Radiation losses of fast heavy particles in thermpnuclear plasma [[1]](#footnote-1)\*)

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In this work, the radiation losses of alpha particles and electrons on heavy impurities of tungsten in a thermonuclear plasma were calculated. Radiation losses of a plasma on impurities of heavy ions caused by excitation by electrons are important for determining the efficiency of a fusion reactor. The main role is played by the excitation of impurity ions by electrons, which is accompanied by their emission. The energy balance of the plasma depends on this, since radiative energy losses by electrons can lead to termination of a thermonuclear reaction at a lethal concentration of impurities. The new channel of radiation losses is associated with the excitation of impurity ions by fast heavy particles, and it must be compared with the value of similar losses of electrons. An important parameter required for plasma monitoring is the ratio between the radiation losses of alpha particles and electrons.

Since the electronic structure of a multiply charged ion is rather complicated, so quantum-mechanical calculations are a complex problem, and therefore, it is necessary to develop methods to simplify them. One of the methods is the statistical approximation, which is applicable in this case, since there are a lot of bound electrons in ions. According to this approach, the specific (per particle and one impurity ion) radiative losses *q* are expressed through the statistical cross sections for photoexcitation σph(ω) and the flux of equivalent photons created by an incident charged particle that moves in the field of a multielectron ion along a classical trajectory. The intensity of this flux is determined by the square of the Fourier expansion of the electric field of the considered incident particle acting on the bound electrons of the ion [1]. These cross sections for photoexcitation should be multiplied by the photon energy, the speed of the incident particle, and integrated over all absorbed frequencies. The statistical approach considers collective excitations of electron shells with frequencies ω(*r*) depending on the distance from the nucleus. Two models of this dependence have been proposed: the model of the local plasma frequency (LPF) [2, 3] and the model based on the principles of Kramers electrodynamics (the Rost model) [4], selective with respect to the orbital moment of the core.The calculation results of statistical models were compared with the results performed in the Coulomb-Born approximation [5]. To calculate the radiation losses, one should take the rate excitation coefficients given in [5] and integrate (sum) them over all excited frequencies.

Comparison of the results of calculations using the statistical and Coulomb-Born approximations showed that all models give results that are close to each other, and with an increase in temperature, an increase in the loss ratio is observed. At the same time, this ratio is up to 1-5%, which is much lower than the initial rough estimates of 20%, performed using the general section for inelastic transitions.

References

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