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Studying Potential Energy Surface for ^{190}Hg ^{188}Pt and ^{186}Os Isotones Using Approximation Model

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دراسة سطح طاقة الجهد للايزونات ^{186}Os , ^{188}Pt , ^{190}Hg بأستخدام أنموذج تقريبي

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ABSTRACT

Background:

The interacting boson model was introduced in 1974 as an attempt to represent the collective features of nuclei in a coherent approach. This model is the fundamental model for explaining nuclear properties. The Bohr and Mottelson collective model was developed from this model to represent quantum mechanical collective motion such as rotations or which called SU(3) and vibrations motion and called U(5).

Materials and Methods:

The surface potential energy of the isotones ^{190}Hg, ^{188}Pt and ^{186}Os was studied using the Interacting Boson Model Potential program (IBMP), which gives an idea of the deformation that occurs in the nucleus from the deflection of the contour lines and their aggregation in a specific region.

Results:

By applying the Hamiltonian for our isotones in this research, the energy levels were be investigated for ground band, beta band and gamma band, comparing with available experimental data then from the results, draw the potential energy surface and study the deformations that occur in the nuclei of these isotones.

Conclusions :

Determining the limit of these isotones, which have the properties of the limit. These isotones contain some deformation specially ^{190}Hg and ^{186}Os, but there isn't in ^{188}Pt. This model is good for studying the isotones properties with high even-even atomic number.

Keywords: Interacting boson model, potential energy, isotones, mercury, osmium, platinum.

INTRODUCTION

The exact nature of the nucleus is still a mystery, many methods have been made towards its understanding. The interaction between nucleons has been studied on the basis of two-body system but the results arrived at can't easily be applied to the many body system[1,2]. In the absence of any definite and precise theory to account for the complex inter-relationships between nucleons, a number of nuclear models are proposed, each based on a set of simplified assumptions and useful in a limited way [3].

In our model, it is assumed that low-lying collective states of even-even nuclei could be described as states of a given (fixed) number N of bosons. Each boson could occupy two levels, one with angular momentum L = 0 (s boson) and another with L = 2 (d boson). In the original form of the model known as IBM-1, proton-boson and neutron-boson degrees of freedom are not distinguished[4].

MATERIALS AND METHODS

The Hamiltonian of this model IBM-1 which can be written as [5, 6]

$$\hat{H} = \varepsilon \hat{n}_d + a_0 \hat{P}.\hat{P} + a_1 \hat{L}.\hat{L} + a_2 \hat{Q}.\hat{Q} + a_3 \hat{T}_3.\hat{T}_3 + a_4 \hat{T}_4.\hat{T}_4 \quad (1)$$

The operators are defined by:

$\varepsilon = \varepsilon_d - \varepsilon_s$ energy of boson, $\hat{n}_d = [d^\dagger . \tilde{d}]$ operator of (d) bosons, $\hat{P} = \frac{1}{2}(\tilde{d}\,.\tilde{d}) - \frac{1}{2}(\tilde{s}\,.\tilde{s})$ pairing operator for the (d) and (s) bosons respectively, $\hat{L} = \sqrt{10}\,[d^\dagger \times \tilde{d}\,]^{(1)}$ angular momentum, $\hat{Q} = [d^\dagger \times \tilde{s} + s^\dagger \times \tilde{d}]^{(2)} + \chi\,[d^\dagger \times \tilde{d}\,]^{(2)}$ quadrupole operator , $\hat{T}_3$ and $\hat{T}_4$ is octupole operators $[d^\dagger \times \tilde{d}\,]^{(3)}$ and is hexadecapole operators $[d^\dagger \times \tilde{d}\,]^{(4)}$.

Potential Energy Surface Basis

As shown in equation(2), the potential energy surface (PES) ($E\ (N,\beta,\gamma)$) gives the nucleus, a final shape that corresponds to the Hamiltonian function [7, 8]:

$$E\ (N,\beta,\gamma) = \frac{\langle N,\beta,\gamma|H|N,\beta,\gamma\rangle}{\langle N,\beta,\gamma|N,\beta,\gamma\rangle} \quad (2)$$

The energy surface has been calculated as a function of (β) and (γ) [9,10]:

$$E(N,\beta,\gamma) = \frac{N\varepsilon_d}{(1+\beta^2)} + \frac{N(N+1)}{(1+\beta^2)^2}\,(a_1\beta^4 + a_2\beta^3\cos 3\gamma + a_3\,\beta^2 + a_4) \quad (3)$$

where (β) represents the deformation of the nucleus, when ($\beta = 0$) the shape is spherical, when ($\beta \neq 0$) the shape is distorted, and (γ) is the measure of deviation from focus symmetry which is related to the nucleus, when ($\gamma = 0$) the shape is prolate, when ($\gamma = 60$) the shape is oblate[11,12].

RESULTS AND DISCUSSION:

The potential energy surface P.E.S. was be calculated using PES.FOR program. It was calculated from the parameters in equation (3), where table 1 shows the parameters that are entered into the effort program and was compared with equation (3) . Figures 1-3 show the symmetry and contour diagrams of the potential.

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Table 1. The potential energy surface's parameters (MeV unit)

The Isotones	EPS	EPD	A1	A2	A3	A4
^{190}Hg	0.111729	0	0.023	0	0.046	0
^{188}Pt	0.2569	-0.1798	0.0790	0	0	0
^{186}Os	0.111729	0	0.023	0	0.046	0

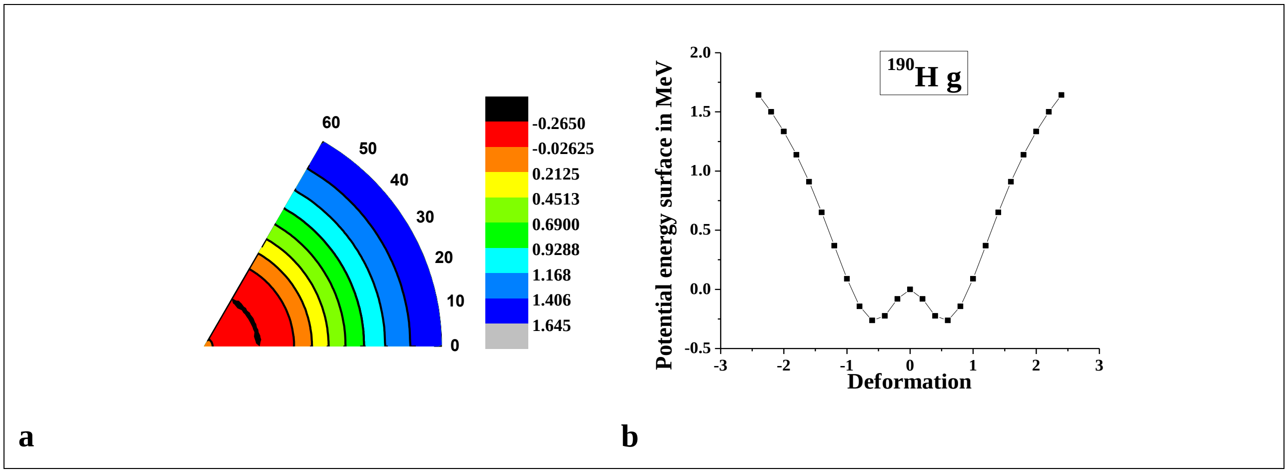

Figure 1. Potential energy for ^{190}Hg ,(a) contour (b) symmetry

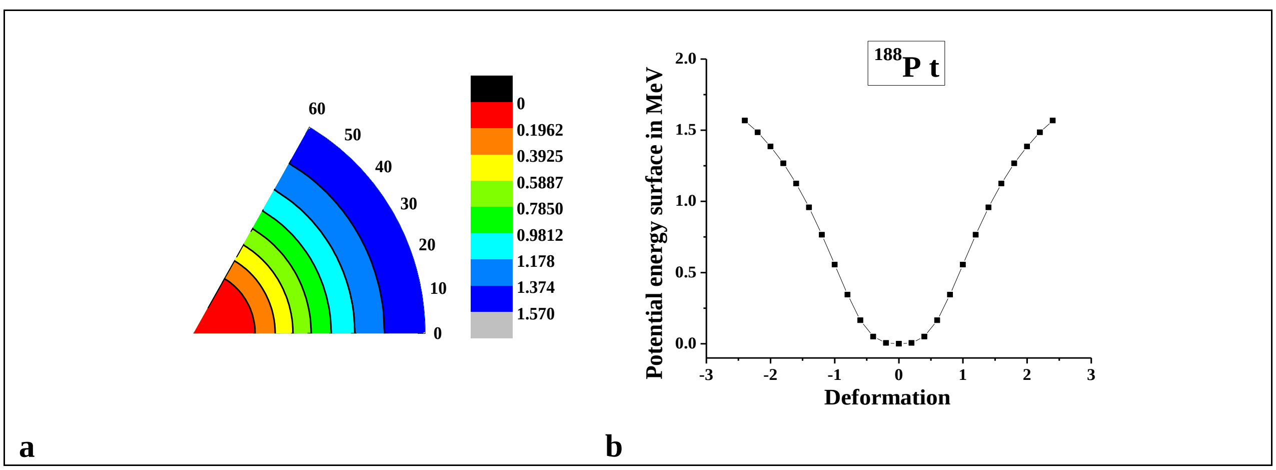

Figure 2. Potential energy for ^{188}Pt ,(a) contour (b) symmetry

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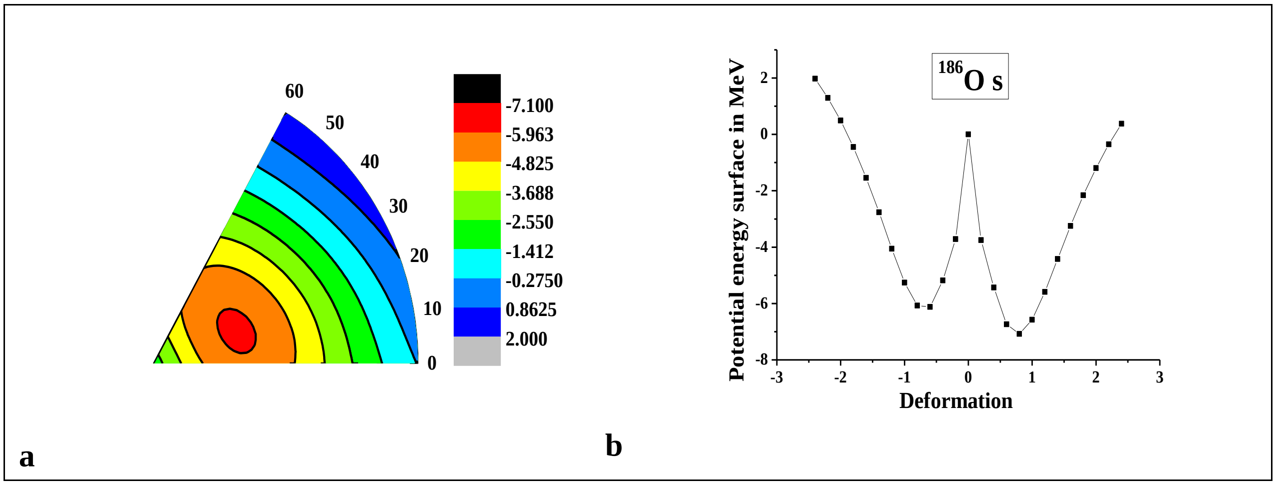

Figure 3. Potential energy for ^{186}Os ,(a) contour (b) symmetry

Figure 1 denoted to: there is some convergence in the contour line with $0.5 < \beta < 1.5$ and maximum potential energy of about 1.5 MeV, but symmetry on both sides. For the second isotone, there isn't any deformation as is clear in figure 2. Figure 3 has a clear view of coaxial deformation close to $0 < \beta < 1$ in contour lines, and unsymmetrical on the prolate side with oblate one.

CONCLUSIONS:

The axial symmetry of the radioactive isotones ^{190}Hg, ^{188}Pt is found to be compatible with the typical axial symmetry of the O(6) limit, where its shape is irregular as the contour lines gather in one place and decrease in another, meaning that the distribution of the contour lines is uneven on the surface of the nucleus. The ^{186}Os is highly distorted where the distribution of the contour lines on the surface of the nucleus is random and irregular, and has no symmetry on both sides, this means that the potential distribution is not equal across the surface of the core and belongs to rotational limit O(6)-SU(3)..

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Conflict of interests.

There are non-conflicts of interest.

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الخلاصة

مقدمة:

تم تقديم نموذج البوزونات المتفاعلة في عام 1974 كمحاولة لتمثيل الصفات الجماعية للنوى بطريقة تقريبية. هذا النموذج هو نموذج اساسي لشرح الصفات النووية. تم تطوير النموذج الجماعي من قبل بور و موتلسون، الى الحركة الجماعية بالميكانيك الكمي كحركة دورانية او مايسمى ب SU(3) وحركة اهتزازية او مايسمى ب U(5).

طرق العمل:

تمت دراسة طاقة جهد السطح للايزوتونات ^{190}Hg،^{188}Pt و ^{186}Os بأستخدام برنامج جهد نموذج البوزونات المتفاعلة (IBMP)، والذي يعطي فكرة حول التشوهات في النواة من خلال انحراف الخطوط الكنتورية وتجمعها في منطقة محددة.

النتائج:

من خلال تطبيق الهاملتوني الخاص للايزونات التي في البحث، تم دراسة مستويات الطاقة للحزمة الارضية، حزمة بيتا و حزمة كاما و مقارنتها مع البيانات العملية المتوفرة ومن ثم رسم سطح طاقة الجهد ودراسة التشوهات التي تحدث في نوى هذه الايزوتونات.

الاستنتاجات:

تحديد منطقة هذه الايزوتونات والتي تمتلك صفات هذه المنطقة. هذه الايزوتونات تمتلك بعض التشوهات خاصة ^{190}Hg و ^{186}Os ووهذا غير موجود في ^{188}Pt. ويعد هذا النموذج جيد لدراسة صفات الايزوتونات عالية العدد الكتلي الزوجية-زوجية.

الكلمات المفتاحية: نموذج البوزونات المتفاعلة، طاقة الجهد، الايزوتونات، الزئبق، الاوزميوم، البلاتين.

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