Laser–assisted radiative recombination

A. Jaroń[1], J.Z. Kamiński[1] and F. Ehlotzky[2]

[1] *Institute of Theoretical Physics, Warsaw University*
Hoża 69, PL 00–681 Warsaw, Poland
Tel +48-22-6283031, Fax +48-22-6219475
E-mail: jaron@fuw.edu.pl, jkam@fuw.edu.pl

[2] *Institute for Theoretical Physics, University of Innsbruck*
Technikerstrasse 25, A-6020, Innsbruck, Austria
Tel +43-512-507-6214, Fax +43-512-507-2964
E-mail: Fritz.Ehlotzky@uibk.ac.at

The process of laser assisted recombination is considered in the context of harmonic generation and coherent X-ray production [1]. Very promising conditions for X-ray generation by means of the laser field induced electron-ion recombination can be met in the Farkas and Horváth experiment [2]. In this contribution we propose an approach, which is applicable both to gaseous and solid targets. The process of recombination is treated in the framework of the inverse Keldysh model in which the ingoing electron is described either by a Gordon-Volkov wave or by a Coulomb-Volkov solution with conclusion that even for higher energies of the impinging electrons visible Coulomb effects are observed. These Coulomb effects are discussed in connection with analogous effects studied for multiphoton ionization and high harmonic generation [3, 4]. The equivalence of the two models for a short-range interaction is shown.

The rates of the generated X-ray field and the energy range of its spectrum are obtained. The maximum photon energy that can be achieved via considered process is given by $\hbar\omega_X = E_{\vec{p}} + U_p + |E_B| + 2\sqrt{2U_pE_{\vec{p}}}$, with $E_{\vec{p}}$ being the kinetic energy of the ingoing electron, $\vec{p}$ the electron momentum, U_p the ponderomotive energy and E_B the binding energy.

The differential power spectrum calculated as a function of the emitted X-ray photon energy for fixed electron energy exhibits plateau centered around $\omega_X = E_{\vec{p}} + U_p + |E_B|$, the width of which is equal to $\Delta\omega_X = 4\sqrt{2U_pE_{\vec{p}}}$ and increases with intensity of the laser beam while its maximum value slightly decreases with intensity. The power spectrum attains maximum values at the edges of the plateau.

Simple and intuitive model considered here allows for the discussion of the energy conversion efficiency for the X-ray production and permits to recognize the most favorable conditions for generation of X-rays. They occur when all vectors $\vec{\varepsilon}$ - , $\vec{\alpha}_0$ and $\vec{p}$ are parallel to each other. Results presented here are in agreement with results of another paper on radiative recombination [5].

Acknowledgments. The reported work was supported by the Scientific-Technical Collaboration Agreement between Austria and Poland for 1998/99 under project number 18/98 and by the East-West-Program of the Austrian Academy of Sciences and the Austrian Ministry of Science and Transportation under project number 45.372/2-IV/6/97. A. J. and J. Z. K. acknowledge support by the Polish Committee for Scientific Research (Grant No. KBN 2 P03B 007 13) and the permission to use the computer facilities of the Computation Center (ICM) of the Warsaw University.

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