I. QUADRUPOLE MOMENT

If the nucleus has **J** and magnetic quantum number **M**, then Quadrupole Moment (Q.M.) will depend on M because it depends on the shape and hence the orientation of the charge distribution. The quadrupole moment is then defined as the value of (Q.M.)operator for which **M** has its maximum value projected along the z-axis. Using spherical coordinates

$$Q = 3z^2 - r^2 = r^2(\frac{16\pi}{5})^{1/2} Y_{20}(\Theta, \Phi)$$

For extreme single-particle shell model only valence particle contribution to the (Q.M.), and without proof we state the resulting prediction that for odd-A, odd-Z nuclei with a single proton having a total angular moment j outside closed sub-shells, the value of (Q.M.) is given by

$$Q.M. = [^{en}_{e_p}] \int (\frac{16\pi}{5})^{1/2} < r^2 >_{Nl} < l\frac{1}{2}jj|Y_{20}|l\frac{1}{2}jj >$$

$$Q.M. = -[^{en}_{e_p}] \frac{2j-1}{2j+2} < r^2 >_{Nl}$$

where e_n for neutron = 0 , and e_p for proton =1

Thus, $\mathbf{Q.M = 0}$ for $\mathbf{j = \frac{1}{2}}$. For odd-A, odd-N nuclei with a single neutron outside closed sub-shells Q.M. is predicted to be zero because the neutron has zero electric charge, as will all even-Z, odd-N nuclei because of the pairing effect.

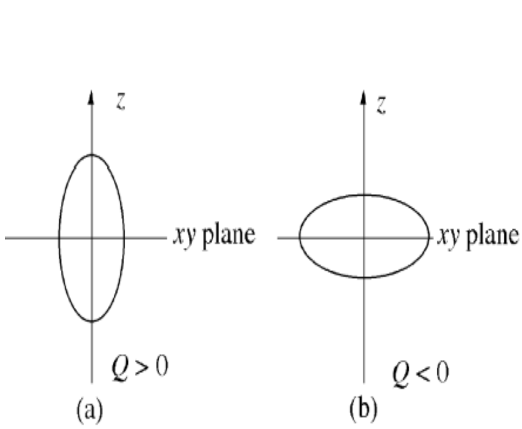
$$Q.M.(particle) = -Q.M.(hole)$$

To estimate the magnitude of Q.M., we assume that the orbital of the valence nucleon lies near the surface of the nucleus. This leads to

$$|Q.M.| \approx < r^2 > \approx R^2 = 1.2^2.A^{2/3} = 1.44A^{2/3} \times 10^{-2} barn$$

$\mathbf{1} barn = 10^{-24} cm^2$

For Comparison, the Experimental data for $^{17}_{9}$F nucleus (orbital $d_{5/2}$) equal to -0.1 barn, while for $^{209}_{83}$Bi nucleus (orbital $h_{9/2}$) equal to -0.46 barn.



Shapes of nuclei leading to (a) $Q > 0$ (prolate), and (b) $Q < 0$ (oblate)

FIG. 1: