Study of isomeric cross section ratios in proton and alpha induced nuclear reactions on ^{113,115}In.

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Introduction

As a part of continuous program of systematic study of progress of nuclear reactions at low and intermediate energies and its dependence on various factors we have analyzed the isomeric cross section ratios (ICR) for the production of nuclei ^{113m,g}Sn, ^{116m,g}Sb and ^{118m,g}Sb produced in the reactions ^{113}In(p,n), ^{113}In(α,n) and ^{115}In(α,n) respectively over the energy range 40 MeV. Some of our earlier analysis on the ICR indicated that the isomeric cross section ratios depend critically on spins of the ground and isomeric states, energy difference between the states and as well as the existence of intermediate states [1, 2]. In this paper we report the study of the dependence of ICR on various factors as mentioned above as well as other factors. The analysis of the data has been performed using pre-equilibrium model nuclear reaction code EMPIRE-II [3].

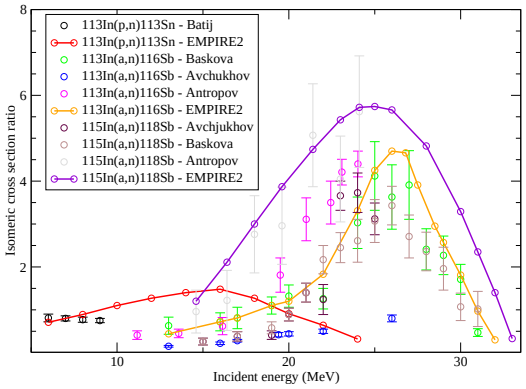

FIG. 1: Isomeric cross section ratio for the isomeric pairs ^{113m,g}Sn, ^{116m,g}Sb and ^{118m,g}Sb.

1 Spins of the relevant states of the isomeric nuclides of interest

Nuclide	Ground state(g)			Isomer state(m)	
—	$J\pi$	$T_{1/2}$	E(MeV)	$J\pi$	$T_{1/2}$
^{113}Sn	$1/2^+$	115.09d	0.0793	$7/2^+$	21.4
^{116}Sb	3^+	15.8m	0.61	8^-	60.3m
^{118}Sb	1^+	3.6m	0.22	8^-	5h

Analysis of the data

The analysis has been performed using the nuclear reaction code EMPIRE-II which makes use of the Hauser-Feshbach (HF) model [4] for the simulation of the statistical part of the nuclear reaction and the NVWY model [5] based on MSD-MSC (Multi Step Direct - Multi Step Compound) approach and the exciton model [6] are used for the PE emission part. A standard set of global parameters for various nuclear parameters are utilized in this code. The HF model is important in calculating the ICR as it takes in to account the spin and parity of each levels in the decay of compound system. The cross sections for the population of each energy level of the nucleus of interest produced in the nuclear reactions are calculated and the ICR is deduced for each pair of isomers at various incident energies. The ICR for the production of isomeric pairs ^{113m,g}Sn, ^{116m,g}Sb and ^{118m,g}Sb are calculated using this code, over the energy ranges from threshold to $\approx$ 40 MeV, and are plotted in Fig. 1. The available literature data [7, 8, 9, 10] are also shown in this figure for the sake

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of comparison on the calculated data with the measured values.

1. Result and Discussion

The analysis of the data shows that ICR increases with increasing incident energy up to a certain ranges and decreases their after in all the cases. It is interesting to note that ICR for ^{116}Sb increases slowly up to ≈ 22 MeV and shows a sharper increases up to ≈ 26 MeV and there after it shows a regular decreasing trend like other cases. Inorder to study the dependence of ICR on various factors the parameters relevant to the pair of levels of interest are tabulated in Tab. 1. As can been read from the table the isomeric state has large spin than that of ground state. Hence it is expected that the population of the levels with higher angular momentum state more and more populated with incident energy. However in the falling of the curve may be due the onset of pre-equilibrium emission where the pre-equilibrium particles may carry relatively larger angular momentum and hence suppressing the population of sates with higher spin. The stepped increases of ICR for ^{116}Sb may be due to the presence of intermediate states (0.0941 MeV and 0.1030 MeV). Therefore the population of isomeric state is relatively delayed by the step wise population of intermediate states. It can also be seen that the levels with larger spin difference as well as the energy differences the ICR increases sharply compare with other case. Further the ICR for alpha particle induced isomers shows sharper increases/deceases relative to that of proton induced one. This is due to the fact that the alpha particles transfer larger angular momentum to the compound nucleus and may be eventually taken by the pre-equilibrium particles. There is no observable effect of life-times of the states on the ICR in any one of the cases as well as the cases reported earlier [2].

2. Conclusion.

The isomeric cross section ratio strongly depends on relative spins and energy difference as well as the onset of PE emission. The trend of ICR is also found to be critically affected by the presence of intermediate state. The pre-equilibrium emission particles carries larger angular momentum.

References

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