ОБЪЕДИНЕННЫЙ
ИНСТИТУТ
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ

Дубна

96-145

E7-96-145

J.Rigol

A SHELL CLOSURE AT $N = 164$: SPHERICAL OR DEFORMED?

Submitted to «Physical Review C»

1996

Brenner el al.[1] compared the systematics of the empirical ratio $\left(\frac{\epsilon}{\Delta}\right)$, with the calculated P factor for nuclei with atomic number A > 200. Here, (ϵ) is the nuclear quadrupole deformation, (Δ) is the pairing gap-parameter, and $P = \frac{(N_p \cdot N_n)}{(N_p + N_n)}$,where N_p and N_n are the valence protons and neutrons numbers respectively. The P-factor can be viewed as proportional to the ratio of the valence p-n interactions to the pairing interaction . Thus, it is logical to expect P to be correlated with an empirical measure of the ratio $\left(\frac{\epsilon}{\Delta}\right)$.

Actually, it was observed [2] a remarkable correlation between the empirical values of $\left(\frac{\epsilon}{\Delta}\right)$, and the P-factor for all even-even nuclei for Z = 42 - 98. Nevertheless, these authors observed [1] that the P-factor values in the actinide region, can not reproduce quite well the experimental $\left(\frac{\epsilon}{\Delta}\right)$ systematics within the framework of traditional shell closures, Z=82, 126 and N= 126, 184. They have found that the P factor systematics reproduces more accurately the features of the experimental ratio if a shell closure is presumed at N=164.

This result is very interesting because, studying the decay properties of several new isotopes with atomic number Z = 106, 108, 110 and neutron number near 162, it has been established [3, 4, 5] a huge increase of their stability as compare to the predictions of models which do not take into account the presence of a new shell [6, 7].

БИБЛИОТЕКА

Furthermore, the α-particle energy measured [5,8] for the N=163 isotope $^{273}110$, ($E_\alpha > 11$ Mev) provides direct and convincing evidence that a neutron shell closure indeed exists and is located at N=162 and not at a higher value of N. The E_α value for $^{273}110$ would have been about 1 Mev lower if the shell closure had occurred at N> 162.

The existence of a new shell closure with N=162, had been predicted in several theoretical papers [10,11,12]. But, in contrast with the conclusion of Brenner et al.[1], the predicted new shell ought be deformed, not spherical.

Experiments like [3,4,5,8,9] do not give the possibility to conclude if the new shell with N=162 corresponds to a spherical shell or to a deformed one. However, the coincidence between the experimental values of such quantities like, α-decay energy, half life, etc, with the theoretical predictions(see for example [11]), gives an indirect indication of the possible deformations of these nuclei.

In [1], the authors did not discuss why they called spherical the shell with N=164. Apparently, the only one reason is that they got the value N=164 from work[13], where an improved parameter fit for the deformed nuclear potential is made. But, if you look at fig.5 in [13], you will observe that there were emphasized the possible spherical neutron shells with N=126,136,170,184,and 196, but any with N=164. Certainly, there is a shell emphasized with the number 164, but it corresponds to a proton shell (Z=164).

In addition, an important property of these heavy nuclei with N near 164,is their fission-ability. The fission process is characterized by a rather sharply defined threshold energy, referred to as the fission barrier. In [13], it is stressed that the detailed dependence of the barrier on N and Z appears not to be reproduced by their model(see page 625 in [13]).

On the other hand, Brenner et al[1] noted that a deformed subshell gap at N=152 could influence the fine structure observed around the proton number Z=90[see fig.2 in [1]]. Because the influence of the deformed shell with N=162, may be stronger that this one with N=152 [11], we would expect that the P-factor values be influenced by that shell. Moreover, the differences in the P-factor values calculated for a supposed shell with N=164, are not dramatically different from those ones calculated considering a shell with N=162.

In any case, it is not clear how to demonstrate the sphericity or not of some shell on the basis only of the nucleon numbers in the shell closure. From the results obtained by Heiss et al.[13,14], it follows that the same magic numbers can be reproduced with pure quadrupole deformed hamiltonian, or with a combination of this hamiltonian with higher multipoles.

So, it is my opinion that the results of Brenner et al [1] could be interpretated as a possible confirmation of the presence of a deformed shell with N=162.

I am specially grateful to Dr.Yu.Lazarev for his outstanding comments and to Drs.Yu.Lobanov and R.Nazmitdinov for important discussions about this paper.

BIBLIOGRAFY

1.- D.S.Brenner,N.V.Zamfir and R.F.Casten, Phys.Rev.C,50,490(1994).
2- B.D.Foy,R.F.Casten,N.V.Zamfir,D.S.Brenner, Phys.Rev.C,49,1224(1994).
3.- Yu.A.Lazarev et al.Phys.Rev.Lett.73,624(1994).
4.- Yu.A.Lazarev et al.Phys.Rev.Lett.75,1903(1995)
5.- Yu.A.Lazarev in Low Energy Dynamics (World Scientific, Singapure,1995)293
6.-G.Royer and B.Renaud J.Phys.G.Nucl.Phys.10,154(1984)
7.- J.Randrup et al.Phys.Rev.C,13,229(1976)
8.-S.Hofmann et al.Preprint GSI-96-09(1996)
9.- S.Hofmann et al.Z.Phys.A350,277(1995)
10.- S.Cwiok et al.Nucl.Phys.A410,(1983)254.
11.- Z.Patyk and A.Sobiczewski,Nucl.Phys.A533,132(1991)
12.- P.Moller and J.R.Nix,J.Phys.G 20,1681(1994)
13.-C.Gustafson et al.Ark.Fys.36,613(1967)
14.-W.D.Heiss et al.Phys.Rev.C 52,3032(1995)
15.-R.G.Nazmitdinov,private communication.

Received by Publishing Department
on April 23, 1996.