Tensor-Force Effects onand N = 20 and 28 Magic Numbers

H. Nakada, **Y. Suzuki**, **S. Miyahara**

Department of Physics, Graduate School of Science, Chiba University,
Yayoi-cho 1-33, Inage, Chiba 263-8522, Japan

As typical manifestation of quantum effects in atomic nuclei, the “magic numbers” are fundamental in nuclear physics and important as well in related fields, *e.g.*, physics of nucleosynthesis. However, experiments using the radioactive beams have disclosed that the magic numbers are not so rigorous as have been expected and may disappear in unstable nuclei, as $N = 20$ and 28 in the proton-deficient region, *i.e.*, “island of inversion” (IoI). It is suggested that the IoI emerges due to the quadrupole deformation, though other possibilities have not been ruled out. Whereas the tensor force has been pointed out to play a significant role in the shell evolution, its effects on the IoI are still under debate.

By the spherical mean-field calculations [1], the semi-realistic interaction M3Y-P6 [2], in which the realistic tensor force is one of the key ingredients, produced a map of the magic numbers compatible with almost all available data. We have here implemented the axial Hartree-Fock calculations with M3Y-P6 [3]. Although the pairing and rotational correlations are yet ignored, the IoI is reproduced reasonably well. The tensor force acts attractively (repulsively) between a proton occupying a $j = \ell \pm 1/2$ orbit and a neutron occupying $j = \ell \mp 1/2$ ($j = \ell \pm 1/2$). This indicates that the tensor-force effects are repulsive at the energy minima. We have found that effects of the tensor force are perturbative, but significantly depend on configurations, favoring deformation for the $N = 28$ nuclei owing to the closure of the jj-shell (*i.e.*, $n0f_{7/2}$), while favoring sphericity for the $N = 20$ nuclei owing to the ℓs-closure of $N = 20$. Explicit inclusion of the realistic tensor force seems useful for reproducing the Z-dependence of the nuclear shapes on the IoI.

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References

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