Contribution ID: **53** Type: **Poster**

Octupole deformation in radium isotopes using the spdf-IBM-1

Tuesday, 18 July 2023 17:40 (15 minutes)

In this work we study the effects of the octupole degrees of freedom in the nuclear structure of the even-even radium isotopic chain, obtaining the energy spectra and electromagnetic transition rates between states of different parity, comparing our calculations with the experimental data currently available. The analysis of the effects produced by the octupole degrees of freedom in radium isotopes is related with the search of non-zero atomic electric dipole moments, that may be evidence of Physics beyond the Standard Model [1], and will also help to better understand the experimental results about the structure of elements in the actinide region, so this work will contribute to both of these studies.

The calculations are made in the context of the *spdf*−IBM-1, which allow us to describe the low energy collective states of medium-mass and heavy nuclei, which have been proven to give an accurate description of the energy spectra of octupole-deformed nuclei [2, 3]. The model considers the nuclear system as composed of four different bosons, each being the s ($L^\pi = 0^+$), p ($L^\pi = 1^-$), d ($L^\pi = 2^+$) and f ($L^\pi = 3^-$) boson, with the negative parity ones being related to octupole phenomena.

Different hamiltonian operators have been used for the description of these phenomena, some of them with a quite large number of parameters which need to be fit. In this context, we propose the use of a similar one to that of Ref. [4] of the form
$\mathrm{H} = \sum_{\ell=1}^{3} \left(\varepsilon_\ell \hat{n}_\ell + \kappa_\ell \hat{Q}^{(\ell)} \cdot \hat{Q}^{(\ell)} \right)$,

using just six parameters, with a given definition of the multipole operators without free parameters in them. Here, $\ell = 1, 2, 3$ corresponds with the dipole, quadrupole, and octupole term, respectively. This hamiltonian, more simple than the ones used in previous works, allows us to develop a good agreement with experimental data while using a more general expression, which needs less parameter fitting. We also eliminated the restriction in the negative-parity boson number, and as far as we know, there have not been works with the *spdf*−IBM-1 without this restriction, so this novelty may allow us to better describe the octupole phenomena in this chain, as suggested by Ref. [5] when using the *spdf*−IBM-2.

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Session Classification: Poster Session

Track Classification: Theoretical Nuclear Structure