Measurement of cross sections for alpha-induced reactions on ^{197}Au

M. S. Basunia[1], H. A. Shugart[2], A. R. Smith[1], E. B. Norman[3]

[1] Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720

[2] Department of Physics, UC Berkeley, Berkeley, California 94720

[3] Lawrence Livermore National Laboratory, Livermore, California 94551

Nucleosynthesis studies of elemental evolution in a stellar environment use an extensive network of nuclear reactions, in which cross section data for various nuclear reaction channels are important. Most of these cross section data are difficult to measure owing to very low cross sections in the relevant energy range. Nevertheless, many cross section measurements have been motivated by the need of theoretical model calibration using the cross section data available from reactions on stable targets. Charged-particle capture reactions for some *p*-process nuclei heavier than iron are important for studying the nucleosynthesis process [1]. Some proton capture and alpha capture reactions are reported in the literature. Most of the alpha-capture reactions are found to be 2 to 5 times lower than the commonly used Hauser-Feshbach statistical model predictions [2,3]. Improved global alpha-optical model potentials were proposed [4] for improving the theoretical results at sub-coulomb barrier energies, and more experimental data for a wider target mass range are important.

A literature survey for the $^{197}Au(\alpha,\gamma)^{201}Tl$ reaction cross section measurements reveals that data reported in Ref. [5] are about 2 orders of magnitude higher than the theoretical predictions and another measurement [6] provides only upper limits [6] for this reaction in the 11.2- to 35.9-MeV energy range because the signature gamma rays of the ^{201}Tl decay were undetectable.

Motivated by such considerations, we have carried out experiments using alpha beams from the 88-inch cyclotron at Lawrence Berkeley National Laboratory (LBNL) for the $^{197}Au(\alpha,\gamma)^{201}Tl$ reaction cross section measurement in the 13.4 to 23.9-MeV energy range. The 167-keV signature γ-ray from the ^{201}Tl decay were detectable only in the energy range 17.9- to 23.9-MeV. Other cross sections such as those for $^{197}Au(\alpha,n)^{200}Tl$ and $^{197}Au(\alpha,2n)^{199}Tl$ reactions are also measured in this work.

Gold foils of ~2 mg/cm^2 thickness and 99.9% purity were used in this experiment. Two stacks of targets, each consisting of four gold foils interspaced by three aluminum foils, and one thick titanium target was placed at the end of each stack. The stacks were bombarded with 24-MeV and 18-MeV alpha beams with about 1 μA beam current for about 6 hours. The aluminum foils were used to degrade the incident alpha-beam energy and to catch the recoil Au and Tl nuclei to determine the recoil fraction. The alpha beam was fully stopped in the titanium target, and the $^{48}Ti(\alpha,n)^{51}Cr$ reaction thick-target yield was used to verify the beam current integration comparing our data with reported experimental data. After irradiations, all samples were counted after a suitable cooling time using an HPGe detector located at LBNL's Low Background Facility. Cross sections were determined using equations and methods as described in Ref. [3].

Measured cross sections for the $^{197}Au(\alpha,\gamma)^{201}Tl$, $^{197}Au(\alpha,n)^{200}Tl$, and $^{197}Au(\alpha,2n)^{199}Tl$ are presented in Table 1. The $^{197}Au(\alpha,\gamma)^{201}Tl$ reaction cross sections of this work along with the earlier experimental data [5,6] and theoretical data [7] are presented in Fig. 1.

TABLE 1: Measured alpha induced cross sections (mb ± 15% to 20%) for ^{197}Au

Energy (MeV)	$(\alpha,\gamma)^{201}$Tl	$(\alpha,n)^{200}$Tl	$(\alpha,2n)^{199}$Tl
23.9	0.038	30	562
22.2	0.030	43	332
20.4	0.018	36	71
18.6		7.2	1.7
17.9	0.004	5.5	0.3
15.8		0.13	
13.4		0.05	

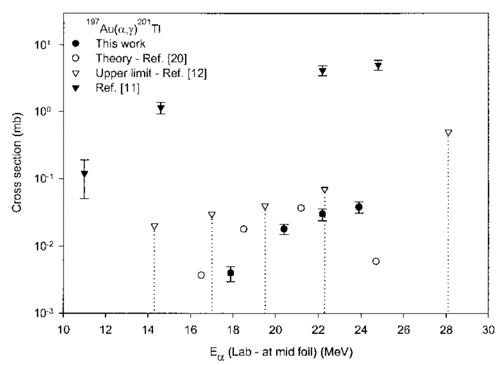

FIG. 1: Cross sections for the $^{197}Au(\alpha,\gamma)^{201}Tl$ reaction.

As can be seen from Fig. 1, the $^{197}Au(\alpha,\gamma)^{201}Tl$ reaction cross sections of this work fall within the reported upper limits [6] and slightly lower than the theoretical data points, but they do not corroborate the high values reported in Ref. [5].

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