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EXCITED STATES IN THE PROTON $f_{7/2}$ SHELL

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Goldstein and Talmi[1] have pointed out that it is sometimes possible to determine the excitation energies of the states of a j^n configuration by making use of the experimentally measured splittings of the j^2 configuration together with the tabulated coefficients of fractional parentage.[2] We have used this technique to make spin assignments for the excited states of nuclei with $(f_{7/2})^n$ protons and 28 (closed shell) neutrons. The purpose of this note is to stimulate interest in obtaining experimental verification of these predictions.

As our starting point we take the excitation energies for the configuration $(f_{7/2})^{-2}$ as given by (p, p') measurements[3] on Fe^{54}. Making use of these, one finds it a simple matter to compute the energy splittings for $(f_{7/2})^{-3}$ --which, of course, should be the same as $(f_{7/2})^3$. We also predict that the lowest states of $(f_{7/2})^4$ should be the same as those of $(f_{7/2})^{\pm 2}$. This conclusion follows from the supposition that the lowest states should be those of lowest seniority. Consequently, the $(f_{7/2})^4$ states of seniority two, $J = 2, 4, 6$, correspond to the

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recoupling of only two of the protons, the identical physical situation occurring in $(f_{7/2})^2$. A summary of our prediction together with the known experimental information is contained in the table.

It should be noted that the predictions for $(f_{7/2})^{\pm 3}$ are extremely sensitive to the values assumed for the two particle energies. If, for example, one averages the $(f_{7/2})^{-2}$ excitation energies from Buechner and the $(f_{7/2})^4$ values obtained by Huiskamp et al.,[4] one obtains for $(f_{7/2})^{\pm 3}$ the energies 0.32 (5/2), Mev (above ground), 0.89 (3/2), 1.73 (9/2), 1.75 (11/2), and 3.12 (15/2). Here the positions of the 5/2, 3/2, and (if one has a sense of humor) 15/2 states are in excellent agreement with experiment, and the relative positions of the 9/2 and 11/2 levels are reversed from the predictions made by using only Buechner's values.

In the table we have given, under Ti^{50}, only the levels that have been found by Pieper.[5] If we take the Ti^{50} level at 1.58 Mev to be a 2^+, we can make use of the known excitation energies of V^{51} to find that the 4^+ and 6^+ levels should lie, respectively, 2.76 and 3.56 Mev above ground. Morinaga[6] has observed coincidence gamma rays from Ti^{50} with energies of 1.59 and 1.17 Mev, which would tend to verify this prediction.

We are indebted to Dr. John Newton for a stimulating discussion.

TABLE

Excitation energies of protons in the $f_{7/2}$ shell. The calculated energies are based upon the levels from Buechner and Sperduto,[3] assuming spin assignments 4^+ and 6^+ for the second and fourth excited states in Fe^{54}. Spin assignments, where known, are given in parentheses.

Configuration	Predicted Spin	Theoretical Energy (Mev)	Known levels		
			$_{22}Ti^{50}$ (5)	$_{24}Cr^{52}$ (4)	$_{26}Fe^{54}$ (3),(8)
$(f_{7/2})^{\pm 2,4}$	0^+	0	0 (0^+)	0 (0^+)	0 (0^+)
	2^+	1.41	1.58	1.46 (2^+)	1.41 (2^+)
	4^+	2.54		2.40 (4^+)	2.54
					2.57
	6^+	3.16	3	3.13 (6^+)	3.16
			$_{23}V^{51}$ (8)		$_{25}Mn^{51}$ (8)
$(f_{7/2})^{\pm 3}$	$7/2^-$	0	0 ($7/2^-$)		0 ($7/2^-$) (7)
	$5/2^-$	0.24	0.32 ($5/2^-$)		0.38 ($5/2^-$)
	$3/2^-$	0.98	0.93 ($3/2^-$)		1.27
	$11/2^-$	1.74	1.61		
	$9/2^-$	1.82	1.84		
			2.22		
			2.43		
			2.65		
	$15/2^-$	3.14	3.11		

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