Spontaneous electron-positron pair creation using the relativistic mirror

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The relativistically moving, subluminal, curved electron-density layer, known as relativistic flying parabolic mirror, is widely observed in laser-plasma interaction experiments and simulations. It is shown that a counter-propagating electromagnetic wave is focused by the relativistic mirror and an unprecedented field strength level can be achieved with a double Doppler-shifted frequency [1]. In this presentation, we discuss the spontaneous electron-positron (e^+e^-) pair creation (Schwinger pair creation) under a two-beam colliding scheme mediated by the relativistic curved mirror [2].

In this scheme, two laser pulses counter-propagate to the relativistic mirror [see Fig. 1(a)]. The preceding and moderate-intensity ($a_{1,0} << 1$) laser pulse is reflected and focused by the relativistic mirror. The following high-intensity ($a_{2,0} > 1000$) laser pulse collides with the focused laser pulse to form a ultra-strong field strength [see Fig. 1(b)] and to produce e^+e^- pairs from the vacuum. Having the spatio-temporal field distribution, the spatio-temporal distribution of e^+e^- pair creation have been calculated using the Euler-Heisenberg Lagrangian formalism. The total number of e^+e^- pairs created is calculated at different $a_{1,0}$ and $a_{2,0}$ combinations, which correspond to the available laser power (10 - 100 PW) in the near future.

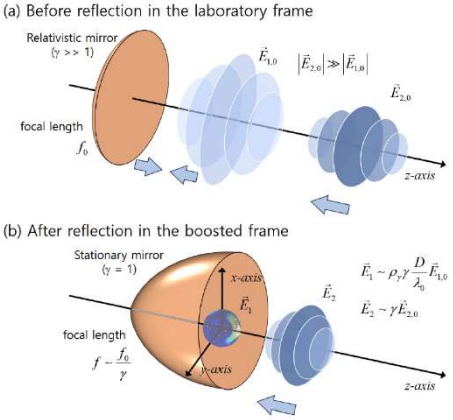

Figure 1. Colliding scheme between the high-intensity laser pulse and the moderate-intensity laser pulse reflected and focused by the relativistic mirror.

The calculation (Table 1) predicts a considerable number (≈2.2 × 106) of electron-positron pairs when a focused 25 PW laser pulse collides with a moderately intense (a = 0.1) and radially polarized laser pulse reflected and focused by a relativistic curved mirror with γ = 100.

Table 1. Summary of the total number of e^+e^- pairs created at different combinations of $a_{1,0}$ and $a_{2,0}$. In the table, γ is the Lorentz γ-factor of the relativisitic flying mirror and $\mathcal{N}$ is the total number of e^+e^- pairs created.

γ	$a_{1,0}$	$P_{2,0}$ (PW) ($a_{2,0}$)	$\mathcal{E}_{i,\max}$	$\mathcal{N}$
50	0.1	25 (720)	0.129	$\approx 1.9 \times 10^{-1}$
50	0.1	100 (1480)	0.186	$\approx 1.7 \times 10^{3}$
100	0.1	10 (460)	0.252	$\approx 6.5 \times 10^{4}$
100	0.1	25 (720)	0.315	$\approx 2.2 \times 10^{6}$

[1] S. V. Bulanov, T. Esirkepov, and T. Tajima, Phys. Rev. Lett. **91**, 085001 (2003).

[2] T. M. Jeong, S. V. Bulanov, R. Shaisultanov, and P. Hadjisolomou, Phys. Rev A **111**, 032218 (2025).