Relationship between incoherent polarization Bremsstrahlung radiation and Compton scattering

A. Astapenko[1], L. Bureyeva, and V. Lisitsa[2]

Scientific Council on Spectroscopy of the RAS,
Leninski Pr., 53, Moscow, 117924, Russia
Tel +7-095-1351420, Fax +7-095-1326508
E-mail: bureyeva@sci.lebedev.ru

[1] *Moscow Physical-Technical Institute, Dolgoprudni, Moscow Reg., 141700, Russia*
[2] *RRC "Kurchatov Institute", Kurchatov Sq., 1, Moscow, 123182, Russia*

Polarization Bremsstrahlung radiation (PBR) of a charged particle on a target (an atom or ion) corresponds to a conversion of the own incident particle field to a real photon on bound electrons. A value of a transmitted momentum q by the incident particle to the target in the emission process determines the type of the PBR process. The PBR is of the coherent type if $q < p_a$ and the incoherent one if $q > p_a$ (p_a is a typical momentum of bound electrons).

According to the energy conservation the PBR is fully incoherent radiation in the frequency domain $\omega > p_a v_0$ (v_0 is the velocity of an incident particle). In this case the incoherent PBR may be interpreted as the Compton scattering the own incident particle field on the electron core of the target where the part of the transmitted energy is high enough to ionize atom (ion).

The universal description of the incoherent polarization Bremsstrahlung radiation of a fast (nonrelativistic) charged particle on a multi electron atom (ion) is obtained in high frequency approximation ($\omega > p_a v_0$). The cross section of the process is expressed in terms of the Compton profiles $J(Q)$ [1], [2] of the X-rays scattering:

$$d\sigma(\omega, v_0, m) = \sqrt[3]{Z} Z_0^2 d\tilde{\sigma}(\omega/p_{TF}^2, v_0/p_{TF}, m), \tag{1}$$

where $d\tilde{\sigma}$ is the reduced cross section depending on the frequency of the radiating photon and velocity of the incident particle normalized on the typical Thomas-Fermi momentum, Z_0 is the charge of the incident particle, Z is the nuclear charge of the target core.

The reduced cross section is expressed in terms of the normalized Compton profiles by the expressions:

$$d\tilde{\sigma}(\tilde{\omega}, \tilde{v}, m) = \sigma_0 \frac{b^2}{\tilde{v}^2} \frac{d\tilde{\omega}}{\tilde{\omega}} I(\tilde{\omega}, \tilde{v}, m), \tag{2}$$

$$I(\tilde{\omega}, \tilde{v}, m) = \int_{q_{min}}^{q_{max}} \frac{d\tilde{q}}{\tilde{q}} \int_{-v}^{-v_m} \{\tilde{J}(-\tilde{q} + \sqrt{-2\tilde{q}^0}) - \tilde{J}(\tilde{q} + \sqrt{-2\tilde{q}^0})\} d(v_0 \cos(\mathbf{q}\mathbf{v_0})), \tag{3}$$

where $q^0 = \omega + \mathbf{q_1}\mathbf{v_0} + \mathbf{q}_1^2/2m$ is the transmitted energy by the incident particle to the target, $\mathbf{q_1}$ is a momentum variation of the incident particle, $v_m = (\tilde{\omega} + \tilde{q}^2/2m)/\tilde{q}$, $b = 0.8853$;

$$\sigma_0 = \frac{16}{3}\frac{e^2}{\hbar c}(\hbar/mc)^2 = 2.074 \cdot 10^{-6} a.u. \tag{4}$$

Thus, Eqs. (1) - (4) show a similarity between the cross section of the incoherent PBR of the fast (nonrelativistic) charged particle on the multi electron atom and the Compton profiles [1], [2] of the X-rays scattering. The cross section (to within to $\sqrt[3]{Z}$) depends on the radiated photon frequency and the incident particle velocity normalized on the Thomas-Fermi momentum.

Acknowledgments. This work was performed with the support of the Russian Ministry of Sciences and Technology (project "Theoretical spectroscopy of Rydberg states of atoms and ions") and the RFBR (project 98-02-16763).

[1] P. M. Bergstrom and R. H. Pratt, *Radiat. Phys. Chem.* **50** 3 (1997).
[2] F. Biggs, L. B. Mendelsohn and J. B. Mann, *Atomic Data and Nuclear Data Tables* **16** 201 (1975).