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LOW-SPIN ODD PARITY STATES IN ^{109}Pd AND ROTATION-ALIGNED MODELS*

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ABSTRACT: The ^{108}Pd(n,γ)^{109}Pd reaction discloses a family of low-spin odd parity states. A Coriolis calculation reveals difficulties in rotation-aligned models for low-spin unfavored states.

Following neutron capture in ^{108}Pd, the following measurements of transitions on ^{109}Pd were performed: 1) Ge(Li) detector measurements of primary and secondary γ rays after thermal and resonance (E_n=2.96 eV) capture (BNL), 2) Angular distribution measurements of primary γ rays following p-wave capture at E_n=2.96 eV (BNL), 3) High precision bent crystal spectrometer (GAMS1 and GAMS23) measurements of secondary γ rays at thermal energy (ILL), 4) (n,e$^-$) measurements with the BILL spectrometer (ILL). Approximately 30 levels below 1.36 MeV have been placed in a level scheme for ^{109}Pd.

Among the levels is an isolated family of odd parity states (Fig. 1) for which <1% of the total population exits to even parity excited states. Based on the E1 multipolarity of the ground state transition, the 245 keV state can be 3/2$^-$, 5/2$^-$, 7/2$^-$. From regional systematics and partially model dependent arguments we consider that this level is very likely 7/2$^-$. Given that choice, unique J^π value assignments then result for all excited states in Fig. 1 except the 1359 keV state which can be 1/2$^\pm$,3/2$^\pm$. Since this level clearly belongs to this isolated family it is almost certainly of odd parity and is probably 1/2$^-$ based on the spin set allowed by the coupling of an $h_{11/2}$ particle to even-spin core excitations. We note that this family provides all but one (a J=5/2 state) of the low spin (J≤5/2) states obtainable from this coupling.

Smith and Rickey[1] have performed a Nilsson model Coriolis calculation with variable moment of inertia (VMI) for ^{101,103,105}Pd in

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which the parameters were chosen from systematics of the even-even Pd isotopes. The results (energy levels, B(E2) values, (d,t) and (d,p) spectroscopic factors and γ-ray transition rates are in good agreement with the existing data, particularly for the $h_{11/2}$ rotation aligned band in each nucleus and for the degradation with increasing mass of the degree of rotation alignment of the $d_{5/2}$ and $g_{7/2}$ bands. Thus, it is plausible to expect a similar calculation to reproduce the general features of the odd parity levels in ^{109}Pd.

We have performed such a calculation for odd parity levels in ^{109}Pd. A deformation of δ=0.15 and a VMI parameter C=2 x 10^7 keV^3 were used based on values applicable to ^{108,110}Pd. The Fermi level is placed at the 3/2-[541] level which gives reasonable agreement with the experimental (d,p) and (d,t) spectroscopic factors for the $11/2^-$ state at 189 keV. As in ref. 1, we employ a constant Coriolis-coupling matrix element attenuation of 0.8. The calculated energies are normalized to the empirical $11/2^-$ energy (189 keV).

Figure 2 compares a portion of the calculated results with the experimental data for ^{105}Pd and ^{109}Pd. Calculated level energies are represented by open symbols and experimental results by solid symbols. The level energies are plotted versus an angular momentum projection in the manner introduced by Rekstad et al.[2] The abscissa is the projection of the total angular momentum J onto the particle angular

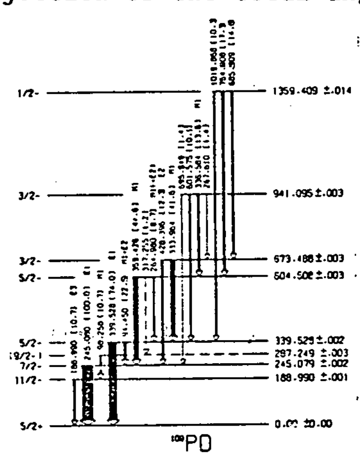

Fig. 1 Partial level scheme for ^{109}Pd. If J(245 keV)≠7/2 allowed spins also include: 339(3/2), 604(1/2,3/2), 673(1/2), 941(1/2).

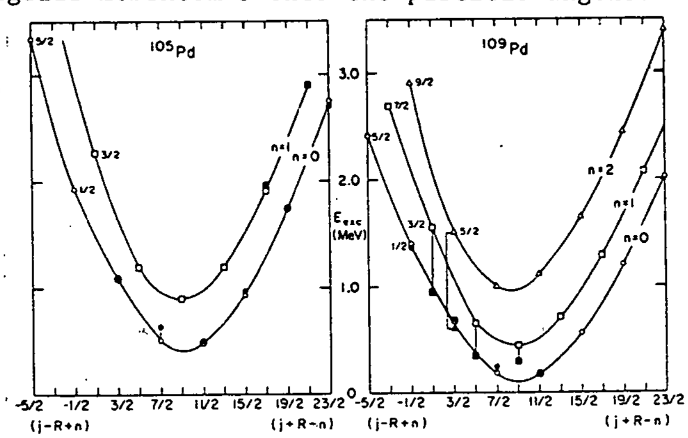

Fig. 2 Comparison of calculated (open symbols) and experimental (closed symbols) level energies for ^{105,109}Pd. For clarity, pairs of corresponding calculated and experimental values are connected by vertical lines. Spins are given by the absolute value of their abscissae unless labelled otherwise.

momentum j. This projection has the values j+R-n for J>j and j-R+n for J≤j, where R is the rotational angular momentum of the even-even core, and n is an indication of the alignment of j with respect to R (n=0 implies maximum alignment or maximum anti-alignment). For an $h_{11/2}$ neutron in the limit of no coupling between the particle and the core, this representation would yield a total of six parabolas. States have spins given by their abscissae unless R and j are anti-aligned and R>j. The validity of such a representation of rotation alignment is justified by inspection of the mixing amplitudes and R components. In both ^{105,109}Pd states on the n=0, 1, 2... curves are characterized by progressively larger expectation values of K (i.e., progressively less R,j alignment) and by dominant R values appropriate to this model.

For ^{105}Pd the calculated energies agree remarkably well with the experimental values, with an rms difference of 0.05 MeV. For ^{109}Pd, only states with J≤11/2 are known, and the results for those states associated with the lowest (n=0) curve also agree very well (rms deviation = 0.04 MeV) with the data. However, there are large discrepancies for the three states with n=1 (rms deviation = 0.4 MeV) and for the one state with n=2. Indeed, within the spirit of the calculations which reproduce the properties of the n=0 states in both ^{105,109}Pd, it has not proved possible to obtain the lower excitation energies found empirically for the states with less than maximum alignment. Even severe attenuation of the matrix elements (≤.35), though giving the correct separation between pairs of $3/2^-$ and $5/2^-$ states, yields poorer results overall. Thus, although a rotation-aligned model seemingly accounts for the properties of the states of maximum R,j alignment, its inability to account for other levels of similar parentage casts doubt on its overall applicability and shows that one must be careful in assessing the success of this or related models based on their predictions for only the specific subsets of states accessible in heavy-ion reactions or other selective processes. Indeed, the non-selectivity of the (n,γ) reaction is seen to offer an important complementary tool needed to provide a sufficient empirical basis for a comprehensive test of such models.

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