INTRODUCTION

During nuclear reactions, in a few cases it is not only the ground state that is produced but at times the nucleus is left in an excited state from which it decays usually to the ground state by the emission of $\gamma$-rays. Such an excited state, decaying with measurable half-life, is called the isomeric state, and $\gamma$-ray transition the isomeric transition. The study of this state is quite important for understanding the details of nuclear structure. A few spectacular advances made in our knowledge of nuclear isomerism can be traced to an understanding of isomeric levels in terms of nuclear shell structure.

Feenberg suggested a close correlation between shell structure and nuclear isomerism. Hammach et al and Nordheim discussed as to how far shell model can account for the island of isomerism. Mayer, and Haxel, Jensen and Suess have developed a model, of the strong spin orbit coupling for the more rigid level assignments. The results are found to be in agreement with the spin deduced from experiments on isomeric transitions in nuclei belonging to the various shells. The measurable life time of transition involved helped to investigate many intrinsic properties of the state i.e. spin, magnetic moment etc. The interest has now shifted from life time measurements of the isomers to its multipole character and matrix elements of gamma ray transition, from the study of which many valuable
conclusions can be drawn to check existing nuclear models and to modify them. The Matrix elements of $M_4$ transition has remarkable uniformity which has strengthened the single particle model. Similarly the most first excited state of even-even nuclei has spin 2 and even parity and the transition being too fast which cannot be explained by a single particle model. This had led Bohr and Mottelson to postulate a 'cooperative phenomenon' which has been reinterpreted as "collective" or rotational motion of the nucleus. In regions where proton or neutron number are far away from the magic numbers, the formulae for rotational states can be successfully used to predict the energies and spins of the excited states of even-even as well as odd '$A$' nuclei. Our study which previously was limited to nuclear properties such as measurement of spins, magnetic and electric moments for ground state has now been extended to excited state thus making a considerable extension of our knowledge hitherto inaccessible.

The study of the cross-section for production of isomeric state is also quite interesting for understanding transition probability and various nuclear models. Inferences from isomeric cross-section ratio for neutron capture have in some cases been quite useful to decide which isomeric level has a spin close to the capturing state. This has assumed a shape in the form of semi-empirical Mateosian and Goldhaber rule. According to the rule the isomeric state with spin close to the compound nucleus is favoured. This is true for those isomeric cases which are formed by slow neutron capture. It is, therefore, quite natural
that with our increased confidence in assignments of multipole orders for isomeric transitions, the emphasis should drift in the direction of investigating the details and finer aspects of nuclear structure.

Many workers in the past and a few recently have tried to relate isomeric ratio to the initial angular momentum deposited in the nuclear reactions and the final isomeric spins. Attempts were made to show the degree to which the isomeric cross-section ratio can give information about the dependence of nuclear level density on spin and the spins of the initial compound state formed in nuclear reaction. This eventually means finding the value of a parameter, $\sigma^-$, which characterizes spin distribution in the compound nucleus where $\sigma^2$ is proportional to the product of moment of inertia and the nuclear temperature.

Hibdon, by most direct method, found the value of $\sigma^-$ by counting the number of levels with various spins for neutron resonance in $\text{Al-28}$. Ericson estimated $\sigma^-$ for several nuclei using data from $(p,p')$ and $(\alpha,p)$ reactions. Dogulus and Macdonald tried to measure $\sigma^-$ by using the data of angular distribution of emitted particles. The angular distribution in the compound nucleus processes considered such as $(n,p)$ and $(n,\alpha)$ depends mainly on the parameter $\sigma^-$ and so it provides a mean of estimating it. Newton and Cameron estimated $\sigma^-$ from the study of level spacing. Most recently Huizenga and Vandenbosch measured $\sigma^-$ from isomeric cross-section ratio.
The present situation with regard to the determination of the important parameter $\sigma$ is unsatisfactory since the values obtained from results of Newton and Cameron differ greatly from those found by Ericson. Moreover the work reported gives information for a fairly limited range of excitation energies. It is, therefore, apparent that any addition on the value of $\sigma$ shall be quite useful. The present work was undertaken to measure more precisely the isomeric ratio, defined as the ratio of cross-section for the isomeric state to the ground state produced both by thermal neutrons from 'Apsara' reactor at Trombay and by 14.8 MeV neutrons from Linear Accelerator in our laboratory. At thermal neutrons, using $(n, \gamma)$ reaction, the experimentally found values were compared with those calculated on the basis of spin distribution form due to Bethe and Bloch for dipole emission and for various values of $\sigma$. The best fit between experimental and computed value of isomeric ratio led us to determine $\sigma$. Since the change in theoretically calculated isomeric ratios from one value of $\sigma$ to another was rather small it was only possible to define limits of $\sigma$. To get precise value of $\sigma$ the isomeric ratio measured at 14.3 MeV neutrons using $(n,2n)$ reaction was used. In this case the energetic particles produces compound nuclei of higher angular momentum and the emission of particle involve large change in angular momentum. The value of isomeric ratios calculated for different values of $\sigma$ are quite away from each other so it becomes possible to easily fit the experimental
isomeric cross-section ratio with that calculated from statistical model. This helped us to measure $\sigma$ in a few cases with greater precision.

At thermal neutron the semi-empirical rule of Mateosian and Goldhaber was studied and it was found that the rule which was supposed to be true for even-even target nuclei is also true for odd neutron and odd proton nuclei.

Simultaneously attempt was made to complete and improve the data on thermal neutron cross-sections and on $(n,2n)$ reactions cross-section as 14.8 MeV.
References Chapter I

1. E. Feenberg, Phys. Rev. 75 (1949) 320
2. E. Feenberg and K.C. hammersch, Phys. Rev. 75 (1949) 1877
3. L.W. Nordheim, Phys. Rev. 75 (1949) 1894
10. A.C. Douglas and N. Macdonald, Nuclear Physics 13(1959) 382
15. H.A. Bethe, Revs. Mod. Phys. 9 (1937) 84