OCTUPOLE DEFORMATION IN RADIUM ISOTOPES WITH THE *spdf*-IBM-1

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Abstract

We present a preliminary systematic study of the spectroscopic and collective properties of the $^{216-226}$Ra isotopic chain in the context of the *spdf* Interacting Boson Model (*spdf*-IBM-1). This model includes the octupole degrees of freedom, allowing us to study positive and negative parity states using the same Hamiltonian for all the phenomena. By this study, we aimed to reproduce the experimental data for the energies and the electromagnetic transition rates of these isotopes, while using a reduced set of parameters.

The Operators

We have used a simple hamiltonian, given by

$$H = \sum_{l=1}^{3} \varepsilon_l \hat{n}_l + \kappa_l \hat{Q}^{(l)} \cdot \hat{Q}^{(l)} . \qquad (1)$$

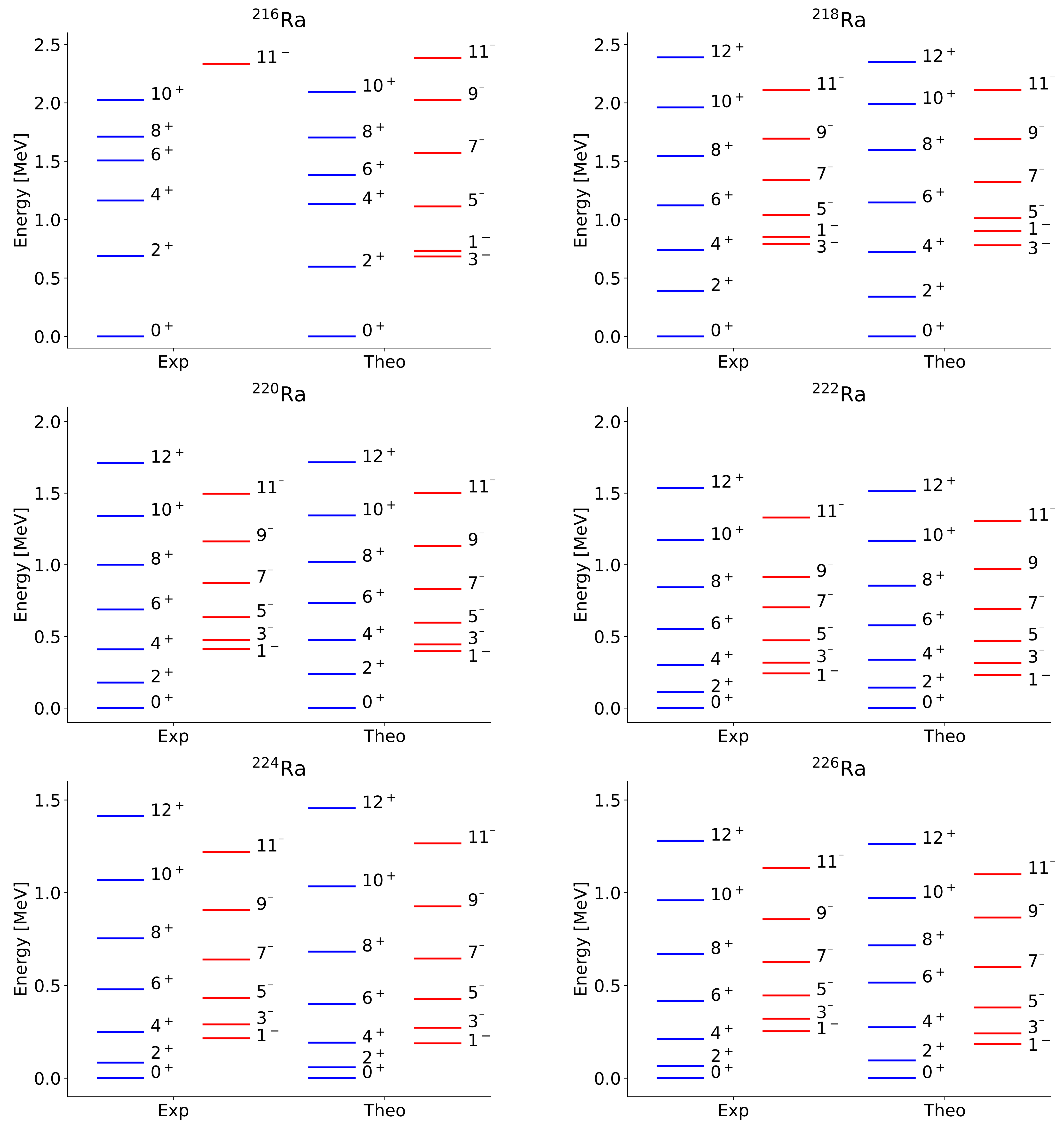
where $\varepsilon_f = \frac{2}{3}\varepsilon_p$ and the definitions for the multipole operators are given in [1]. For the electric transition rates $B(E\lambda)$, we have defined the transition operators with a Q-consistent approach, as used previously for the *spdf*−IBM-2 in [2], such that

$$\hat{T}(E\lambda) \sim \hat{Q}^{(\lambda)} .$$

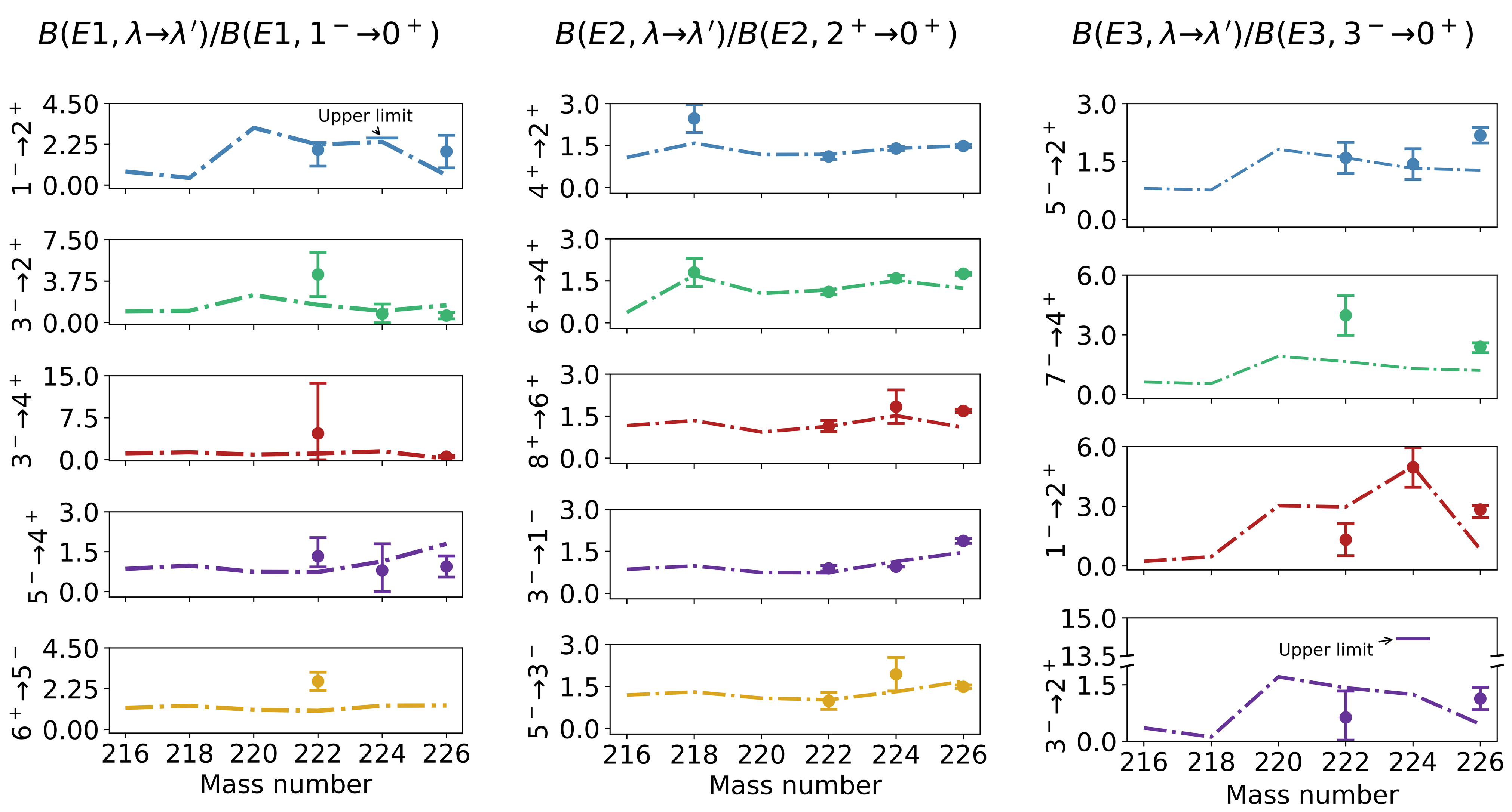
The Parameters (in MeV)

Mass	ε_d	ε_p	κ_2	κ_1	κ_3
216	0.669	0.985	-0.00110	-0.00503	-0.00010
218	0.400	1.235	-0.01088	-0.00322	-0.00139
220	0.370	1.200	-0.00132	-0.00507	-0.00314
222	0.310	1.400	-0.00741	-0.00508	-0.00353
224	0.300	0.338	-0.02536	-0.00377	-0.00010
226	0.300	0.653	-0.01300	-0.00048	-0.00143

Energy Spectra



Electric Transition Rates



Discussion

- The parameters presented above were calculated with a minimization routine making use of the iMinuit Python package, the ArbModel computer program [3], and the experimental data abvailable for energy levels and electromagnetic transition rates in Refs. [4–7].
- As it can be seen in the block above, the energy levels can be well reproduced by our calculations, both for the positive and negative parity levels. We note that the predicted 3^- and 1^- levels for ^{216}Ra show the same behavior than those of ^{218}Ra.
- Regarding the transition probabilities, we can see that for ^{224}Ra we are able to reproduce quite well the ratios for $B(E1)$ and $B(E3)$ transitions, with the values obtained being inside the error bars of the experimental data. However, the same can not be said for ^{222}Ra and ^{226}Ra, which show a better agreement for the $B(E2)$ ratios rather than for those between states of different parity.

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