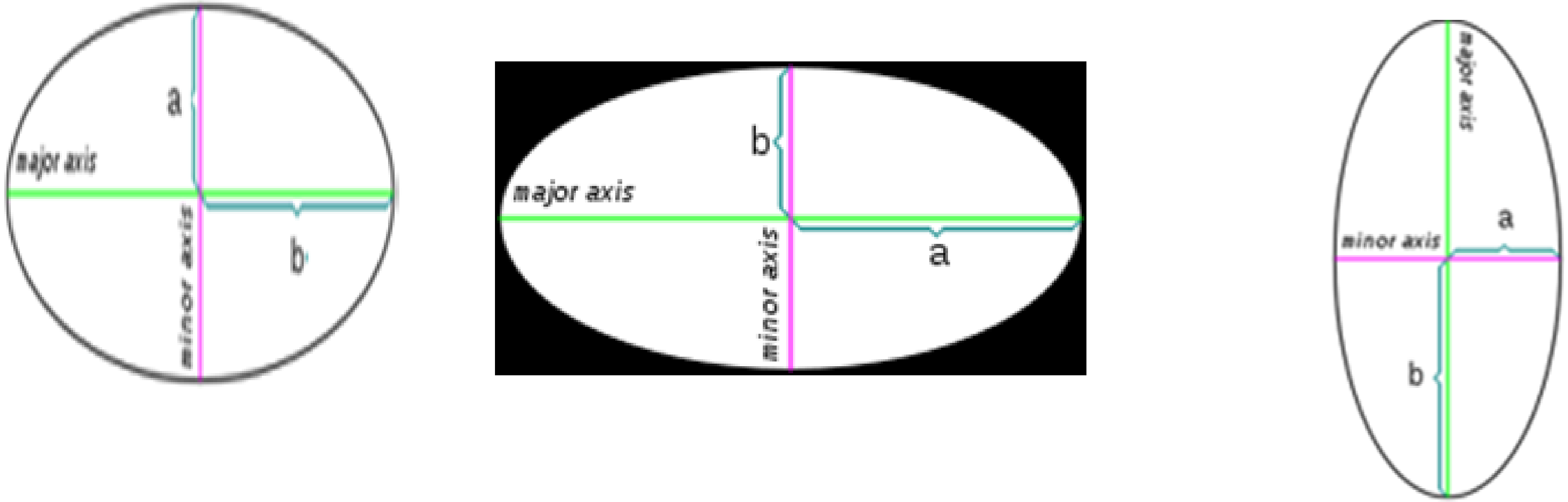
- الكلية : كلية التربية القائم
- استاذ المادة :م.م. سماهر ثابت مشعان
- اسم المادة : الفيزياء النووية
- اسم المادة باللغة الانكليزية: **NUCLEAR PHYSICS**
- اسم المحاضرة باللغة العربية: التشوه النووي
- اسم الحاضرة باللغة الانكليزية: **NUCLEAR DEFORMATION**

Introduction

- One of the most interesting and fundamental emergent properties of the nucleus is the shape that these nucleons are distributed across. When the number of both protons and neutrons equal the “magic numbers” (2, 8, 20, 28, 50. . .) ,the nucleonic distribution is spherical. However, when the nucleon numbers are mid-way between the magic numbers, the nuclear distribution can take on a stabilized non spherical configuration. The quadrupole deformations constitute the simplest form of stable deviations from spherical shapes. The two types of this deformation are labelled as prolate (rugby ball) and oblate (discus) as shown in Fig. (1).



(a)spherical (b) oblate (c)prolate

Fig (1) a diagrammatic representation of three types of nuclear shape

Theoretical Bases

- The single-particle matrix elements as given the following equation

$$\left\langle f \| \hat{X}(\lambda)_{t_z} \| i \right\rangle = \sum_{k_a k_b} \mathrm{OBDM}(f i k_a k_b \lambda) \left\langle k_a \| \hat{X}(\lambda)_{t_z} \| k_b \right\rangle$$

where the OBDM is given by

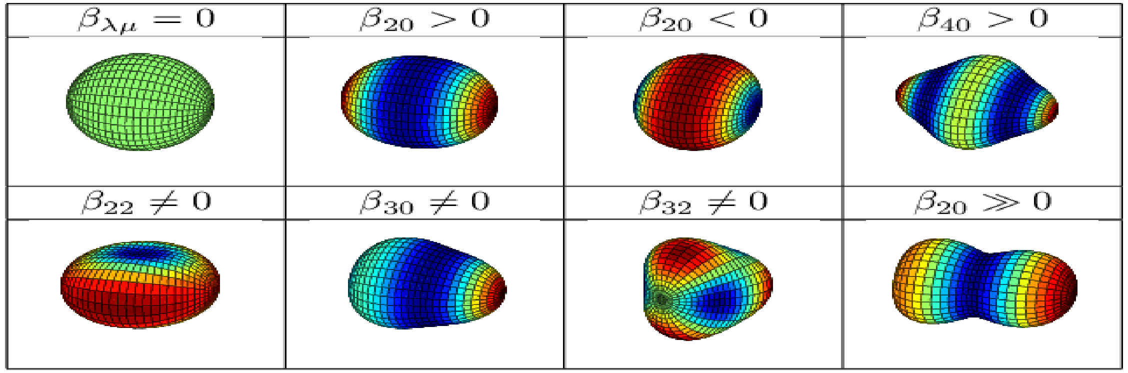
$$\mathrm{OBDM}(f i k_a k_b \lambda) = \frac{\left\langle f \left\| \left[a^{+}_{k_a} \otimes \tilde{a}_{k_b} \right]^{\lambda} \right\| i \right\rangle}{\sqrt{2\lambda + 1}}$$

- The combinations can be quantified in terms of the spherical quadrupole moments as this equation:

$$Q_{2m,type} = \int dV\ r^2 Y_{2m}\ \rho_{type}\left(\vec{r} - \vec{R}_{type}\right)$$

- The quadrupole deformation parameter

$$\beta_{20} = \frac{4\pi}{3}\frac{Q_{20}}{AR^2}$$



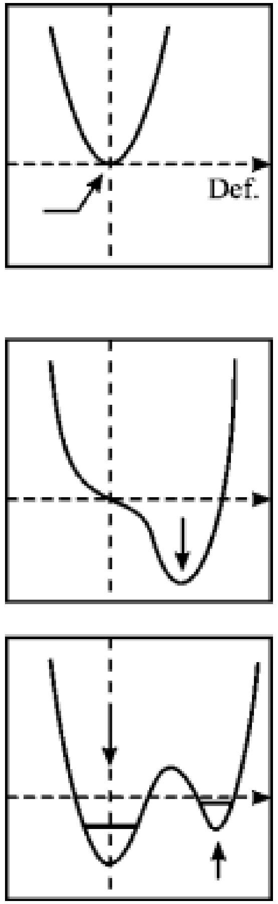
- The nuclear magnetic dipole moment is defined in terms of the M1 operator as:

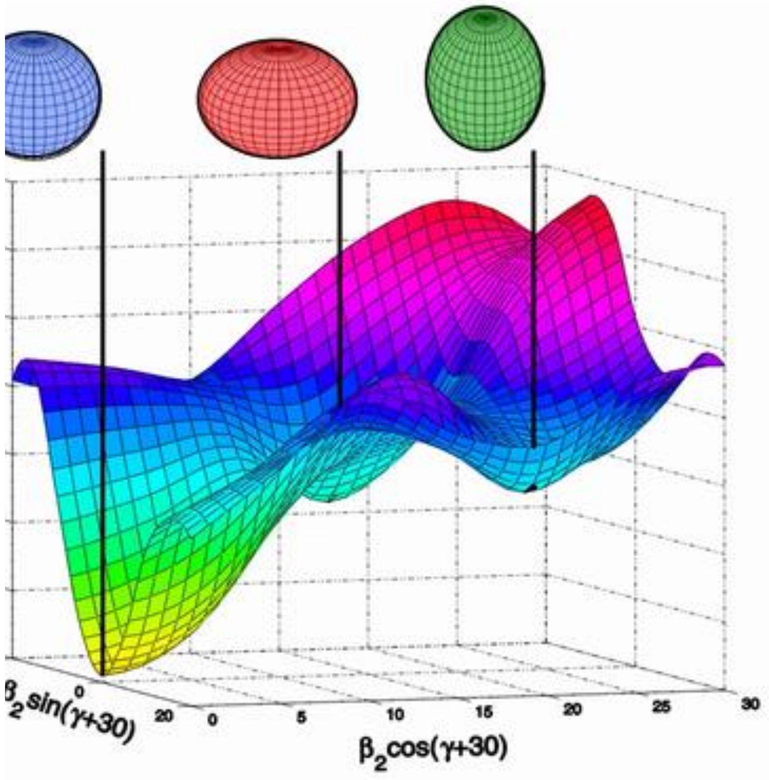
$$\mu = \sqrt{\frac{4\pi}{3}} \begin{pmatrix} J & 1 & J \\ -J & 0 & J \end{pmatrix} \sum_{t_z} \left\langle J \middle\| \hat{O}(\mathrm{M1})_{t_z} \middle\| J \right\rangle \mu_N$$

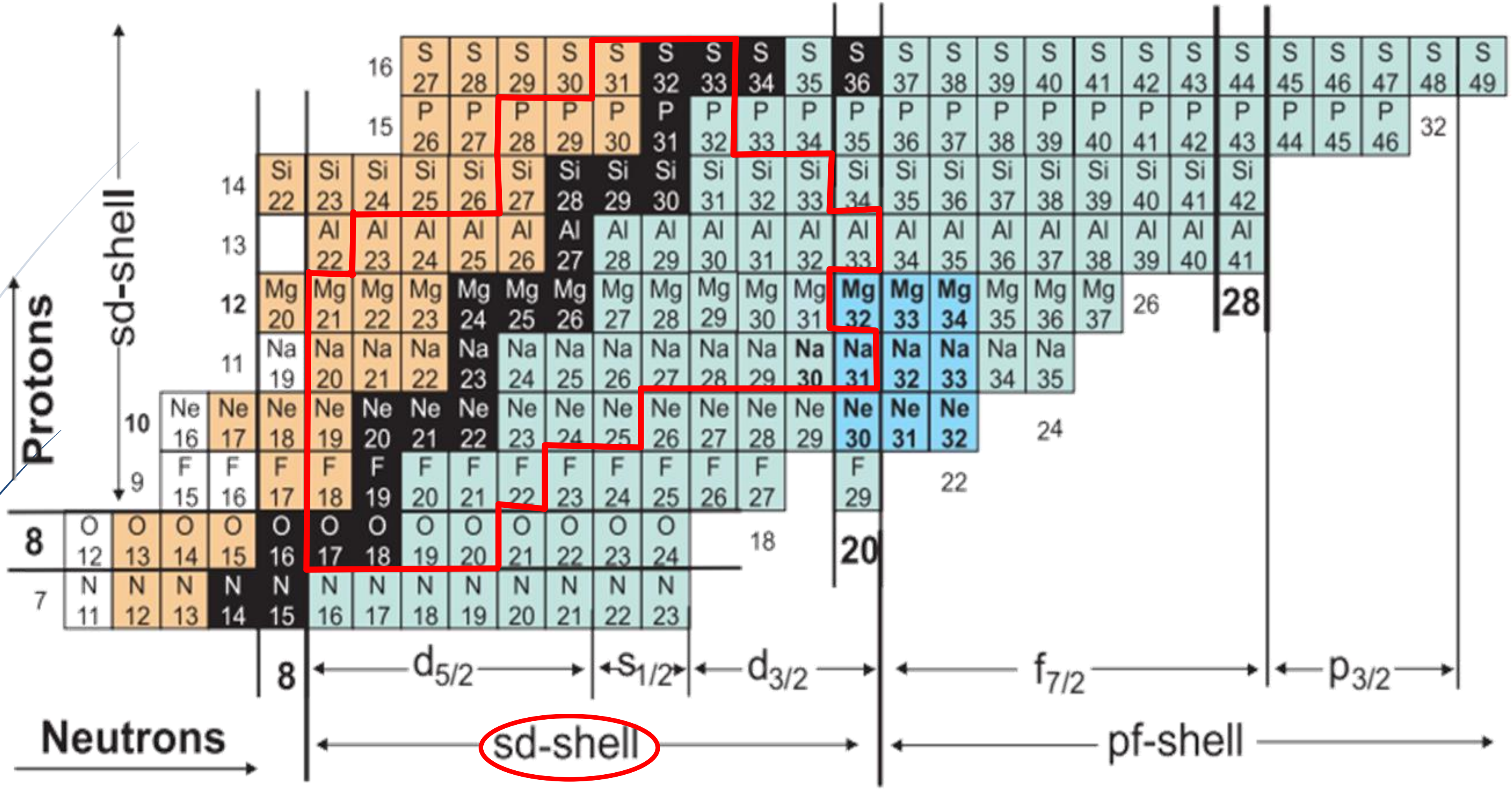
while the electric quadrupole moment is defined in terms of the E2 operator as

$$Q = \sqrt{\frac{16\pi}{5}} \begin{pmatrix} J & 2 & J \\ -J & 0 & J \end{pmatrix} \sum_{t_z} \left\langle J \middle\| \hat{O}(\mathrm{E2})_{t_z} \middle\| J \right\rangle e_{t_z}$$

The experimental data on the electric quadrupole moment in nuclei measure the extent to which the nuclear charge distribution deviates from spherical symmetry. The magnetic moments of nuclei are sensitive to the orbits occupied by the valence nucleons; thus, magnetic moments provide an ideal test of the purity of a certain configuration mixing SM.







(Fig. 2); Part of the nuclear chart explains the nuclei in the *sd*-shell model space studied in the present work.

The electron scattering form factor will be taken the form

$$\left|F_J^L(q)\right|^2 = \frac{4\pi}{Z^2(2J_i+1)} \left| \sum_{T=0,1} (-1)^{T_f - T_{f_z}} \begin{pmatrix} T_f & T & T_i \\ -T_{f_z} & 0 & T_{i_z} \end{pmatrix} \left\langle J_f T_f \left\| \hat{T}_{JT}(q) \right\| J_i T_i \right\rangle \right|^2 \times \left|F_{cm}(q)\right|^2 \left|F_{fs}(q)\right|^2$$

The reduce electric transition probability is

$$B(EJ) = \frac{1}{2j_i+1} \left\langle J_f \left\| \hat{M}_{EJ} \right\| J_i \right\rangle$$

Nuclear Single Particle potential

Skyrme Interaction can be used with the Hartree-Fock method as a single particle potential which is given by:

$$V_{Sky}(\vec{r}_i,\vec{r}_j) = t_\circ\left(1 + x_\circ \hat{P}_\sigma\right)\delta(\vec{r}_i - \vec{r}_j)$$

$$+\frac{1}{2}t_1\left(1 + x_1\hat{P}_\sigma\right)\left\{\hat{k}'^2\delta(\vec{r}_i - \vec{r}_j) + \delta(\vec{r}_i - \vec{r}_j)\hat{k}^2\right\}$$

$$+\mathrm{t}_2\left(1 + x_2\hat{P}_\sigma\right)\hat{k}'.\delta(\vec{r}_i - \vec{r}_j)\hat{k} + \frac{1}{6}t_3(1 + x_3\hat{P}_\sigma)\rho^\alpha\left(\frac{\vec{r}_i + \vec{r}_j}{2}\right)\delta(\vec{r}_i - \vec{r}_j)$$

$$+\mathrm{iW}_\circ\,\hat{k}'(\hat{\vec{\sigma}}_i + \hat{\vec{\sigma}}_j)\times\hat{k}\,\delta(\vec{r}_i - \vec{r}_j)$$

The local nucleon density is defined as

$$\rho_q(\vec{r}) = \sum_{\alpha \in q} \sum_{s} \upsilon_\alpha^2 \left| \psi_\alpha(\vec{r}, s) \right|^2$$

The total energy is composed as

$$E_{tot} = T + E_{Skyrme} + E_{Coulomb} + E_{pair} + E_{cm}$$

The Aim of the Present Work

- The single-particle matrix elements
- The effect of model space.
- The effect of two-body effectice interactions.
- The effect of single-particle.
- The effect of the nuclear effective charges.

- The experimental data from (stone paper).

Thank You