Opacity of relativistically underdense plasmas for multipetawatt laser pulses

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In accordance with [1], relativistically underdense plasma ($n_e < a_0 n_{\rm cr}$) is transparent for laser radiation. Here n_e and $n_{\rm cr} = m\omega^2/4\pi e^2$ are the plasma density and the critical density, $a_0 = eE_0/mc\omega$ is the normalized laser field amplitude. However, numerical simulations with QUILL code [2] show that above the treshold of $a_0 \approx 1200$ abnormal laser field absorption is observed in the relativistically underdense plasma ($n_e = 50 n_{\rm cr}$). The absorption is caused by the generation of dense electron-positron plasma, which in turn occurs due to synchrotron emission of hard photons in strong laser field and subsequent pair photoproduction. At higher laser amplitudes, $a_0 \gtrsim 1800$, the pair production becomes so copious that the laser pulse propagation distance (estimated by losing 80% of the field energy) do not grow with the further increase of the laser amplitude. Contrary, if pair production not taken into account, the plasma remains transparent, and the propagation distance grows approximately linearly with the increase of the laser field amplitude. Previously in the simulations the laser field absorption in the self-generated electron-positron plasma have been observed only for complex field configurations or for relativistically overdense plasma targets.

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[1] Cattani F, Kim A, Anderson D and Lisak M 2000 *Physical Review E* **62** 1234–1237

[2] QUILL, `https://github.com/QUILL-PIC/Quill`