Angular correlation between proton and neutron rotors

N. Tajima[a)]
a) Department of Applied Physics, University of Fukui, *Fukui, 910-8507, Japan*

Contact e-mail: tajima@quantum.apphy.u-fukui.ac.jp

I discuss first the main results from my collaboration with Professor Otsuka on the meaning of the antiparallel proton and neutron angular momenta at low spins [1].

This fact that the total angular momenta of protons and that of neutrons are oriented in the opposite directions has first been demonstrated by Otsuka et al. for the angular-momentum projected Nilsson wave functions[2-4]. A question was raised immediately [5] that it might be incorrect because it would mean an unphysical free contra-rotation of proton and neutron ellipsoids while only small-amplitude oscillations in the scissors mode are possible from a physical point of view. (Actually, Ref. [2-4] has never described this opposite rotations as *free* contra rotations.) Ref.[5] argued that the removal of the spurious center-of-mass motion could make the angular momenta of protons and neutrons parallel. Afterwards, two papers [6,7] have cited Ref.[5] as solving the controversy.

In Ref.[1], by using a two-rotor model, we have confirmed the fact that the directions of angular momenta of protons and that of neutrons are indeed opposite to each other, but that this fact does not mean an unphysical free contra rotation. On the contrary, it originates in a close binding of the two ellipsoids, which is accompanied with a large spreading of the relative angular momentum due to the uncertainty principle. We have also shown that the elimination of the spurious center-of-mass motion does not substantially change the situation in a classical treatment of independent nucleon motions.

Second, I would like to discuss further on the angular correlations between protons and neutrons expressed by two rotors.

The principal intention of Ref. [2] has been to suggest the possibility that collective rotational excitations are accompanied with a narrowing of the angle between the proton and neutron angular momenta. Namely, along a rotational band, the angle changes from 180 degree at spin zero to smaller angles at high spins, and close to zero at band terminations. In this paper, I pay attention to the angle between the symmetry axes of rotors as well as to the angle between the angular momenta. These two angles have different kinds of information because of the quantum mechanical uncertainty in the directions of the angular momenta relative to the principal axes of the ellipsoids, and also owing to dynamically correlated rotational motions of the two rotors. I would like to discuss also the distributions of these angles, not only their expectation values.

In Ref. [1], it has been stressed a close relationship between the opposite-direction correlation between the angular momenta of protons and neutrons and the properties of the scissors mode which is the oscillation of the angle between the symmetry axes of the proton and neutron ellipsoids. I would also like to discuss further on this point.

References

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