A study of the nuclear structure in the even–even Yb isotopes

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NUSTRAP Nuclear Structure, Reactions & Applications

PANIC Lisbon Portugal 22nd edition Particles and Nuclei International Conference

Introduction & Motivation

The nuclear properties of the Ytterbium isotopes and their evolution as the neutron number increases has been a central objective in this work. The collective behavior of the even–even $^{164-180}_{70}$Yb isotopes was investigated using several well–established theoretical models in synergy with available experimental data. The medium–to–heavy mass Yb isotopes are known to be well–deformed rotational nuclei which can be populated to very high spins. Spectroscopic information becomes scarcer for neutron-rich nuclei, impeding the understanding of nuclear structure in this mass region, where interesting phenomena, such as shape coexistence [1], have been predicted to exist.

Related Quantities

$B(E2;0_1^+\to 2_1^+)$ values along with values of other observables, such as the electric quadrupole moment Q and the deformation parameter β_2, which exhibit quadratic distortion, have been presented for the employed models.

$$B(E2;0_1^+\to 2_1^+)=\frac{5}{16\pi}Q_0^2 \quad (\text{in } e^2b^2) \tag{1}$$

$$\beta_2=\left(\frac{4\pi}{3ZR_0^2}\right)\left[\frac{B(E2;0_1^+\to 2_1^+)}{e^2}\right]^{1/2}. \tag{2}$$

Interacting Boson Model (IBM–1)

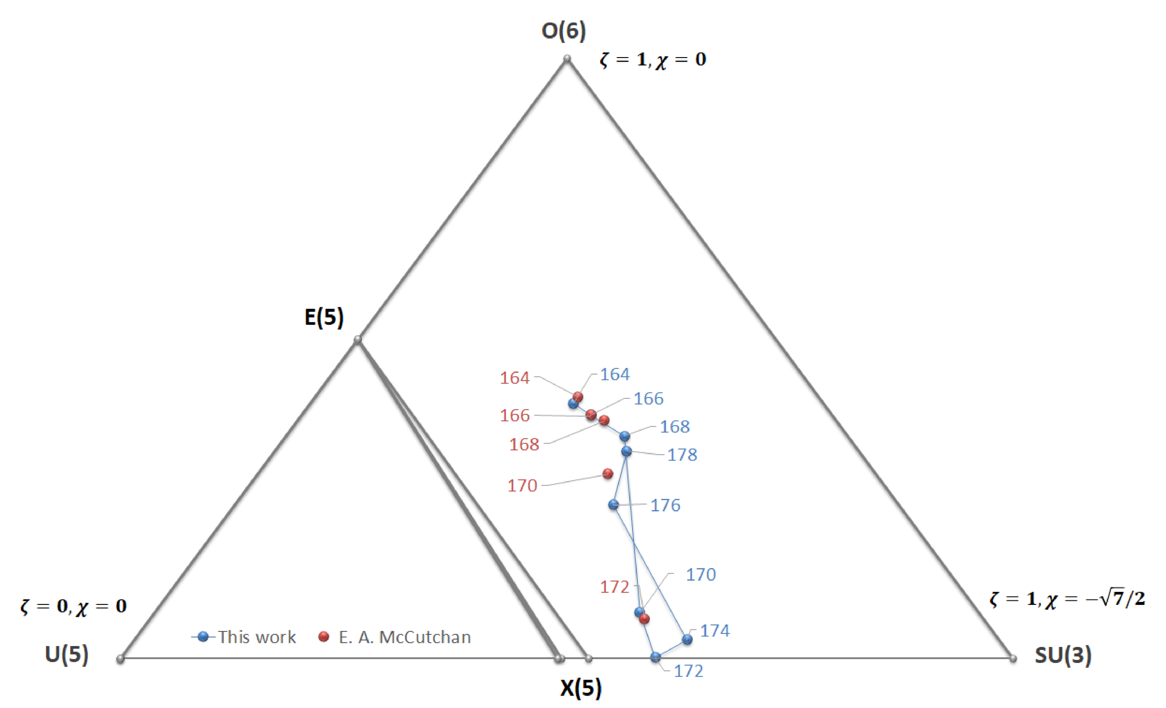

Figure 1: Trajectories in the IBM symmetry triangle for the Yb isotopes [2].

These specific ratios can explain the low–spin structure of the collective even–even nuclei.

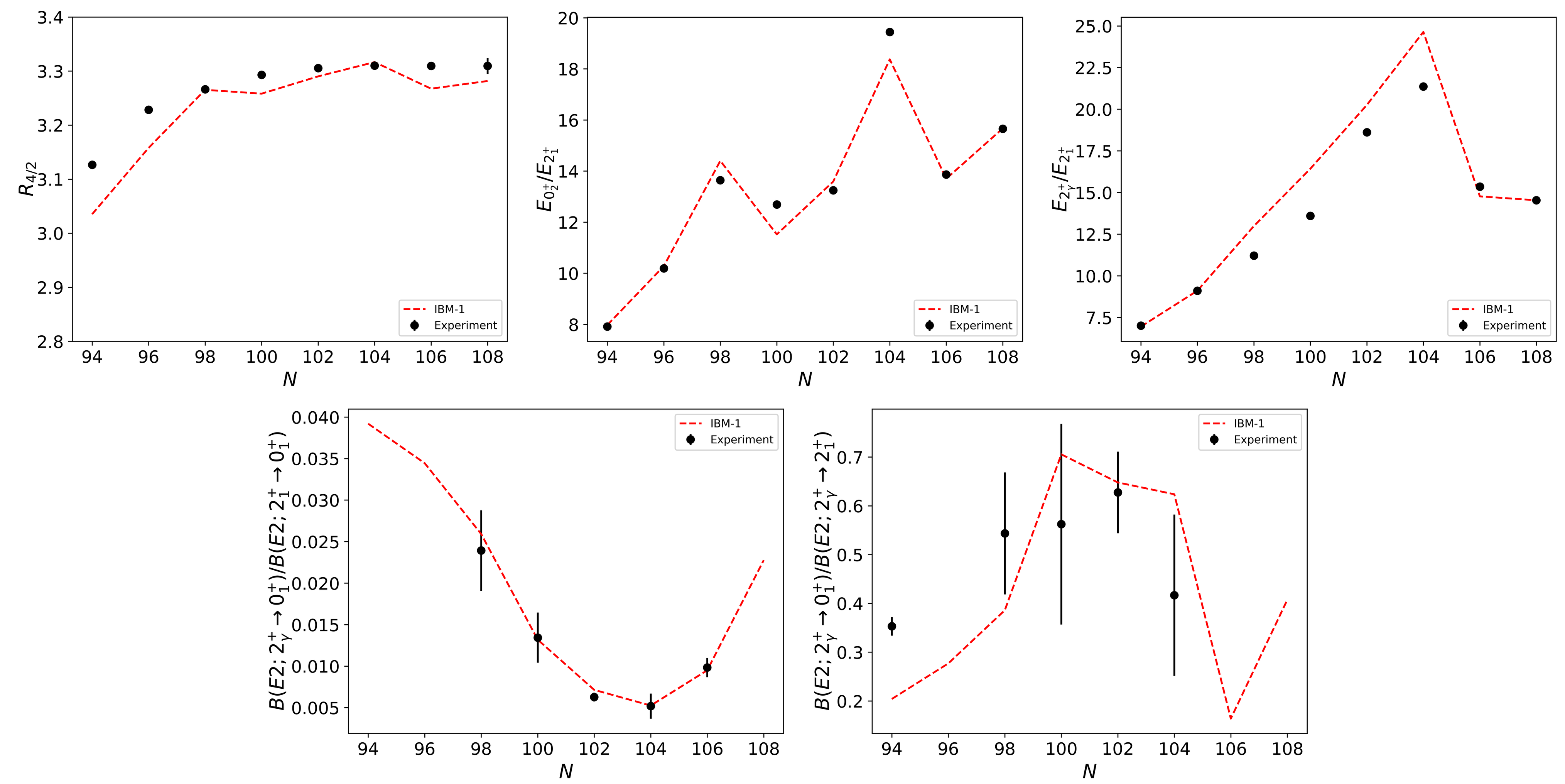

Figure 2: Experimental (symbols) [3] and IBM-1 calculated (dashed lines) ratios for $^{164-178}$Yb.

Results

We present the calculated values of $B(E2)\uparrow$ and compare them with the experimental ones [4]. In the case of the models HFB–Gogny, HFB–UNEDF1, RHB–NL3*, Proxy SU(3) and Pseudo SU(3), $B(E2)\uparrow$ values have been derived from Eq. (2) using the deformation parameter β_2 for each model. In the case of FRDM and HFBCS–MSk7 they have been obtained by means of Eq. (17) of Ref. [5]. For IBM–1 and PhM they have been calculated directly from the models.

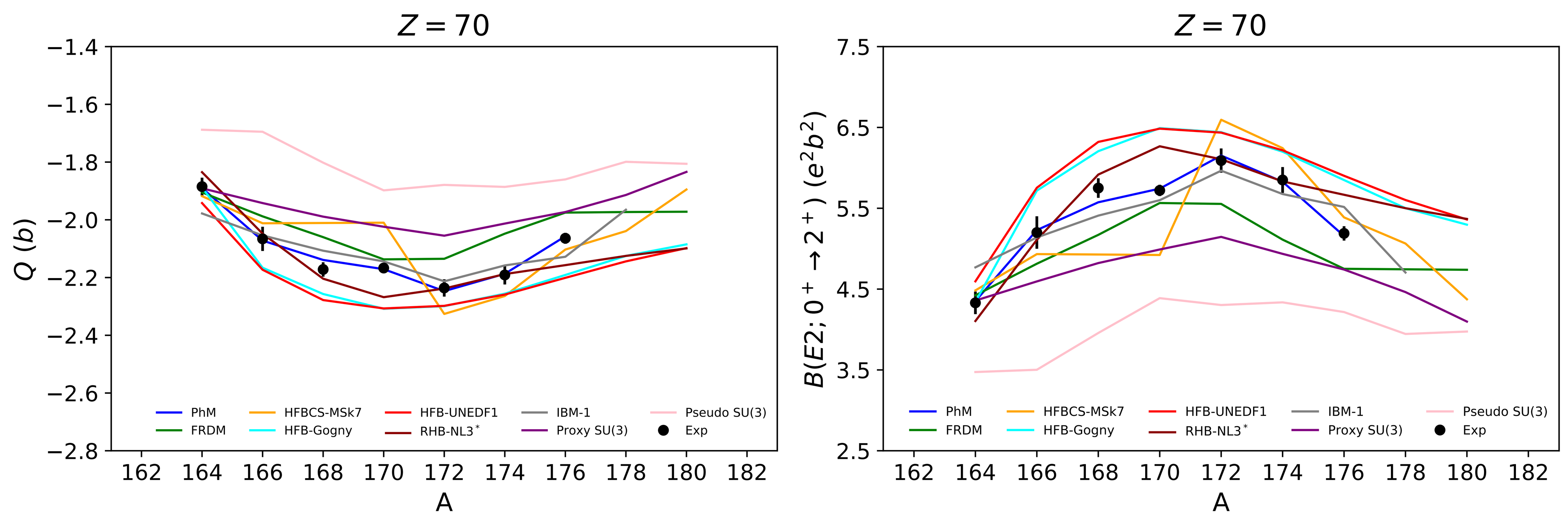

Figure 3: Reduced transition probabilities $B(E2;0^+\to 2^+)$ values and electric quadrupole moments Q values for all models are compared with experimental ones [4].

Acknowledgements

This research work was supported by the Hellenic Foundation for Research and Innovation (HFRI) under the HFRI PhD Fellowship grant (Fellowship Number: 101742/2019) for AZ.

H.F.R.I. Hellenic Foundation for Research & Innovation

Energy Ratios

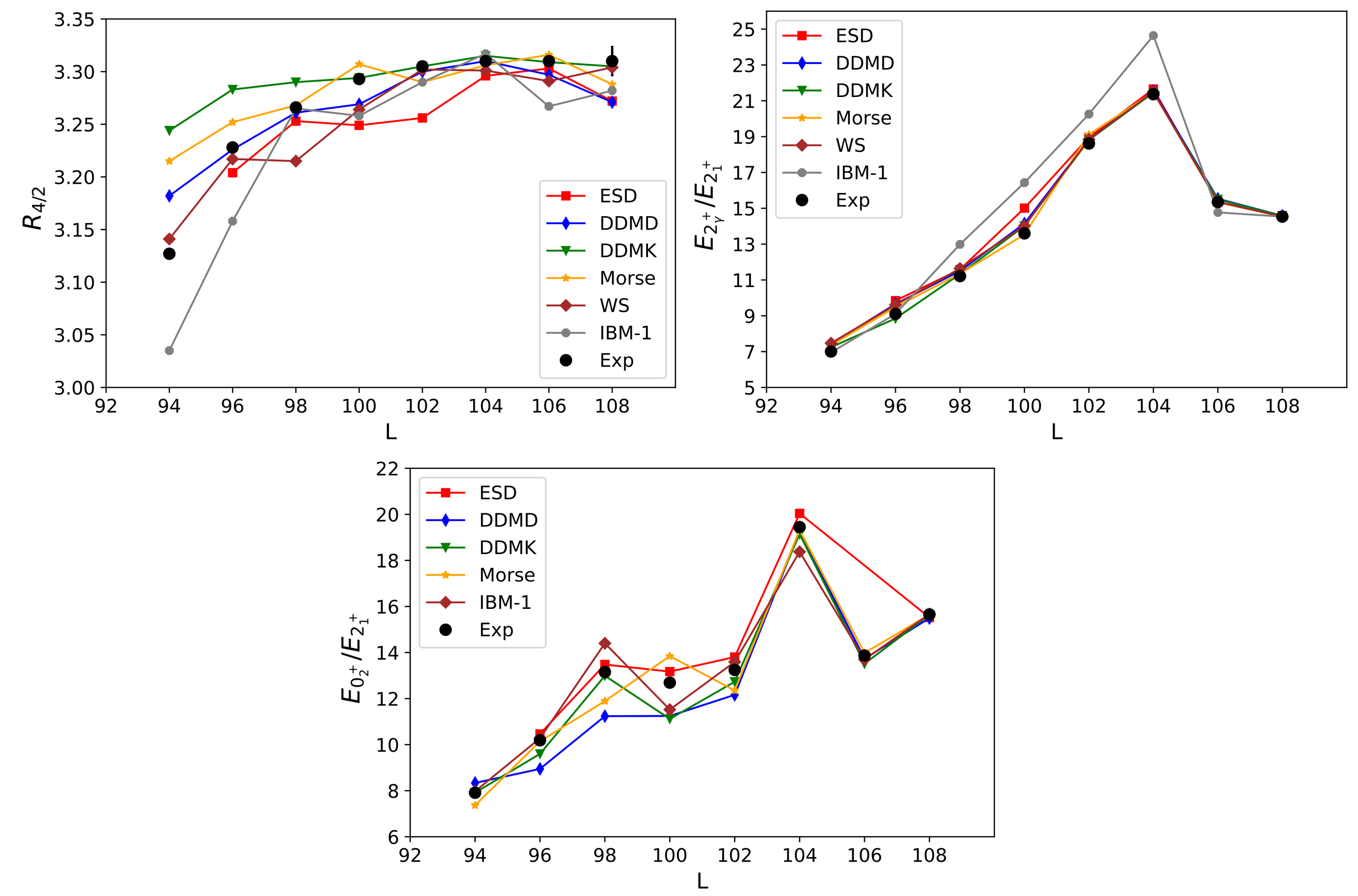

Figure 4: Numerical results for energy ratios for the Yb isotopes, with the Exactly Separable Davidson (ESD), Exactly Separable Morse (Morse), Exactly Separable Woods Saxon (WS), Deformation Dependent Mass Davidson (DDMD) and Deformation Dependent Mass Kratzer (DDMK) analytical solutions of the Bohr Hamiltonian have been obtained.

Conclusion & Future Directions

In the framework of the nuclear collective model, the nuclear observables examined in this work for a number of permanently deformed ^{178,180}Yb isotopes are calculated in agreement with available experimental results. This work can serve as a reference point for future experimental and theoretical work in this mass region, which will provide useful information towards understanding the nuclear structure as one moves closer to the neutron dripline.

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