Ionization-Induced Synchrotron Radiation in Laser Fields of Extreme Intensity

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We consider radiation emitted by electrons liberated from multiply charged ions through tunnel ionization in a laser field of intensity 10^{22}W/cm^2 or higher. Such radiation could be observed in the forthcoming experiments on the interaction of extremely intense laser pulses with low-density gas beams. This interaction will lead to multiple sequential ionization of atoms, the process which can be used for verification of different theoretical approaches to the description of tunnel ionization in electromagnetic fields of extreme intensity as well as for calibration of laser intensity [1]. At the same time, the electrons detached from their parent ions will emit radiation whose properties can also be used for the characterization of the electromagnetic field in the laser focus. *In-situ* characterization of extremely intense laser radiation is of high demand in connection with the commissioning of several multi-petawatt laser facilities worldwide [2-7].

In this work, we show that such radiation can be described in quite a universal manner by using the constant crossed field (CCF) approximation to calculate the photoelectron trajectory. This approximation greatly reduces the numerical efforts required to find the radiation signal from an ensemble of atoms located in the laser focus. The spatial structure of the electromagnetic field in focus plays an important role in forming the radiation spectra and angular distributions. Within our approach, this structure is accounted for by calculating the radiation power from a realistic field distribution along the photoelectron trajectory, which is in turn found in the CCF approximation. We also show that radiation emitted from a significant part of the photoelectron trajectory can be described by equations known in the theory of synchrotron radiation.

Our findings can be used to qualitatively describe and quantitatively calculate the spectrum of high-energy synchrotron-like radiation emitted in the process of tunnel ionization of heavy atoms up to very high charge states [8]. The universal structure of spectral and angular distributions of this radiation will simplify the experimental verification of the radiation mechanism and serve as an extra tool for the intensity calibration of extremely intense laser pulses.

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