Shell-model description of N=44 pfg-shell nuclei

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It has long been a challenging problem for nuclear structure theory to understand two fundamental aspects of nuclear dynamics, the single-particle motion and the collective motion, within a unified framework. Large-scale shell-model calculation can be a possible way to approach this problem. Owing to innovative advances in computer technology as well as developments of novel methods for numerical calculations, the scope of the shell-model calculation is rapidly extending far beyond the magic nuclei, where the collective feature becomes significant.

Recently, we have proposed an effective interaction JUN45 for the shell-model description of nuclei with masses A=56-100 in the model space consisting of single-particle orbits $p_{3/2}$, $f_{5/2}$, $p_{1/2}$ and $g_{9/2}$.[1] Starting from a microscopic interaction[2] derived from the Bonn-C nucleon-nucleon potential, we have modified 45 well-determined linear combinations of single-particle energies and two-body matrix elements by fitting to 400 experimental energy data taken from 87 nuclei in this mass region. We have tested this interaction extensively and found it successful for nuclei with $N = 50$ magic number and also for less-neutron cases with $N \geq 45$.

In is expected that, as N decreases from 50 (the number of holes increases on top of the N=50 core), the collectivity gradually develops especially near the middle of the shell with $Z \sim 40$. In order to investigate the validity of the present model space and the effective interaction for such cases, we have carried out shell-model calculations for $N = 44$ isotones. The calculated results for electromagnetic moments of low-lying states show reasonable agreement with available experimental data. In addition, the description of energy levels looks successful even for high-spin states.

As an example, Fig. 1 shows the energy levels of ^{80}Kr. One can find a remarkable correspondence between the experimental band structure[3] and the shell-model results for both positive and negative parity bands. As for the 2_1^+ state, the calculated magnetic moment is $+0.64\mu_N$ which compares well with the experimental value $+0.76(10)\mu_N$.[4] The quadrupole moment is not known experimentally. The calculated value $+27e\mathrm{fm}^2$ indicates weak oblate deformation, which is consistent with the prediction based on the Hartree-Fock-Bogolyubov cranking model with a Woods-Saxon potential.[5] The experimental data suggest the two-quasiparticle alignment for $J > 8$ in the ground-state band, which was interpreted as the alignment of neutrons.[3] By the analysis of the shell-model wavefunction, we have found that the angular momentum gain around $J \sim 8$ is mainly due to the neutrons in the $g_{9/2}$ orbit.

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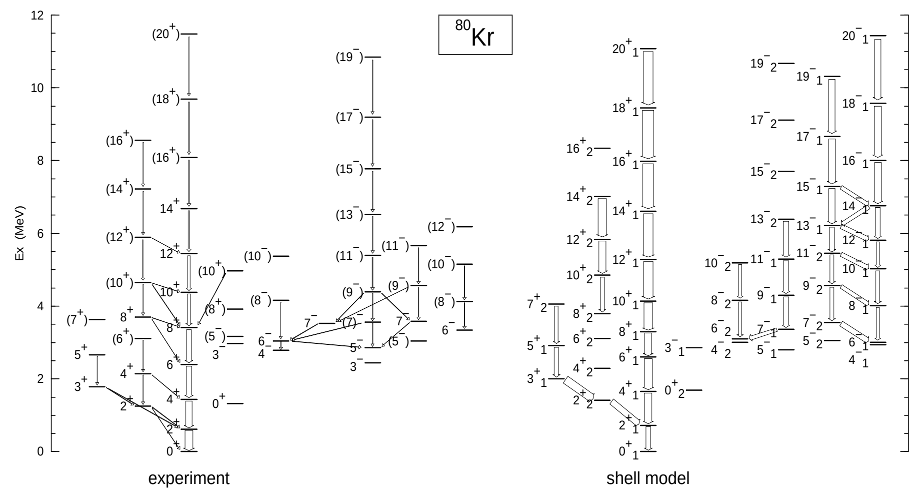

Fig. 1. Comparison of energy levels between the experimental data and the shell-model results for ^{80}Kr. The width of the arrow drawn in the experimental part corresponds to the relative γ-ray intensity, while it stands for the relative B(E2) values in the theoretical part. Experimental data are taken from Refs.[3,4]. The shell-model results are obtained by using the efficient shell-model code MSHELL[6].