ISSN 2249-0582

World J of Engineering and Pure and Applied Sci. 2011;1:5

Syed et al. *Methodological Analysis of Bremsstrahlung Emission*

OPEN ACCESS

Original Article

Basic Science

Methodological Analysis of Bremsstrahlung Emission

Syed Bahauddin ALAM *, Fahim Arefin KHANDAKER, Palash KARMOKAR, Sirat HASAN, Hussain Mohammed Dipu KABIR, Abdul MATIN

ABSTRACT [ENGLISH/ANGLAIS]

Bremsstrahlung in rays is significant factor for high vitality electrons. At medium to high laser intensities absorption by the classical inverse bremsstrahlung process decreases rapidly and this mechanism alone is insufficient to explain the levels of absorption measured in recent experiments. Bremsstrahlung radiation measurement is one of the most commonly used plasma diagnostics methods. Most of the bremsstrahlung measurements with electron cyclotron resonance ion sources have been performed in continuous operation mode yielding information only on the steady-state bremsstrahlung emission. The processes of absorption of laser energy are fundamental to the study of laser-heated thermonuclear plasmas and have received considerable attention from theorists and in experiments. This paper describes results of bremsstrahlung. An algorithm for the simulation of bremsstrahlung emission by fast electrons using numerical cross sections is described.

Keywords: Bremsstrahlung, electron position, Monte Carlo

RÉSUMÉ [FRANÇAIS/FRENCH]

Bremsstrahlung dans les rayons est un facteur important pour les électrons de haute vitalité. À moyen et à absorption laser haute intensité par l'inverse classique bremsstrahlung processus diminue rapidement et que ce mécanisme ne suffit pas pour expliquer les niveaux d'absorption mesurée dans des expériences récentes. Mesure de rayonnement de freinage est l'un des diagnostics plasma le plus couramment utilisé des méthodes. La plupart des mesures de rayonnement de freinage avec des sources d'électrons par résonance cyclotronique ionique ont été réalisées en mode de fonctionnement continu donnant des informations uniquement sur l'émission bremsstrahlung l'état d'équilibre. Le processus d'absorption d'énergie laser sont fondamentales pour l'étude des plasmas thermonucléaires laser chauffe et ont reçu une attention considérable de la part des théoriciens et des expériences. Ce document décrit les résultats de bremsstrahlung. Un algorithme pour la simulation de rayonnement de freinage d'émission par des électrons rapides en utilisant numériques sections est décrite.

Mots-clés: Bremsstrahlung, position d'électrons, Monte Carlo

Affiliations:

Department of EEE, Bangladesh University of Engineering and Technology, Dhaka

* Address for Correspondence/ Adresse pour la Correspondance: info@sbahauddin.com

Accepted/Accepté: May, 2011

Citation: Alam SB, Khandaker FA, Karmokar P, Hasan S, Kabir HMD, Matin A. Methodological Analysis of Bremsstrahlung Emission. World Journal of Engineering and Pure and Applied Sciences 2011;1:5-8.

INTRODUCTION

Monte Carlo simulation of electron photon showers has become the fundamental tool used for these studies, and a number of general-purpose Monte Carlo codes are widely available [1]. Quantum outcomes on the nonrelativistic Bremsstrahlung procedure in electron plasmas are inquired using the rectified Kelbg potential allowing the classical effect as well as the quantum-mechanical effect. Many of the characteristic features of plasmas can be understood by knowing the energy or velocity dependence. The general equilibrium velocity distribution function of a collision less plasma is known to be the Boltzmann distribution. For the characterization of medical and analytical x-ray sources, for the dosimetry of high-energy electron beams and, in general, for studies of high-energy radiation transport. This Maxwellian plasma is in thermal equilibrium, which implies that it no longer contains free energy and, hence, there are no energy exchange processes between the particles in the plasmas. It is then clear that the velocities of the particles are assumed to be distributed around the average velocity [2].

Bremsstrahlung is produced in the head, in the cerrobend or lead cutout, and in the tissue. The difficulty of modeling ties with the lack of knowledge of the Bremsstrahlung component. Most electron beam algorithms ignore the bremsstrahlung components. This becomes increasingly important for high energies and for small fields. Bremsstrahlung from the head dominates and increases with beam radius [3]. The bremsstrahlung radiation due to electron-ion Coulomb collisions in plasmas has received much attention since this process is widely used to diagnose astrophysical and laboratory plasmas. In isotropic weakly coupled plasmas, the electron-ion bremsstrahlung process is described by the Debye-Huckel potential. Bremsstrahlung from cerrobend decreases with increasing radius because the amount of cerrobend intersecting beam is decreased. These components were separated using measurements in water with variable collimation by 12-cm thick Lucite or by cerrobend blocks for clinical electron beams. [4].

The classical Debye Huckel model describes the properties of low density plasma and corresponds to a pair correlation approximation. It has been known that the plasmas described by the Debye Huckel model are ideal plasmas since the average interaction energy between charged particles is smaller than the average kinetic energy of a particle [5].

SIMULATION OF BREMSSTRAHLUNG PRODUCTION & EMISSION

Via Radiation Power Mitigation Reaction, the virility of waste may be weakening. For the sake of weaken the radiotoxicity of the radioactive material as early as possible, waste treatment and management is done.

When a laying out electron motions with atomic Electrons, collision energy loss goes on and this consequence in either ionization or excitation of the nuclei. Large energy departures pass off less oftentimes where a substantial ratio of the energy of placing electrons is transported to an orbital electron, which is named a knock-on collision, and the expelled electron is pertained. This process is modeled by collision of "free electron"' as the outermost shell electrons are loosely colligated. Where the electron loses a negotiable amount of energy, there takes place "Collisional Energy Losses". The rate of energy release by this mechanics devolves on the electron energy and the ionization free energy.

Bremsstrahlung irradiation is rendered in the contour of photon emanation while an electron acts with the coulomb field of the nucleus. When an electron conks close to the nucleus of a particle, it goes through an electromagnetic force and issues in an energy loss. The probability of such an fundamental interaction gains as the outstrip of the electron's near to the atom diminishes. Subsequently the energy lost is reborn to a Bremsstrahlung photon, this procedure is referred to as a radiative energy loss. The uttermost energy of the Bremsstrahlung photon cannot be heavier than the incidental electron energy and a orbit of photon energies beneath this evaluate is produced. The energy release due to output of photons per path distance dz from electrons of energy $E=h\upsilon_{max}$, max, where n is the Bremsstrahlung absolute frequency, is given close to by the following relationship.

$$(dE/dZ)_{rad} = 5.343Z^2ENr_0^2Z^{\frac{-1}{3}} \quad (1)$$

where Z is the atomic number, N the number of nuclei per unit volume and r_0 the classical radius of the electron. The collision stopping power [7] of radioactive element is as equation

$$(-dE/dS)_{coll} = \rho(Z/A)z^2 f(I,\beta) \quad (2)$$

where $f(I,\beta)$ is a complex function for radioactive resources. The photons developed by excursus of charged radioactive particle are called "Bremsstrahlung". When the electron is deflected by both ambient nuclei and ambient electron of unstable fabric, Bremsstrahlung is released. The radioactive power can be written as equation

$$(-dE/dS)_{rad} = \rho(N_a/A)(E+m_ec^2)Z^2F(E,Z) \quad (3)$$

Where is a radioactive function strongly dependent on radioactive energy. For a relativistic radioactive particle of rest mass M, with $E >> M_ec^2$, it can be shown that the radioactive to ionization losses is approximately. From the equation (6), energy equation can be written as equation (7),

$$\frac{(-dE/dS)_{rad}}{(-dE/dS)_{coll}} = 1.4285\times10^{-3}EZ(m_e/M)^2 \quad (4)$$

In equation (7), derivatives of radiational and collisional energies are negative. In that ratios energy E is divided up by the amount of 1.4285 × 10^{-3} = 700. As Energy variance is large enough and energy derivatives are negative. That negative derivatives of energies are multiplied by 700 in equation (8). So, energy reduction of nuclear material is higher in that case. At that particular energy, as there is the ratiocination of radiation and collision derivatives, an electron can move through radioactive waste as it can lose energy by bremsstrahlung by exciting and ionizing radioactive wastes. So, Radiation stopping power can lessen the effect of waste characterization and hence it is primed for dispensation and conditioning.

The most advanced ones generate the photon energy from the scaled differential cross sections (DCS) compiled by Seltzer and Berger [6] which represent the state of theart in theoretical high-energy bremsstrahlung calculations. However, all of these codes determine the direction of the photons emitted from very rough approximations, in spite of the fact that intrinsic angular distributions shape functions consistent with the scaled DCS have been available for a long time. The difficulty is the enormous size of the numerical database needed to define the DCS as a function of the electron energy E, the photon energy W and the direction of emission u. It has been claimed that using inaccurate

shape functions is not a serious problem for thick targets, because a parallel electron beam is rapidly randomized by multiple elastic scattering and this washes out the intrinsic

angular distribution, which would then be relevant only for thin samples. We consider the bremsstrahlung DCS for electrons of energy E in a low-density, amorphous, single element medium of atomic number Z. After integrating over the angular defection of the projectile, the DCS depends only on the energy W of the photon and the direction of emission, represented by the polar angle u relative to the direction of the projectile, and can be expressed as

$$\frac{d^2\sigma_b}{dWd(cos\Theta)} = \frac{d\sigma_b}{dW}\vec{P} \quad (5)$$

The shape function obtained from the Kirkpatrick Wiedmann Statham (KWS) fit is

$$\vec{P} = \frac{\sigma_X sin^2\theta + \sigma_Y(1+cos^2\theta)}{(1-\beta cos\theta)^2} \quad (6)$$

Using the second-order nonrelativistic perturbation theory, differential elastic scattering cross section is

$$d\sigma_b = \frac{1}{2\Pi\hbar v^2}\overline{V^2}qdq \quad (7)$$

dW is the differential probability of emitting a photon of frequency within d for a given impact parameter when a projectile electron changes its velocity in collisions with the target ion. For all impact parameters, dW is given by the Larmor formula [7] for continuum radiation from an accelerated electron:

$$dW = \frac{\alpha}{4\Pi^2}\Lambda^2 \sum |e.q|^2 \frac{d\omega}{\omega}d\Omega \quad (8)$$

In the region of partial degenerate and strong coupling, the interaction of charged particles cannot be represented by a pure Coulomb potential but it can be introduced by effective pair potentials. However, it has been known that the Kelbg potential has a deviation from the exact value of the Slater sums for small separations. Very recently, the corrected Kelbg potential for the electron positron interaction was obtained using the Slater sum and its first derivative for small separations. The corrected Kelbg potential for the electron positron interaction in electron positron plasmas including all quantum effects can be shown to be [8]

$$\overline{V} = -4\pi^2 a_{02}\widetilde{V}/(1+c(\gamma)) \quad (9)$$

Here, Electron positron bremsstrahlung radiation cross section in electron positron plasmas in units of πa_0 as a function of the radiation photon energy. The solid line represents the electron positron bremsstrahlung radiation cross section for T=10000K.

CONCLUSION

To ensure the reliability of the algorithm in general-purpose Monte Carlo simulations, it is desirable to have calculated shape functions for a denser grid of energies and atomic numbers and an algorithm for the simulation of bremsstrahlung emission by fast electrons using numerical cross sections is described in this paper. It can be concluded that the proposed algorithm provides a fast and accurate method for sampling the energy and direction of bremsstrahlung photons.

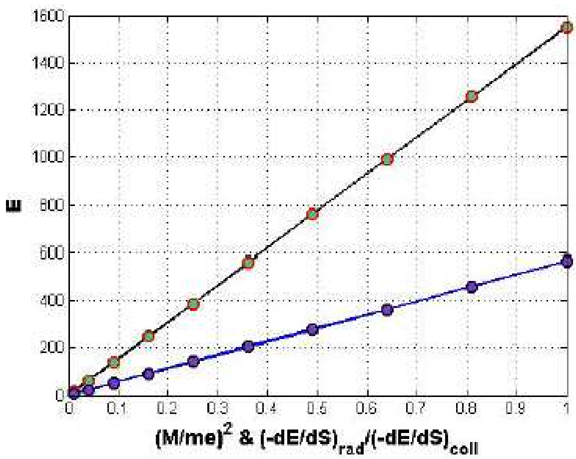

Fig. 1. Bremsstrahlung production

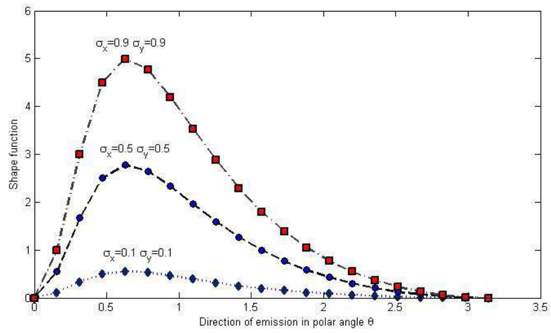

Fig. 2. Position Vector

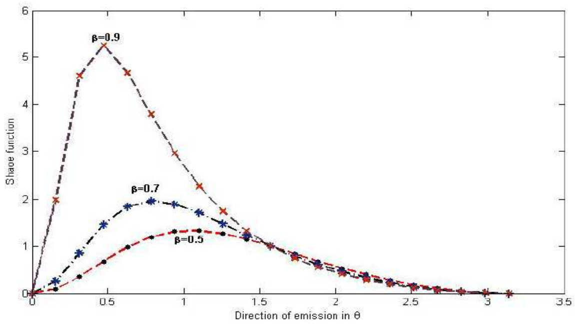

Fig. 3. Position Vector for fixed σ

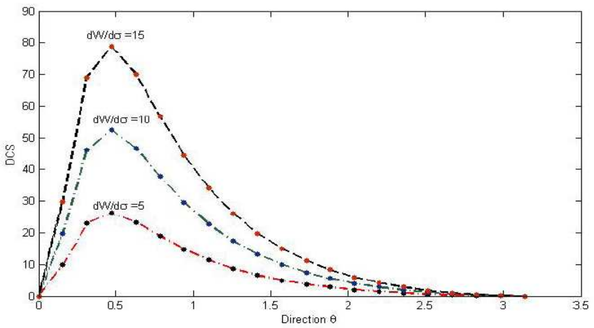

Fig. 4. DCS

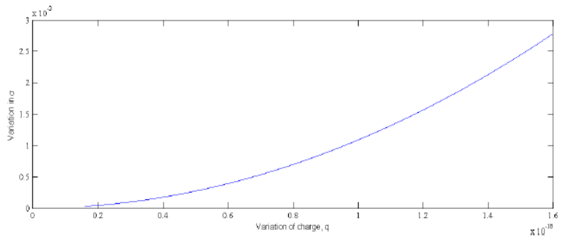

Fig. 5. DCS vs Charge

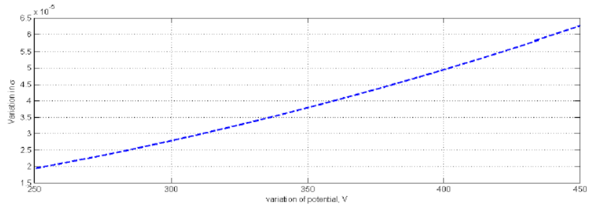

Fig. 6. DCS vs Potential

REFERENCES

[1] Acosta E, Llovet X, Salvat F. Monte Carlo simulation of bremsstrahlung emission by electrons. Applied Physics Letters 2002;80(17): 3228-30.

[2] Young-Dae J. Coulomb corrections on the electronion bremsstrahlung spectrum from a generalized Lorentzian (kappa) distribution plasma. AIP 1999;6(6):86-8.

[3] Luther-Davies B. Evidence of resonance absorption in laserproduced plasmas from the polarization and angular dependence of high-energy x-ray bremsstrahlung emission. American Institute of Physics 1978;32(4):209-11.

[4] Bittencourt JA. Fundamentals of Plasma Physics Processes. Springer, New York, 2004.

[5] Zubarev D, Morozov V, Rpke G. Statistical Mechanics of Nonequ- librium Processes. Basic Concepts, Kinetic Theory. Akademie, Belin , Vol. 1, 1996.

[6] Seltzer SM, Berger MJ. Nucl. Instrum. Methods Phys. Res. B 12, 1985.

[7] Beyer HF, Shevelko VP. Introduction to the Physics of Highly Charged Ions. Institute of Physics, Bristol, 2003.

[8] Ebeling W, Kelbg G, Rohde K. Binary slater sums and distribution functions for quantum-statistical systems with coulomb interactions. Ann. Phys. 1968;21:235-43.

ACKNOWLEDGEMENT / SOURCE OF SUPPORT

The authors would like to thank Mr. Young-Dae Jung for his papers "Quantum effects on bremsstrahlung spectrum from electron positron plasmas" and "Quantum effects on bremsstrahlung spectrum from electron positron plasmas" published on APPLIED PHYSICS LETTERS for taking the multitude of conceptions.

CONFLICT OF INTEREST

Nil