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Foreword

This is the sixth issue of annual report of Institute of Modern Physics, Academia Sinica. It summarizes the research activities, technical developments and the progress of HIRFL project carried out during the year of 1986.

The project for construction of HIRFL has been progressed as intended in this year. The assembling of the main parts of SSC including the vacuum chamber, sector magnets and RF cavities was realized according to their designed position. The first pumping of the vacuum chamber has been completed smoothly. The pressure in the vacuum chamber was reached to 8×10^{-6} torr. The mechanical and physical parameters of the RF cavities and the control system of RF system have been tested. The south cavity was excited up to the rated 130KV dee voltage at 8.64MHZ. The construction of eight experimental equipments for nuclear physics and applied physics with heavy ions is progressing steadily, two of them i.e. the on-line isotope separator and the heavy ion time of flight spectrometer are almost ready for assembling. The construction of the measurement room and the experimental area is starting now and the NIM pool is setting preliminarily. The first stage work of the data acquisition and analysing system has been fulfilled.

52 scientific papers published in this annual report are concerning to the theoretical nuclear physics, experimental nuclear physics and nuclear chemistry with heavy ions. Through inland and international collaborations, significant progress has been made for our researches in several fields of experimental and theoretical nuclear physics. Among them I would like to mention that the collaboration with a number of institutions abroad in the theoretical research on the spin and cofiguration dependence of the nuclear shape and paring correlation and the collaboration with KVI in [illegible] experimental research on the incomplete deep inelastic [illegible] s[illegible]l. The first results of the experiment with KVI [illegible] and the Lanzhou [illegible]lled position sensitive detectors on 11MeV/A ^{20}[illegible] very [illegible]ising.

Technical service [illegible]ational economy has [illegible]een [illegible]eveloped such as the surface cleaning steel by chem[illegible]l m[illegible] etc.

The rebuilding of S[illegible]ch will [illegible] as the injector of SSC is progressing, there is no major difficulty that would hinder its completion in 1987. The preparation of the experiments on it is being under progress.

The Director of Institute of Modern Physics, Academia Sinica

B.W. Wei

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1. Theoretical Nuclear Physics

1-1 α-Backbending, Nucleon-Nucleon Correlation and Shape in Nuclei

Gu Jinnan

The relation between α -backbending[1], nucleon-nucleon correlation and shape in nuclei has been discussed. In general the pairing backbending behavior in gauge space are related to the quadrupole shape transition. However α-backbending is not only related to the quadrupole shape transition which just corresponds to the backbending region of α-backbending plot, but also may related to other kind of shape transition. For example, there are two backbendings for $T_3=17$, the first one ($A\simeq190$) corresponds to the quadrupole shape transition from oblate to prolate, the second one ($A\simeq180$) corresponds to the hexadecapole shape (β_4) transition from $-\beta_4$ to $+\beta_4$.

The α-backbending behavior also largely depends on the competition between the n-p, as well as the p-p and the n-n effective interaction energy (W_{np}, W_{pp}, W_{nn}) calculated by unified shell model. Fig.1 shows the results for $T_3=12,13,14$. One sees that the deformation sets in when $W_{np}/(W_{nn}+W_{pp})\geqslant1$ and α - backbending appears when $W_{np}/(W_{nn}+W_{pp})\leqslant1$. Therefore n-p interaction is a necessary condition for producing deformation. Similarly n-p interaction is also responsible for combining n-n pair with p-p pair, i. e. for forming α-cluster in heavy even-even nuclei. So it is due to nucleon-nucleon correlation, especially n-p correlation that the change of shape is close related to the α-backbending phenomena. These seem to tell us the change of nuclear shape with increasing nucleon number and the α-backbending behavior can be fundamentally described by unified shell model.

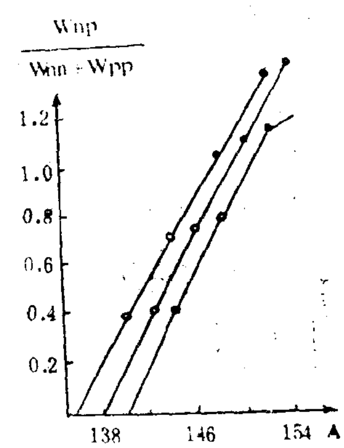

Fig.1 $\frac{W_{np}}{W_{nn}+W_{pp}}$ vs. A plot.

Reference

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1-2 The Odd-Even Staggering of $N_n/2$ of Isotopes

Gu Jinnan   Gao Yuanyi

With increasing neutron number N_n outside closed-shell, there is an odd-even staggering of $N_n/2$ in the parameter C of VMI model for well-deformed isotopes in the rare-earth and actinide region.

As is well known, the two-parameter formula of VMI model is given by

$$E(I) = \frac{I(I+1)}{2J(I)} + \frac{1}{2}C(J(I) - J_0)^2 \tag{1}$$

where J_0 is the moment of inertia of ground state, C is stiffness parameter which can be determined from a least-squares adjustment of the experimental spectra data of ground band in even-even nuclei. Obviously there is an odd-even staggering of $N_n/2$ of C value in Fig.1 in well-deformed actinide nuclei. The odd-even mass difference of $N_n/2$, i.e. pair energy for neutron pairs may be define as[2]

$$\Delta_{2n}(N,Z) = -\frac{1}{4}\left\{S_{2n}(N+2,Z) - 2S_{2n}(N,Z) + S_{2n}(N-2,Z)\right\} \tag{2}$$

where S_{2n} is the separation energy of a couple of neutrons. Similar to Fig.1, there is an odd-even difference of $N_n/2$ of Δ_{2n} value in Fig.2. But the trend is just opposite, while Δ_{2n} is relatively small (so the nucleus is a little stiff) corresponding C value is relatively large. Therefore the staggering of $N_n/2$ of C values may originate from the neutron-pair correlation, mainly the pair correlation of neutron pairs and their response on rotation.

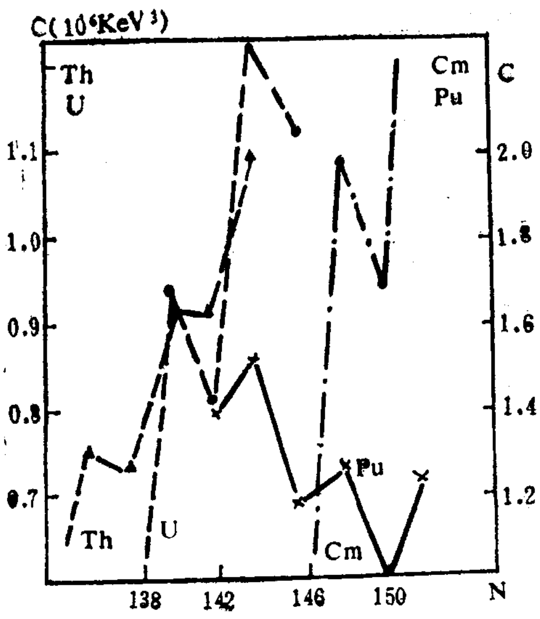

Fig.1 C vs. N plot for actinide nuclei.

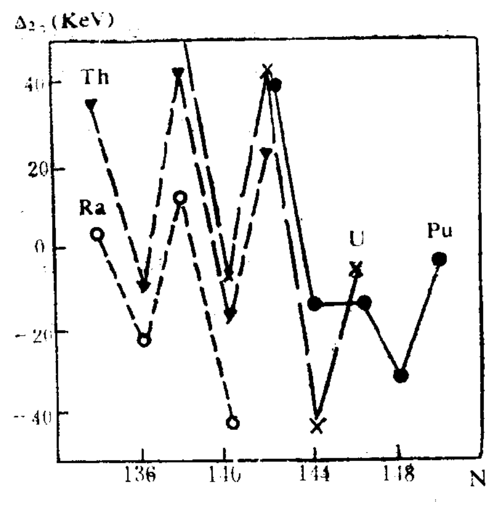

Fig.2 Δ_{2n} vs. N plot for actinide nuclei.

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2) A.S.Jensen et al., Nucl.Phys. A431(1984)393

1-3 The Band 2 of Nuclei ^{156}Er and ^{158}Er

Gao Yuanyi

With increasingly improving detection technique we can not only measure the high spin leves of the yrast band of the nuclei ^{156}Er and ^{158}Er, but also a new band called as the band 2 with even spin and positive parity for both of them.

Using VMI model, namely variable moment of inertia model, we calculated the rotational aligned momentum $i = 8.4$ and the ground-state moment of inertia $J_0 = 0.015$. The value of J_0 is close to the ground state band and the value of i is large enough to reveal that the band 2 of nucleus ^{168}Er is a neutron-pair-rotational aligned band, but differs from the superband. Simultaneously, we got the band 2 of nucleus ^{156}Er $i = 3.3$, $J_0 = 0.02$. Using the method of band mix, we got effective aligned momentum $i \approx 4$ for some nuclei of shape transition with increasing I, by constract to ground-state moment of inertia $J_0 = 0.0033$, $J_0 = 0.022$ is very large. Zhang Jingye et al.,[1] mentioned the deformation of ^{156}Er is about $\varepsilon_2 = 0.26$ around $I = 16^+$. So we considered the band 2 of ^{156}Er result from a shape transition with increasing I[2].

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2) Gao Yuanyi PEFEON to be published

1-4 An Improved Nilsson Parameter Set in the Au-Pt Region

Zhang Jingye A.J.Larabee* L.L.Riedinger*

Recent data on ^{185}Au indicate that previously published Nilsson (κ,μ) parameter sets for the Au-Pt-Hg region are not able to reproduce either the bandhead energies for the odd proton configurations or the single-particle structure of the higher-spin states in ^{185}Au. A new set of (κ,μ) parameters are deduced for the N=5 and N=6 proton shell as follows. The neutron (κ,μ) parameters are the same as that in reference [1].

	protons		neutron	
N	κ	μ	κ	μ
0	0.120	0.00	0.120	0.00
1	0.120	0.00	0.120	0.00
2	0.105	0.00	0.105	0.00
3	0.090	0.30	0.090	0.25
4	0.065	0.57	0.70	0.39
5	0.060	0.54	0.062	0.43
6	0.060	0.52	0.062	0.34
7	0.054	0.69	0.062	0.26

Such a new set of (κ,μ) parameters can give better agreement between the calculated and experimental results not only for ^{185}Au itself but also for neibouring nuclei. For instance the closely location of the alignment freguencies of proton $h_{9/2}$ pair and neutron $i_{13/2}$ pair in ^{184}Pt observed recently[2]. The Nilsson proton single-particle orbits obtained using the new (κ,μ) parameter are close to the Woods-Saxon results for this region.

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1) T.Bengtsson and I.Ragnarsson, Nucl. Phys. A436(1985)14

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1-5 On the Quadrupole Deformation in Even-even Rare-earth Nuclei

Zhang Jingye Zhong Jiquan Liao Bicheng

Deformation of e-e rare-earth nuclei has been studied fairly carefully so far from both theoretical and experimental aspects. It is well known, the moment of inertia is closely related to the deformation and pair correlation existed in nucleus. In this paper by comparing the theoretical and experimental value of the moment of inertia, quadrupole deformations are extracted systematically for the ground states of most e-e rare-earth nuclei, which are in good agreement with the values read out from the quadrupole moments data and in agreement with Möller and Nix's calculations[1] (neglecting ε_4). It tells, the approximate estimation of the strong dependence of the moment of inertia on the pair correlation given by Bohr and Mottelson[2] is quite reasonable.

As an example, Fig. 1 shows the results extracted from the experimental moment of inertia (solid line), from the quadrupole moment measurement (open circles) and the Möller and Nix's calculations (deshed line).

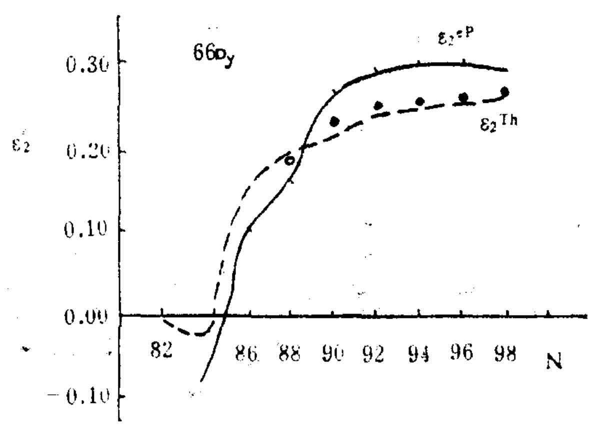

Fig. 1

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2) A.Bohr and B.Mottelaon. "Nuclear Structure", V.II. (1975) P.82

1-6 On $\pi h_{9/2}$ Alignment in Pt Even Isotopes

Zhang Jingye Zhong Jiquan

$\pi h_{9/2}$ alignment in Pt even isotopes has been calculated and discussed systematically. It is found that $\Delta\hbar\omega_c \equiv \hbar\omega_c(\pi h_{9/2}) - \hbar\omega_c(\nu i_{13/2})$ approaches the minimum, about 75KeV, for $^{184}Pt_{106}$ by using modified Nilsson's parameters k, μ[1]. This result is in agreement with the experimental evidence that the big up-bend observed in the yrast band of ^{184}Pt is caused by the close alignment of $\pi h_{9/2}$ and $\nu i_{13/2}$, while the standard Nilsson's k,μ can not give out such a result. As shown in Fig.1. Where the solid line corresponds to tne new k,μ parameters set, while the dashed line corresponds to the standard k,μ. The problem of the order of $\pi h_{9/2}$ and $\nu i_{13/2}$ alignments needs further investigation. Theoretical prediction about the $\pi h_{9/2}$ alignment frequency for neighboring Pt even isotopes should be checked by new experiments.

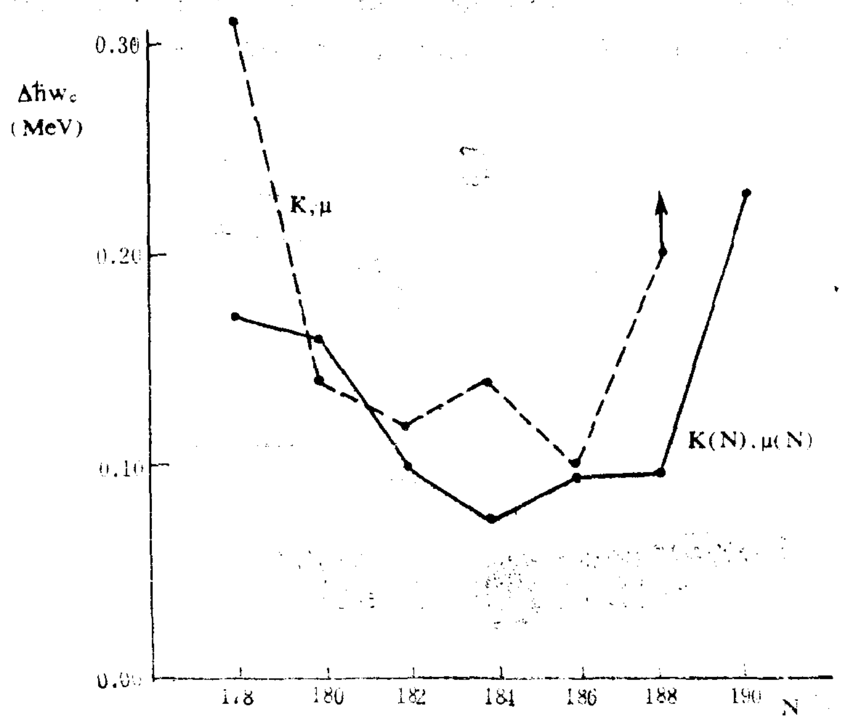

Fig. 1

Reference

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1-7 The Deformation of the α-band in Some Rare-earth and Actinide Nuclei

Zhang Jingye Zhong Jiquan

Recentiy, it is found there is probably a new band (some people call "α-band"), in some actinide and rare-earth nuclei. Such α-band has larger moment of inertia than that of ground-, β-and γ-band. Besides there observed a negative parity band with approximate triplet structure and the groups of the negative parity states have roughly the same splitting as the α-band. These phenomena, together with the large α-decay in probabiiities suggeste that α-clusttering effects may play a role in heavy nuclei as important as that played in light nuclei[1].

Two schools of thought have been developing regarding the observation mentioned above: (i) α-clustering effects are important[1], and (ii) static or dynamical octupole deformation occurs[2]. It seems, more experimental tests and theoretical calculation are still needed before the final judgement between these two approches can be down.

In this paper, some estimation about the deformation of these α-band was done based on an intuitive geometrical picture. Supposing an α-cluster is formed on the surface of a core nucleus (as shown in Fig.1) for some period of rotations, which corresponds to the formation of α-band. In order to reproduce the moment of inertia of the α-band, the polarization of α-cluster on the core should be assumed, especially for the soft core.

Table 1 tells the deformation of the core nucleus without and with polarization of α-cluster. Such polarization effects, if exist, should show up on the effect of the nonspherical part of the Coulomb field, and can be measured through the angular dependence of the wave function imposed by the penetration of the non-spherical barrier[3].

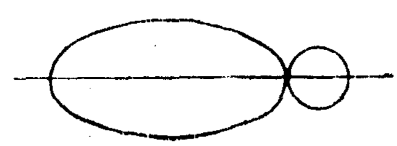

Fig.1

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