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Generation of gigantic quasistationary magnetic fields in an electron-positron plasma created in colliding laser pulses

Introduction

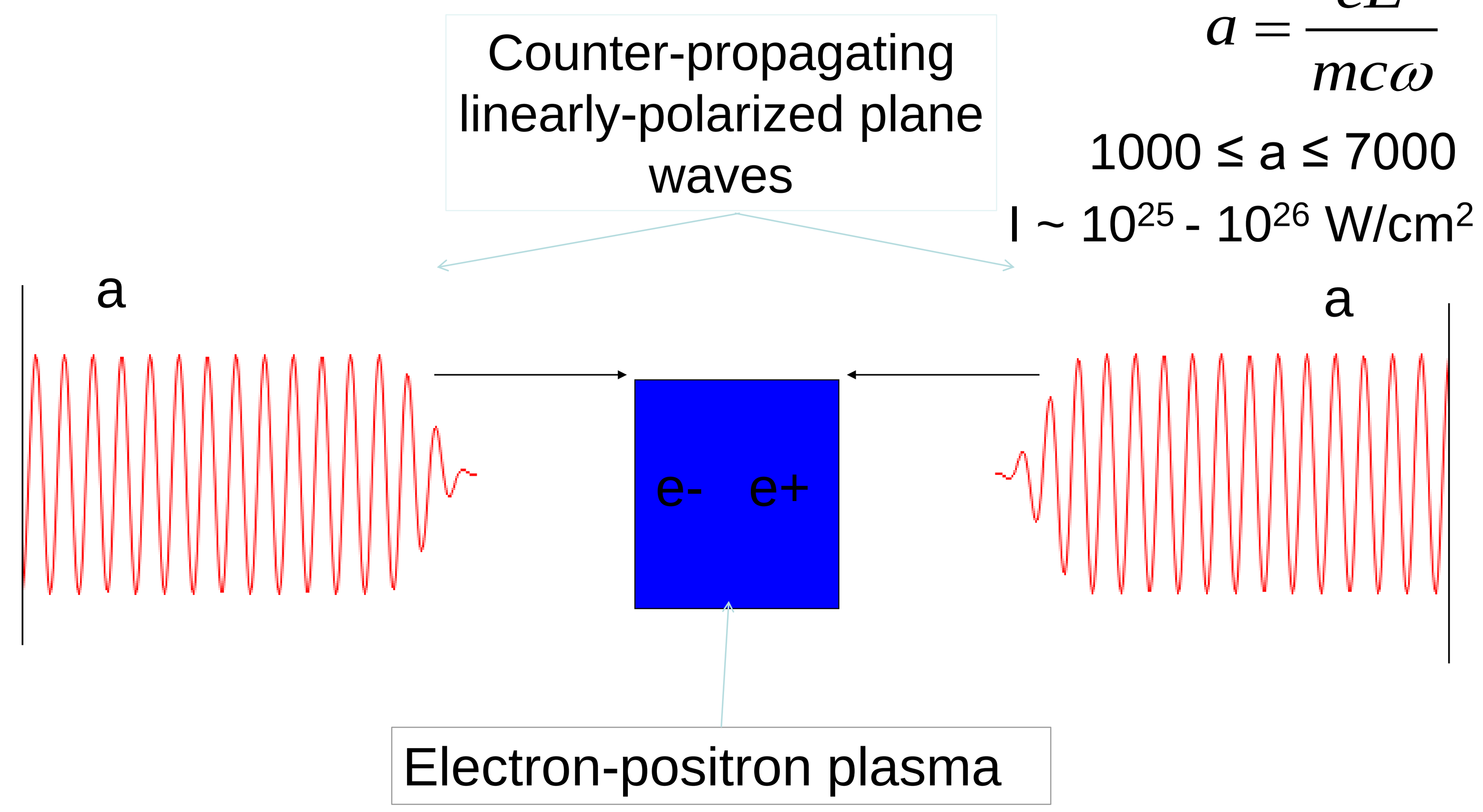
In this work we study self-consistent pair plasma dynamics in colliding linearly-polarized laser pulses of extreme intensity (10^{25}-10^{26} W/cm^2). At these levels of laser fields, qualitatively new processes manifest: **emission of photons**, which can carry a significant part of the parent electron's (or positron's) energy, and **decay** of these photons **into electron-positron pairs[1]**. We research capabilities of electromagnetic cascades in colliding laser pulses of extreme intensity.

Physical problem description

$$a = \frac{eE}{mc\omega}$$

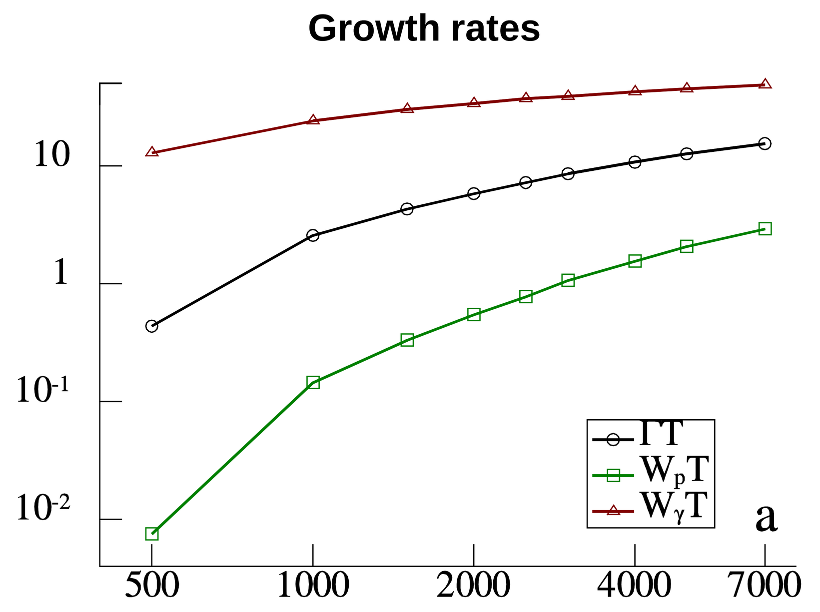
$1000 \le a \le 7000$

$I \sim 10^{25}$ - 10^{26} W/cm^2

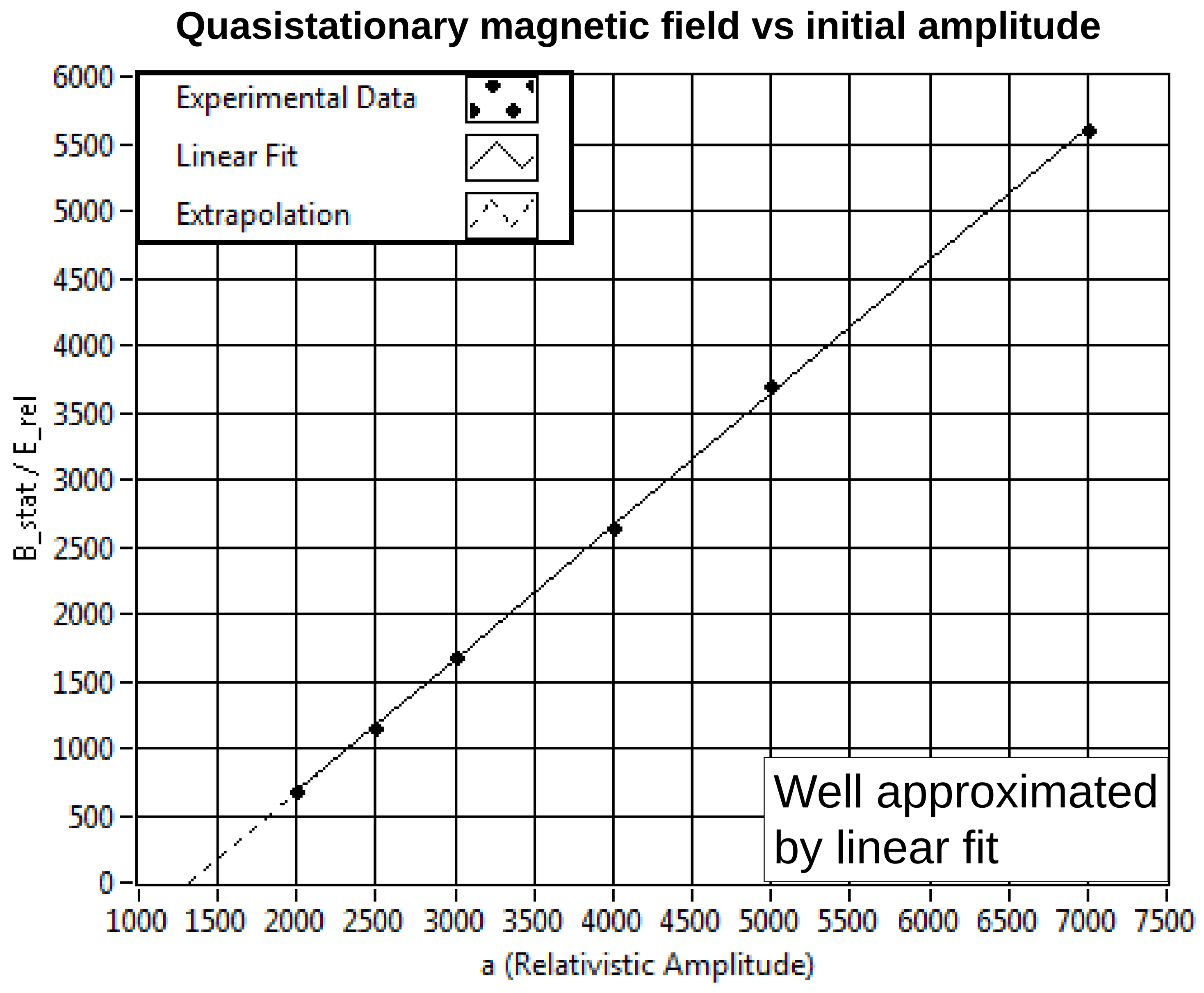


The research was completed on the basis of numerical modeling using the PICADOR PIC-code**[2]**. We pay particular attention to the **1D geometry**. A low-density pair plasma is used to initiate the cascade.

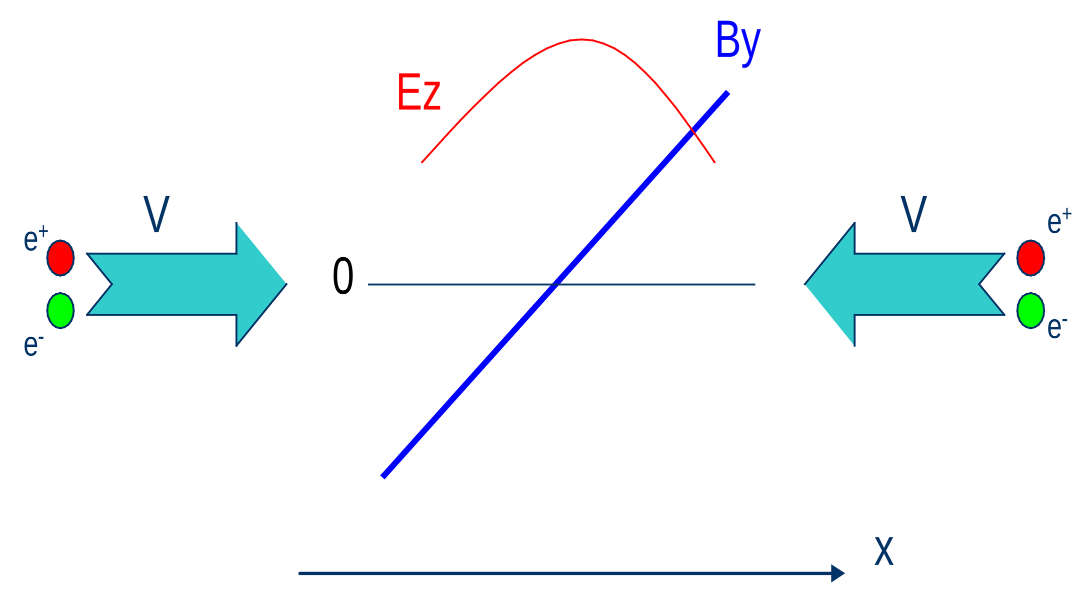
For field amplitudes above a certain threshold (a>a0) the characteristic time of cascade growth τ becomes significantly less than the wave period (τ<<T).



Results

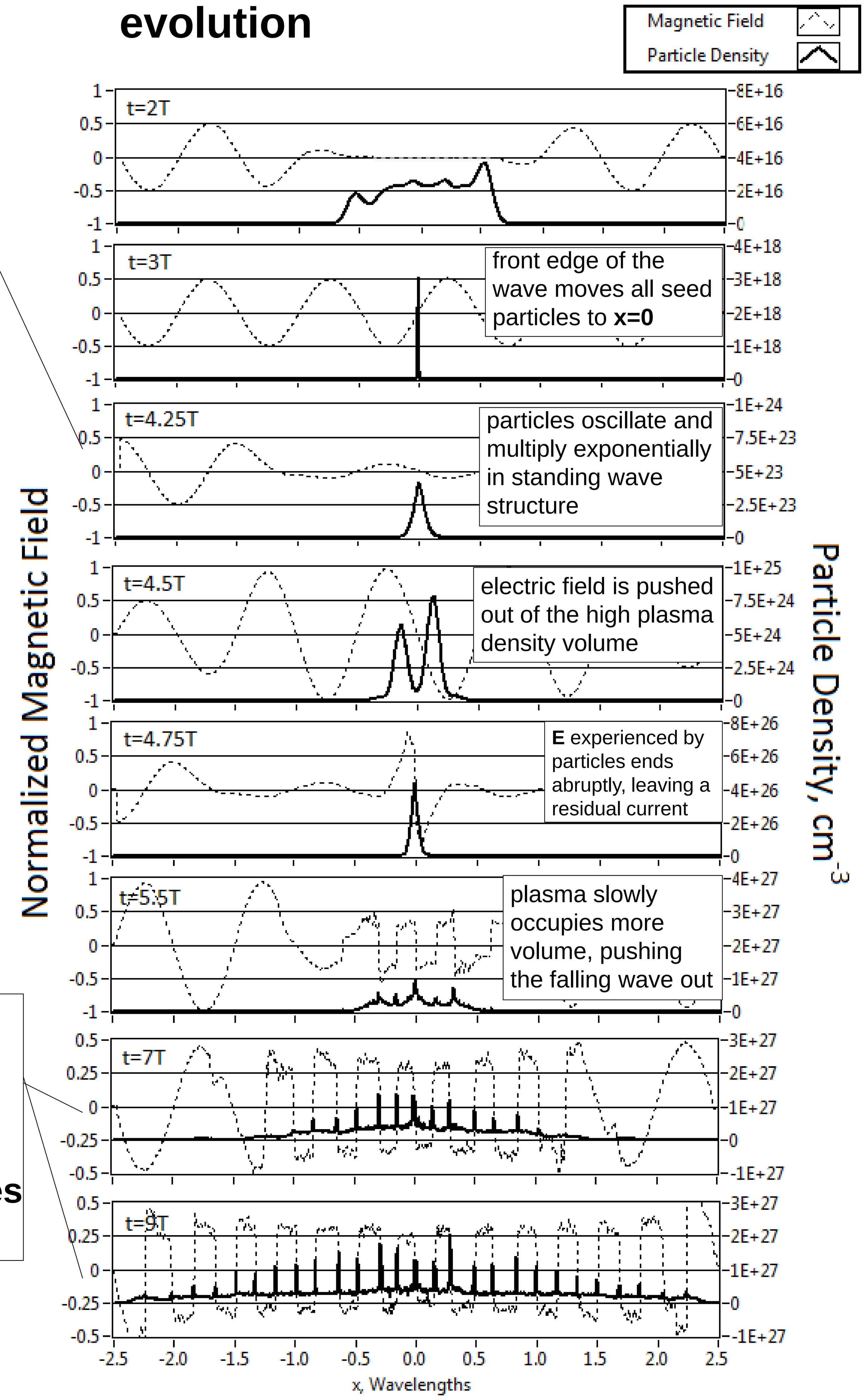


The instantaneous plasma density distribution on this stage is strongly influenced by the type of trapping regime, which is dominating at the current amplitude**[3]**.



Every half-period of the falling wave forms a new current layer in a null point of the magnetic field.
The alternating-sign current structure in a 1D geometry creates a meander-like magnetic field.

Magnetic field and plasma density evolution



Conclusion

It was found that for field amplitudes above a certain threshold electromagnetic cascading can lead to creation of thin (on a wavelength-scale) **current sheets** with extremely high plasma density (exceeding 10^{27} cm^{-3}). These alternating-sign current sheets separate regions of the **gigantic quasistationary meander-like magnetic field**. For higher amplitudes, quasistationary magnetic field magnitude can reach values up to the initial falling wave amplitude, and energy conversion into the magnetic field can exceed 20%.

Citations

1. A.R.Bell, J.G.Kirk. Possibility of Prolific Pair Production with High-Power Lasers, Phys. Rev. Lett. **101**, 200403 (2008).
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3. A. Gonoskov, A. Bashinov, I. Gonoskov, C. Harvey, A. Ilderton, A. Kim, M. Marklund, G. Mourou, A. Sergeev. Anomalous Radiative Trapping in Laser Fields of Extreme Intensity, Phys Rev Lett. **113**, 014801 (2014).