited by M. Jean and R. A. Ricci (Academic, New York, 1969), p. 80.

[8] T. T. S. Kuo and G. E. Brown, Nucl. Phys. A114, 241 (1968).

[9] D. H. Youngblood, R. L. Kozub, R. A. Kenefick, and J. C. Hiebert, Phys. Rev. C 2, 477 (1970).

[10] G. H. Fuller and V. W. Cohen, Nucl. Data A5, 445 (1969).