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Experimental investigation of angular dependence of photon induced L-shell X-ray emission intensity

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Abstract. The angular dependence of emission intensity of L shell X-rays induced by 59·57 keV photons in Pb and U is investigated by measuring the normalized intensities of the resolved L X-ray peaks at different angles varying from 40° to 120°. It is observed that while L_l and L_α X-ray peaks (originating from $J = 3/2$ state) show some anisotropic angular distribution, the emission of L_β and L_γ X-ray peaks is isotropic. The present results contradict the calculations of Co-oper and Zare (1969) that after photoionization of inner shell, the vacancy state has equal population of magnetic substates and the subsequent X-ray emission is isotropic but confirm the predictions of Flugge *et al* (1972) that the atomic inner shell vacancies produced after photoionization are aligned and the x-ray emission from the filling of vacancies in state with $J \geqslant 3/2$ is anisotropic.

Keywords. Photoionization; inner-shell vacancies; Fluorescent L shell X-rays; angular distribution.

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1. Introduction

Contrary to the predictions of Co-oper and Zare (1969) that after photoionization of inner shell, the vacancy state has equal population of different magnetic substates and the subsequent emission of X-rays is isotropic, the theoretical calculations by Flugge *et al* (1972) have shown that after the ionization of inner shells by an unpolarized photon beam, the state of ion thus formed turns out to be aligned i.e. it has unequal population of different magnetic substates if its total angular momentum $J > 1/2$. This alignment is manifested by the anisotropic emission of characteristic X-rays or Auger electrons from such state. Therefore, the X-rays originating from the states corresponding to $J = 1/2$ (K-shell and L_I, L_{II}, M_I, M_{II} subshells etc.) are expected to be isotropic and those corresponding to state $J = 3/2$ (e.g. L_{III}, M_{III} and M_{IV} subshells) and $J = 5/2$ (e.g. M_V subshell) are expected to be anisotropic in their spatial distribution.

The angular distribution of ion induced K and L shell X-rays has been extensively investigated by many workers and some measurable anisotropy in L_l and L_α X-rays induced by ions of different energies has been observed in some elements (Middlemann *et al* 1970; Hardy *et al* 1970; Codling *et al* 1976; Stoller *et al* 1977; Palinkas *et al* 1979; Jitschin *et al* 1979a, b; Ellsworth *et al* 1979; Kabachnik *et al* 1980; Baros Leute *et al* 1982; Forrest *et al* 1983; Papp and Palinkas 1988). However, to the best of our