New 0^+ States in ^{146}Sm and the Particle-Particle-Core Coupling Model

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We have studied the ^{148}Sm(p,t)^{146}Sm reaction in a search for new 0^+ states. The experiment has been performed at the Q3D magnet spectrometer of the University of München, at 26 MeV beam energy, on 64(10) μg/cm^2 thin and 95% enriched targets. We have measured angular distributions in 8 points between 5° and 45°; fig. 1 shows the characteristic pattern for the L=0 states.

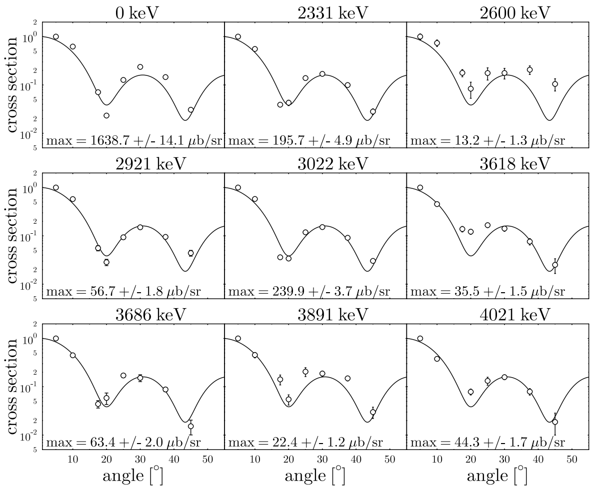

Fig. 1: Sample angular distributions of the 0^+ states in ^{146}Sm. The cross sections are normalized to unity and the value at maximum (5°) is given for each state.

The small background and the 5 keV energy resolution of the spectra allowed us to resolve and analyze states with cross sections as low as 1 μb/sr. As many as 10 excited 0^+ states were identified by their angular distribution, only one of them (at 2600 keV) known before. Their cross-sections vary in magnitude between 2–300 μb/sr and less than 10 μb/sr. The ground state to ground state transitions from the heavy impurities contained by the target material have been identified, as well as from some isotopes of Hf, which was used to reduce the Sm oxide. It was also checked for the possible presence of states with L=0 from the (p,t) reaction on impurities, other than g.s. to g.s. transitions. The cross section of the strongest of such states amounts to 2μb/sr. We can therefore conclude that the remaining observed L=0 transitions lead to excited 0^+ states in ^{146}Sm.

We obtain an accurate theoretical description of the N=84 isotones using an improved version of the particle-particle-core coupling model (PPCM) [1]. The two neutrons outside the closed N=82 shell couple to the quadrupole and octupole surface vibrations of the magic core through the particle-vibration coupling (PVC), and interact with each other through the residual surface delta interaction (SDI). The parameters of the model are the strengths of the quadrupole and octupole PVC, the SDI strength, the single-particle energies of the orbitals in the open shell and the energies and quadrupole moments of the core phonons. We have used the single particle energies and the quadrupole moments of the phonons as extracted from particle-vibration coupling calculations for the N=83 nucleus ^{145}Sm [2]. This choice substantialy reduced the number of free parameters and ensured a consistent frame for the particle-vibration calculations.

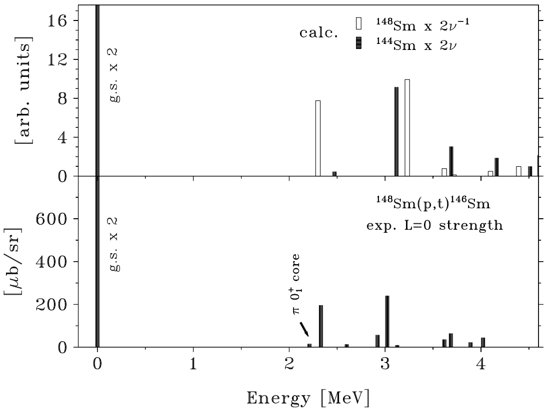

Fig. 2: Strength distribution of the 0^+ states in the (p,t) experiment (lower) and in the Particle-Particle-Core coupling Model (upper part)

The two types of configurations highly favourized by the (p,t) reaction are the ones involving either the transfer of a coupled pair of particles from above the closed shell, or of a coupled pair of holes from below the shell. We have included both in the calculations; the first as ^{144}Sm + two particles and the second as ^{148}Sm + two holes. For the moment, no mixing of the two subspaces was considered. The common energy scale of the two subspaces was fixed by identifying the first strong 0^+ state at 2331 keV with the g.s. of the second subspace. For the two-particle transfer we have used a simple pairing operator. The results of the calculations are shown in fig. 2, to be compared with the experimental data. The PPCM calculations correctly predict the large number of 0^+ states, their position as well as qualitatively the strength distribution. We expect to further improve the results by taking into account the coupling of the two subspaces and a more apropriated form of the transfer operator.

References

[1] K. Heyde and P.J. Brusaard, Nucl. Phys. **A104**, 81(1967)
[2] A.M. Oros et al., Physica Scripta **T56**, 292(1995)