Nuclear Structure of W Isotopes

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The W isotope having atomic number *Z*=74 and neutron number *N* varies from 86 to 116. These isotope contain various band i.e. ground state band, K=0 β-band, K=2 γ-band, K=4 band which depends on the combination *N* and *Z*. In 2022, the Lifetime measurements in the tungsten isotopes $^{176\text{-}180}$W studied in A. Harter et al. [1]. The interpretation of $R_{4/2}$ is close to SU(3) limit of ^{180}W and transitional phenomena observed around N=108.

We see the variation in the energy of spin I=2 $E(2_1^+)$ [2] , is 609.9 keV, maximum at *N*=86, which falls to 123.2 keV at *N*=98. Thereafter, $E(2_1^+)$ is almost constant up to *N*=108. Again the energy $E(2_1^+)$ rises up to 219 keV at *N*=118. Here the slope of decreasing or increasing energy on two sides of *N*=108 shows shape phase transition.

The systemetics of energy ratio $R_{4/2}$ [= $E(4_1^+)$/ $E(2_1^+)$], versus N is illustrated for $^{160\text{-}190}$W is shown in Fig. 1. For N=86, $R_{4/2}$ of 2.07, close to *U*(5) symmetry signifies the vibrational nature of the ^{160}W. For N=88, $R_{4/2}$ =2.26, corresponding to *E*(5) symmetry. At N=90, $R_{4/2}$ of 2.5, corresponds to *O*(6) symmetry. $R_{4/2}$ for *N*= 96 is close to *X*(5) symmetry. For *N*=102-108, the nuclei lie close to *SU*(3) symmetry. For N > 108, $R_{4/2}$ decreases from 3.29 to 2.73. Thus, the W isotopes cover the full range of the shape symmetry from the U(5) to SU(3), with the range different on two sides for *N* greater than 108 and *N* less than 108.

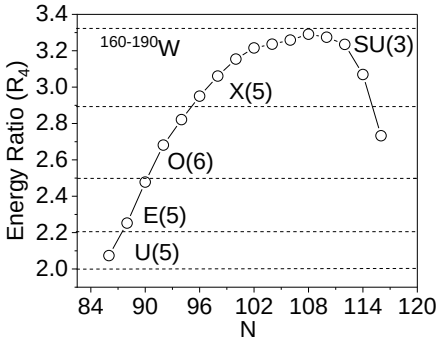

Fig. 1.Critical point symmetry diagram for $^{160\text{-}190}$W with energy ratio R_4 versus N.

The systematics of power index 'b' of the power index formula $E(I) = aI^b$ [3] is plotted in Fig. 2 with spin (I) for $^{178\text{-}182}$W nuclei. For *N*=104, at spin I=4 to spin I=6, the power index rises, then from spin I=6 to spin I=10 is almost uniform and from spin I=10 to spin I=12 decreases for ^{178}W nucleus. For ^{180}W nucleus, the power index 'b' having high value and shows similar variation as like ^{178}W rises with rises slope. The power index 'b' for ^{182}W nucleus, at spin I=4 is 1.74 and

maximum, sharp rises to spin I=6, then gradually rises to spin I=10, and after that almost saturated from spin I=10 to spin I=12. On the other hand, for N=110 ^{184}W, at spin I=4 the value of 'b' is 1.71 and rises similar to ^{182}W, but with minimum increament, having different slope and nature of structure variation as well as shape phase transition at both side i.e. for neutron number N>108 and N<108.

Here the plot of $\boldsymbol{B(E}2; 0_1^+ - 2_1^+)$ in e^2b^2 with 1/ $\boldsymbol{E}(2_1^+)$ $(MeV)^{-1}$ for $^{178\text{-}186}$W is shown in Fig. 3. For N=104 to N=108, the energy $\boldsymbol{E}(2_1^+)$ for spin I=2 decreases , its inverse increases and this inverse of energy plotted with electromagnetic transition $\boldsymbol{B}(\boldsymbol{E}2)$ from spin I = 0 to 2, decreases from N=104 to N=108. For N=110-112, the B(E2) values are small and inverse of energy $\boldsymbol{E}(2_1^+)$ lies lower and shows different slope in the fig. 3. Here for N< 108 and N> 108, the W isotope shows different shape and transition.

Also the ratio of electromagnetic transtion ($\boldsymbol{B}$42) between spin I=4 to spin I=2 and spin I=2 to spin I=0 shows shape phase transition (to be shown in poster).

Result: Here we see, the shape changes in W nuclei both side of N=108, with energy of spin I=2 $\boldsymbol{E}(2_1^+)$, energy ratios $\boldsymbol{R}_{4/2}$, power index '$\boldsymbol{b}$' and $\boldsymbol{B}(\boldsymbol{E}2; 0_1^+ - 2_1^+)$ with 1/ $\boldsymbol{E}(2_1^+)$. This is also observed in the energy's and B(E2)'s in [4,5].

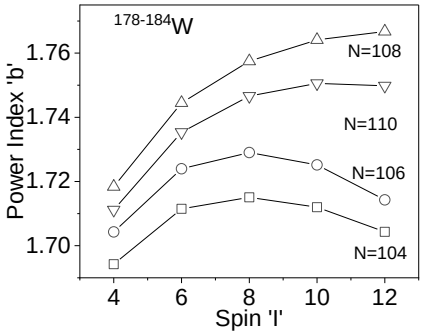

Fig. 2. Systematics of power index 'b' with spin (I) for $^{178\text{-}184}$W.

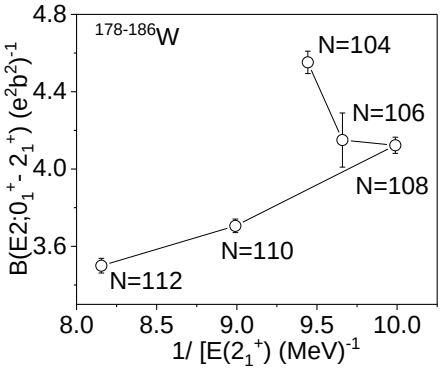

Fig. 3. The plot of electromagnetic transition B(E2; $0_1^+ - 2_1^+$) with 1/ E(2_1^+) for $^{178\text{-}186}$W.

Reference:

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