Relativistic Mean Field Investigation of the Superdeformed Bands in the $A \sim 60$ Mass Region

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In 1997, a superdeformed(SD) band in ^{62}Zn was discovered[1], which is the first experimental observation in this mass region. Several new SD bands in Zn isotopes have been observed and reported in recent experiments[2, 3]. This makes it possible to perform a systematic investigation and comparison between the theoretical results and the experimental data in this mass region. Here, we apply the relativistic mean field (RMF) model to the SD bands in $^{60-62,65}$Zn. As for the details of the formulation and the numerical technique, see refs.4 and 5. The cutoff parameters for the expansions of the nucleon and meson fields are taken to be $N_{\rm F}$=10 and $N_{\rm B}$=10, respectively. The SD configurations are symbolically denoted as $\pi 4^{N_{\rm p}}$ and $\nu 4^{N_{\rm n}}$, which means that $N_{\rm p}$ protons and $N_{\rm n}$ neutrons occupy the N=4 ($g_{9/2}$) orbits.

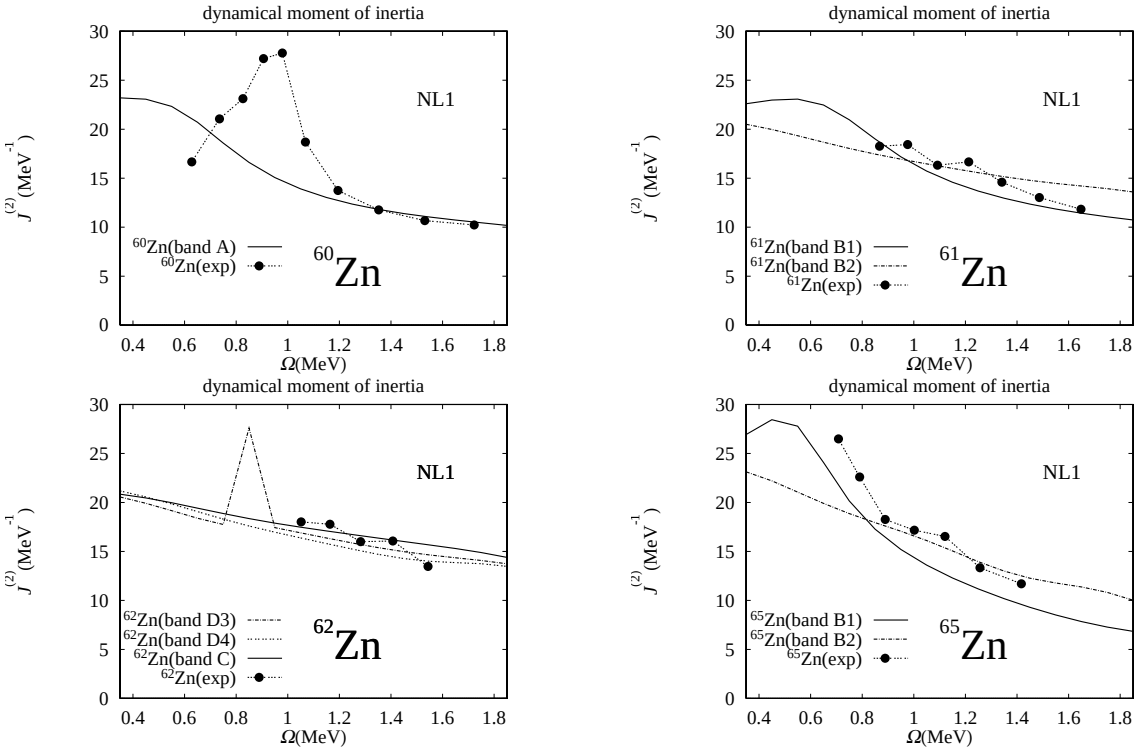

Figure 1: The dynamical moments of inertia.

Figure 1 shows the dynamical moments of inertia. The parameter set NL1 is used. As for the SD configurations, we consider the following ones:

^{60}Zn: band A ($\pi 4^2 \nu 4^2$)
^{61}Zn: bands B1, B2 ($\pi 4^2 \nu 4^3$)
^{62}Zn: bands D3, D4 ($\pi 4^2 \nu 4^3$), C ($\pi 4^2 \nu 4^4$)
^{65}Zn: bands B1, B2 ($\pi 4^2 \nu 4^3$)

Thanks to the large single particle gaps at $N = Z = 30$, the band A in ^{60}Zn is well separated from other bands in this nucleus which contain more than 3 neutrons in the N=4 orbits. The experimental data of ^{60}Zn show clear band crossing at $\Omega \sim 1.0$ MeV. Because we are interested in the high spin region, we do not show the calculated result of the band which is crossed by the band A. For $\Omega \gtrsim 1.2$ MeV, we see that this lowest band A reproduces the experimental value very well. For ^{62}Zn, the bands D3 and C reproduce the experimental data, although the band D4 is also good. In the cases of ^{61}Zn and ^{65}Zn, the moments of inertia of the band B1 are slightly smaller than the experimental data. In both nuclei, the band B2, which is the (unfavored) signature partner of the band B1, gives better results. As a whole, our calculation can reproduce the experimental moments of inertia well. We find that, however, there are some problems in terms of the excitation energies in the cases of ^{61}Zn, ^{62}Zn and ^{65}Zn, that is, the bands which we think correspond to the experimentally observed ones do not become the lowest [6, 7, 8]. One possible reason for this is that the position of the $g_{9/2}$ orbit may be unexpectedly high. To see this, we calculate the single neutron levels in the ground state of the doubly magic ^{56}Ni nucleus. The results are shown in Fig. 2. At a glance we can see that the experimental position of the $g_{9/2}$ orbit is significantly lower than those of theoretical calculations. To this time, no one has given a definite explanation for this puzzle. One way to clarify what is the origin of this deviation and what is necessary to cure it will be to perform an investigation which contains those effects that are not included in the present calculations, for example, the effects of the reflection-asymmetric deformations and so on. Such work is now under progress.

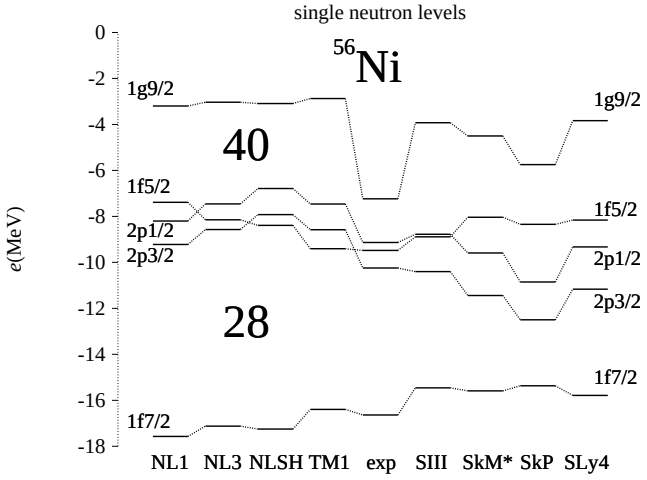

Fig. 2: The single neutron levels in the doubly magic ^{56}Ni nucleus.

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