Study of Single Particle Excitations in ^{153}Sm via $(\vec{\mathrm{d}},\mathrm{t})$ and ARC ◇

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The ^{154}Sm$(\vec{\mathrm{d}},\mathrm{t})$ reaction using the high resolution Munich Q3D at a beam energy of 25 MeV and (n,γ) ARC [1] measurements at Brookhaven were used to study the deformed nucleus ^{153}Sm. The combination of the information from the polarized $(\vec{\mathrm{d}},\mathrm{t})$ and ARC provides a guarantee of completeness for $I^\pi = \frac{1}{2}^-$ and $I^\pi = \frac{3}{2}^-$ states up to 1500 keV. The observation of numerous higher lying states with small cross sections, suggesting configurations in which a neutron is coupled to core vibrations, provides an ideal test case for the Interacting Boson Fermion Model (IBFM) in a multi-orbit environment. Calculations with that model account reasonably well for both the large number of low spin states and for the magnitude of the (d,t) cross sections as well.

Because of the sensitivity of neutron pickup reactions to the values of the Nilsson expansion coefficients $C^K_{j,L}$, the data are particularly valuable to obtain the projection of the actual states on quasi particle states coupled to the ground state band of the core. However, the selectivity of transfer implies that states with very small $C^K_{j,L}$ coefficients or states involving predominantly vibrational core excitations may be missed. Thus complementing the transfer data with ARC is ideally suited for this purpose.
Two negative parity states in the ARC spectrum at 127.3 keV and 404.9 keV have anomalous high intensities suggesting that at least one of them could be a doublet. It is currently assumed that the level at 127.3 keV contains an additional $\frac{1}{2}^-$ state, because of the bigger intensity of that peak. But the reanalysis of (n,γ) data taken with a Bent Crystal [2] suggests that this $\frac{1}{2}^-$ could be at 404.2 keV. The clarification of this point needs an additional coincidence experiment that is in progress, but hardly influences our comparison with nuclear structure calculations.

The combination of these three types of data, which lead to several changes in I^π assignments and to the discovery of a number of new levels, give unique data to test the comprehensive modern models such as the IBFM [3]. In the IBFM the even-odd nucleus is a system of a single valence fermion in a single particle orbit j coupled to the even-even core with all its bosonic excitations. In fact, in the energy region below 1.5 MeV, as shown in Fig. 1, the IBFM reproduces very closely the observed number of low spin states. Note that in contrast, the Nilsson model only accounts for about half the number of $\frac{1}{2}^-$ and $\frac{3}{2}^-$ states.

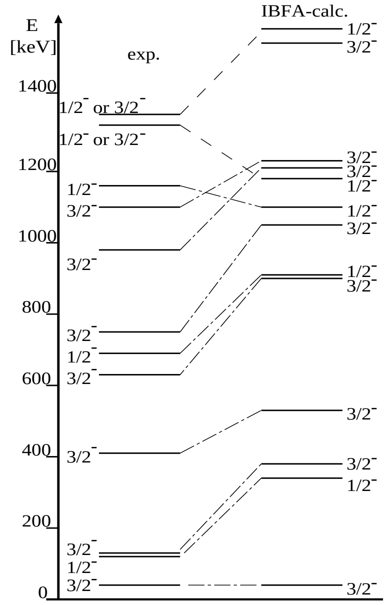

Fig. 1: Comparison of exp. energies with IBFA for $\frac{1}{2}^-$ and $\frac{3}{2}^-$

For $I^\pi = \frac{7}{2}^-$, $I^\pi = \frac{9}{2}^-$, $I^\pi = \frac{11}{2}^-$ the (d,t) strength distribution is well described by the IBFM [5]. A number of (mostly higher lying) levels predicted to have low cross sections are observed. These are levels involving single particle states coupled to intrinsic excitations of the core.

For the positive parity levels all models face a serious and unresolved problem, namely the large empirical separation of the $\frac{1}{2}[660]$ and $\frac{3}{2}[651]$ orbits. These orbits stem from the same single particle orbit, $i_{13/2}$, and neither the Nilsson model, nor the QRPA-calculations of Soloviev [4], nor the IBFM, are able to account for their large separation.

References

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