Shell correction and level density parameter - a function of angular momentum

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Introduction

To reproduce the microscopic fluctuations in excited high spin nuclei a thermodynamical approach is required in which temperature and spin effects are incorporated as done in our earlier work [1, 2] where the shape and structural transitions arising out of rearrangement of particles near fermi level due to temperature and spin have been studied thoroughly. At low temperatures the shell structure plays an important role in the determination of single particle level density parameter. The single particle density fluctuations are different for different angular momentum states of the nuclei at low temperature. As is usually expected shell effects melt away and the fluctuations smoothed out with increasing T and equillibrium shape of the nucleus is driven towards the sphericity. Here we evaluate shell correction as a function of angular momentum at a fixed temperature. An interesting pattern showing strong dependence of level density parameter on the variation of shell correction and deformation as a function of angular momentum is seen.

Brief description of work

Excited spinning nuclei are treated using the statistical theory of hot rotating nuclei. Total excitation energy (thermal + rotational energy) are incorporated to the total ground state energy of the nucleus evaluated using macroscopic - microscopic approach where the Strutinsky shell correction and deformation energies are added to macroscopic energy. Then free energy [1] of the system is minimized w.r.t. the Nilsson deformation parameters β and γ and the corresponding β and γ give deformation and shape respectively. Calculations are performed for doubly magic nucleus ^{208}Pb, nucleus with magic proton number ^{124}Sn and highly deformed nucleus ^{165}Ho.

Results and Discussions

In Fig. 1(a), 2(a) and 3(a) shell correction is plotted as a function of angular momentum M from 0 to 60$\hbar$ for ^{124}Sn, ^{165}Ho and ^{208}Pb respectively. Shell correction fluctuates with M for all the three nuclei studied in this work.

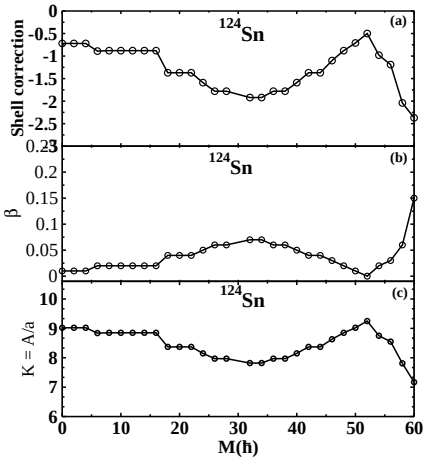

FIG. 1: Shell correction (b) deformation β (c) level density parameter vs. angular momentum M$\hbar$ for ^{124}Sn at T=0.8 MeV

Deformation parameter β seems to follow an inverse pattern showing that whenever shell correction is more, β is small and vice versa. Shell correction is large at shell

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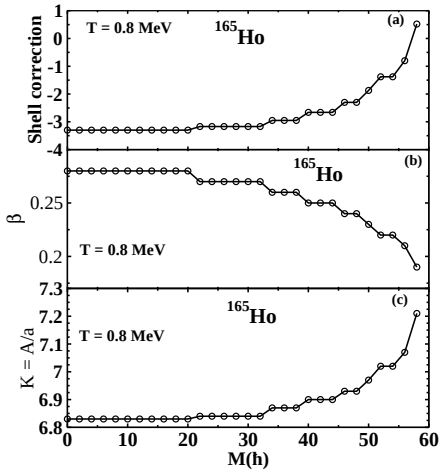

FIG. 2: Shell correction (b) deformation β (c) level density parameter vs. angular momentum M$\hbar$ for ^{165}Ho

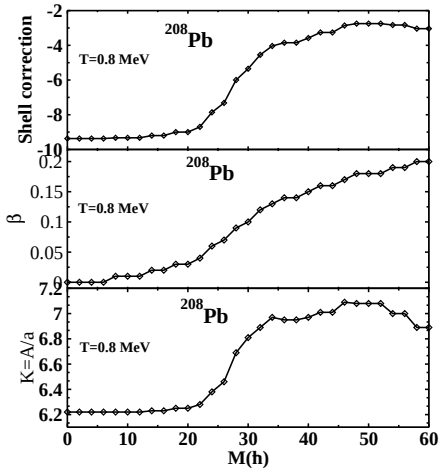

FIG. 3: (a) Shell correction (b) deformation β (c) level density parameter vs. angular momentum M$\hbar$ for ^{208}Pb

closures where the deformation is mostly 0. Level density parameter is minimum at shell closures where the shell correction is large and the deformation is small or zero and hence the inverse level density parameter (K) is maximum. K follows the same pattern as that of the shell correction and β shows the inverse dependence which is expected. ^{165}Ho is a highly deformed nucleus even in ground state with $\beta = 0.27$ in close agreement with Moller- Nix value [3] of 0.29. In case of doubly magic nucleus ^{208}Pb in Fig. 3, deformation is 0 or 0.01 in the ground and low T state as expected and also in Ref.[3]. Rotation of the nucleus brings in the structural transitions and fluctuaions appear in shell correction and the nucleus approaches a deformed state. Inverse level density parameter follws the same pattern as that of shell correction for all the three rotating nuclear systems. A lot more work has to be done to understand the behaviour of shell correction with angular momentum and also with the shape transitions associated with it.

Conclusion

Shell correction fluctuates with angular momentum. Strong dependence of level density parameter on shell correction and deformation with spin is seen in hot rotating nuclei ^{124}Sn, ^{165}Ho and ^{208}Pb.

Acknowledgments

M. Aggarwal acknowledges the financial support from DST, India, under the WOS-A scheme.

References

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