# Core Polarization in the Light of New Experimental $g$ Factors of $fp$ Shell N=28 Isotones ◇

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The effect of core polarization on nuclear magnetic moments has been studied for N=28 isotones of fp shell nuclei. Core polarization by valence nucleons generally causes a quenching of the magnetic moment of nuclear states, a pattern which has been observed in many $g$ factor measurements [1,2]. One particular feature of this phenomenon was predicted by Arima and Horie [3,4] in their early work on core polarization, especially with respect to the odd-mass N=28 isotones which span a region from $^{49}$Sc(Z=21) to $^{55}$Co(Z=27). Their groundstates have spin and parity $7/2^-$ corresponding to a $(f_{7/2})^n$ proton configuration implying for all four nuclei the same magnetic moment, $g(\pi\ f_{7/2})=1.655$.

The very precise experimental $g$ factors of $^{51}$V, $^{53}$Mn and $^{55}$Co [5] exhibit in fact much lower values and differ from each other. Core polarization accounts for both these features. The first order perturbation theory calculations by Arima and Horie yield a substantial quenching of the $g$ factor whose magnitude increases linearly with the number of proton holes in the $f_{7/2}$ shell which is experimentally confirmed.

For the even mass N=28 isotones new precise experimental $g$ factors of the first $2_1^+$ state of $^{54}$Fe, $^{52}$Cr and $^{50}$Ti were obtained in measurements employing Coulomb excitation in inverse kinematics to beams of these nuclei and multilayered targets with natural carbon for the excitation. The beam energies ranged from 130 MeV for $^{54}$Fe to 110 MeV for $^{50}$Ti which were provided by the tandem accelerators in Munich and Cologne, respectively. The result for $^{52}$Cr has been already reported in [6]. It turns out that all even nuclei have significantly lower $g$ factors than those of their odd neighbours, which lie also on a straight line by varying the number of $f_{7/2}$ proton holes, however, exhibiting a strikingly different slope (see fig. 1).

This feature has been discussed in terms of shell model calculations considering commonly used effective interactions as FPD6 [7] and KB3 [8] as well as first order perturbation theory. In the shell model diagonalization considering the excitation of one particle from the $f_{7/2}$ shell to the other fp shell orbits only the results of using the FPD6 interaction gives good agreement with both the odd and even nuclei (see fig. 1). While the difference in slope is rather well described the quenching is not fully reproduced. It is noted, however, that larger scale model calculations cause for the even nuclei a flattening of the straight line whereby the $^{50}$Ti($2_1^+$) $g$ factor is significantly lower than the experimental value. Moreover, the differences between different effective interactions vanish, a result being not yet understood.

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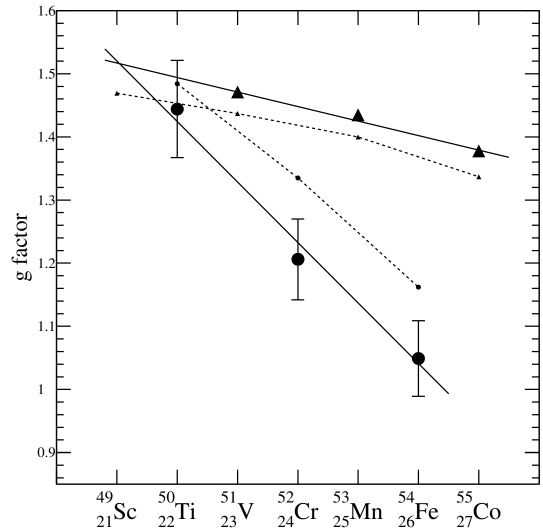


Fig. 1: Comparison of the experimental (large symbols) and theoretical (small symbols) $g$ factors of the $N = 28$ isotones. The solid lines are linear fits to the data; the dashed lines are drawn to guide the eye.

The approach of first order perturbation theory yields different results in part because only the excitation of $f_{7/2}$ to $f_{5/2}$ contributes to the change in $g$ and of course only linear terms in the interaction are kept. The difference between the $g$ factor of a nucleus with two protons coupled to spin I and that of a one proton nucleus in the I=j groundstate, $\delta g^I \sim M^I$ where $M^I = (g_l - g_s)\langle (jj)^I|\frac{V}{E}|(jj')^I\rangle$. It can be shown that $\delta g^I$ for two holes or two particles have the opposite sign. Thus $g(^{54}\mathrm{Fe})^I = g(^{55}\mathrm{Co})$ - $\delta g^I$. A relation between the different slopes of even ($m_I$) and odd ($m_j$) isotones can then be written in terms of $\delta g^I$: $m_I = \frac{3}{2} m_j - \frac{1}{2}\delta g^I$. Evidently, the magnitude and sign of $\delta g^I$ depend on the interaction $V$ supporting the result that only the FPD6 interaction gives a fairly good account of the data. On the whole one can conclude that the experimental data require calculations which extend beyond first order perturbation theory.

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