L shell and M shell X-ray Production Cross-section for Pb and Au by low energy Proton impact

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Introduction

X-ray based analytical techniques, such as, PIXE and XRF, have large number of applications in different branches of science. PIXE (Particle Induce X-ray Emission) is one the very important non-destructive x-ray based technique used for sample characterization. In this technique an energetic beam of primary radiation is used to ionized the atoms of the sample and then de-excitation of these atoms lead to emission of characteristic x-rays. Energy and intensity measurements of these x-rays are used for identification of the atoms of different elements and also in determination of the chemical composition of the sample. Hence, the accurate knowledge of X-ray production cross sections is necessary for proper application of the PIXE.

The process of x-ray production can be affected due to presence of various other processes, such as, Auger process in which the vacancy of a singly ionized atom is transferred from one of the inner shells to another and the difference in energy is released by the emission of one of the outer-shell electrons. Similarly, in the case of Coster–Kronig transition, the two inner-shell electrons are situated on two different sub-shells of the same inner shell (e.g. L1 and L3). Such transitions do not produce x-rays directly; they redistribute the primary vacancies between the different shells and between the different sub-shells of the same shell. As a consequence, these process change the intensity of the x-rays. Precise knowledge of these processes is important in order to have correct estimation of the chemical composition of the sample. Hence, the proper understanding of various processes is very important.

Existing literature shows significant discrepancy between experiment data and theoretical predictions for the X-ray cross sections [1]. The x-ray production crosssection by impact of H^+ ion on Au, Pb, [1], shows large discrepancy (up to 30%) for L and M shells [1,2]. The complexity increases for the calculation of L-shell and M-shell due to interference of various physical processes.

The aim of the present work is to calculate the L shell and M-shell x-ray crosssection in order to understand the reason for large discrepancy between experiment and theory.

Calculations and Results:

In present calculations, the modified plane wave Born Approximation (PWBA) theory was used [3]. Effect of various processes, such as, energy loss, coulomb deflection of the projectile, modification of the electronic energy state due to perturbed energy state of a united atom was included. The details of theoretical expressions of the model are describe in details elsewhere [3,4].

The x-ray crosssection were calculated for L and M shells for low energy H^+ ions incident on Au and Pb and data for Coster–Kronig transitions was taken from Chauhan and Puri [5]. In this work mainly the effect of florescence yield and emission rates on x-ray production cross section was investigated. For this purpose two different data sets of Campbell [6] and that of Krause [7] were used. These results are also compared with the experimental data for L-shell [1] as shown in figure 1 (a and b). Present result show that there is no significant effect of florescence yield and emission rates on L-shell x-ray production cross section.

Similarly M-shell calculations are also carried out for impact of H^+ ion on Au, Pb targets and compare with the experimental data [2]. The results show that deviation with experimental data increases as the energy of H^+ ion increases from 700 keV to 2400 keV, as shown in figure 2 (a and b). Further calculations are underway for studying the effect of florescence yield and emission rates on M-shell x-ray production cross section which will be presented later on.

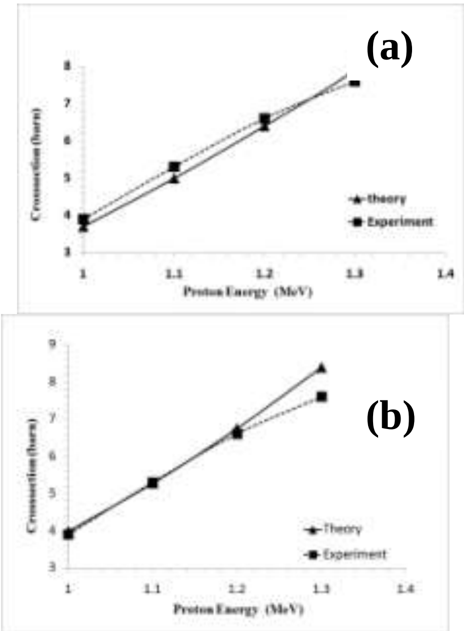
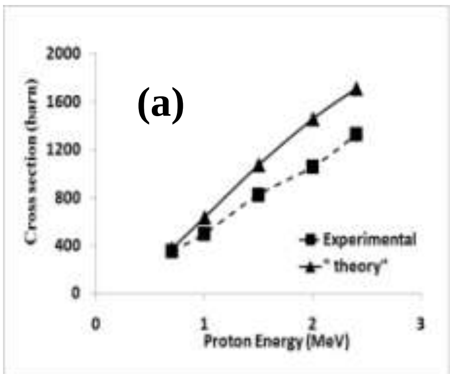


Figure 1: L shell x-ray production cross section calculations for Pb target using low energy proton beam with florescence yield and emission rates taken from **(a)** Campbell [6], (**b**) taken from Krause [7]. Experimental data was taken from [1].



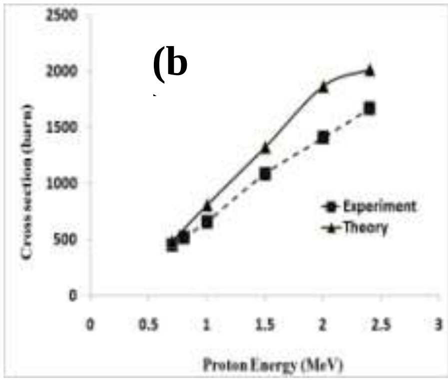


Figure 2: M shell x-ray production cross section calculation for (**a**) Pb target and (**b**) Au target for low energy proton beam. Experimental data was taken from [2].

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