CHAPTER I

INTRODUCTION

It is well known that a charged particle when it comes in the neighbourhood of another charged particle experiences some acceleration and emits electromagnetic radiation called the external bremsstrahlung. The external bremsstrahlung emitted by electrons under the influence of the Coulomb field of the nucleus has been a subject of both theoretical and experimental study.

One may consider theoretically the bremsstrahlung emitted by a collimated beam of monochromatic electrons incident on an infinitely thin target and obtain an expression for the bremsstrahlung production cross section that is differential in photon energy and angle. By using monochromatic electrons from particle accelerators and target foils which have negligibly small thickness compared with the range of the incident particle in the target material, one can determine experimentally the bremsstrahlung production cross section that is differential in photon energy and angle. Many investigators have determined the external bremsstrahlung cross section using monoenergetic electrons and extremely thin targets (of the order of $\mu g/cm^2$). Their results for electrons of kinetic energy
in the range of 0.5 to 5 Mev show that the disagreement between the Bethe-Heitler theory and the experimental results increases with (a) the atomic number \( Z \) of the target, (b) the photon energy and (c) the photon angle.

On the other hand when one uses electrons having continuous distribution of energy from beta sources, such as S-35, RaE, P-32 and Y-90 one cannot consider any target as infinitely thin for electrons of all energies present in the beta decay. In order to avoid this difficulty one can use a target thick enough to stop all beta particles and measure the emitted bremsstrahlung. Because of the multiple scattering of the electrons in the thick target, from the experimentally observed spectrum one can determine the external bremsstrahlung production cross section that is differential in photon energy only. Further the electrons can undergo elastic, inelastic and radiative collisions with the atoms of the target and so the observed bremsstrahlung is a net result of the radiation emitted over the whole path of the electron. So the observed spectrum should be corrected for the loss of energy of the electrons in passing through the matter and also for the attenuation of the emitted photons while passing through the rest of the foil. The correction for the loss of energy of the beta particles is normally made
by using the theoretical expression for the stopping power of electrons in the material and the experimentally determined excitation potential. Further the corrections are also made for the attenuation of the emitted photons in passing through the rest of the foil. Though this correction is quite large, it can be evaluated fairly accurately. But the important point to remember is that both the corrections are dependent on the atomic number of the target and so the dependence of the observed bremsstrahlung spectrum on the atomic number is different from that expected from theory for infinitely thin target. In fact, the experimental data on the external bremsstrahlung using beta particles and thick targets have shown that the disagreement between theory and experimental results increase with (a) the atomic number of the target and (b) the photon energy. In the case of beta particles it is rather difficult to assess what part of this disagreement is due to the disagreement between the actual and the theoretically expected bremsstrahlung spectrum and what part is due to possible disagreement between the actual and the theoretically assumed stopping power of the material.

In order to resolve this difficulty, an attempt has been made in the present investigations to determine the external bremsstrahlung spectrum that is free from
the effects of the slowing-down of beta particles and the attenuation of the emitted photons in the finite thickness of the target foil. This has been achieved by adopting an extrapolation method not used so far.

The external bremsstrahlung produced by beta particles from Sr-Y-90, has been measured with a NaI(Tl) scintillation detector and a single channel pulse height analyser as a function of thickness $t$ of the target. The measured intensity $I_{EB}$ is found to increase initially with the target thickness $t$ (mg/cm$^2$) for $t$ up to 0.4 times the range $R$ of beta particles of maximum energy and then decreases slowly for higher values of target thickness. The initial rise of intensity is due to the predominance of the production of bremsstrahlung over the attenuation of emitted photons while the later decrease of intensity is due to the predominance of the attenuation of emitted radiation over the production of bremsstrahlung in the target. But the deviation of external bremsstrahlung intensity (integrated as well as differential in energy) from linear increase with $t$, for $t < 0.4R$ is found to be due to the slowing-down of beta particles and not due to the effects of attenuation of the emitted radiation in the target, as one is likely to assume. We have adopted, exploiting this fact, as an extrapolation method which gives
external bremsstrahlung intensity per atom in the limit of the target thickness $t$ tending to zero, which intensity is free from the effects of finite thickness of the target, namely the effects of slowing-down of beta particles and the attenuation of radiation in the finite thickness of the target. Using this method we have investigated

1. $Z$-dependence of the integrated external bremsstrahlung intensity for target elements in the range of $Z=29$ to $82$,
2. the relation between the slowing-down of beta particles and the non-linear increase of the external bremsstrahlung intensity (both integrated as well as differential in energy) as a function of the target thickness $t$ in the range of 0.1 to 0.4$R$ and
3. the external bremsstrahlung spectrum that is differential in photon energy for targets of atomic number 29, 48 and 82. In all these measurements a difference method has been adopted to correct for the internal bremsstrahlung from the source and the natural background.