Phase-space analysis of the Schwinger effect in inhomogeneous electromagnetic fields

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We have studied Schwinger pair production in spatially and temporally inhomogeneous high-intensity few-cycle pulses [1, 2]

$$\mathbf{E}(t,z) = -\partial_t \mathbf{A}(t,z) = \frac{\varepsilon}{\omega} \exp\left(-\frac{z^2}{\lambda^2} - \frac{t^2}{\tau^2}\right) \times \frac{\left(2t\sin(\omega t+\phi) - \omega\tau^2\cos(\omega t+\phi)\right)}{\tau^2}\,\mathbf{e}_x, \quad (1)$$

$$\mathbf{B}(t,z) = \nabla\times\mathbf{A}(t,z) = -\frac{\varepsilon}{\omega} \exp\left(-\frac{z^2}{\lambda^2} - \frac{t^2}{\tau^2}\right) \frac{2z\sin(\omega t+\phi)}{\lambda^2}\,\mathbf{e}_y, \quad (2)$$

where ε determines the electric field strength in units of m^2/e, τ sets the temporal scale and λ specifies the spatial scale. The parameters ω and ϕ control the pulse structure.

Employing advanced numerical methods, we have been able to produce accurate numerical solutions of a quantum kinetic theory. We have computed particle (electrons and positrons) momentum spectra, see Fig. 1, as well as spatial-momentum distribution functions in order to thoroughly investigate how spatial and temporal variations in the electric and magnetic fields affect the particle distribution $n(z, p_x, p_z)$. Moreover, we have introduced a semi-classical model on the basis of an effective theory for the particle production rate taking into account instantaneous pair production and relativistic single-particle dynamics.

We have found remarkable signatures of quantum interferences and spin-field interactions. Additionally, we observed the formation of characteristic patterns strongly depending on the carrier-envelope phase of the background fields.

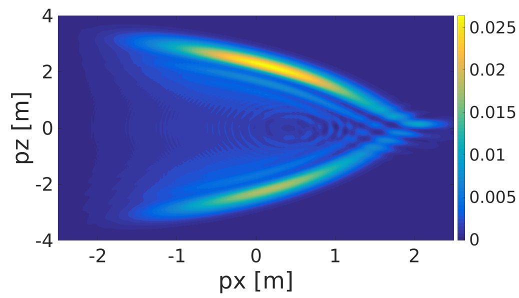

Figure 1: *Density plot of the particle distribution function $n(p_x, p_z)$ (quantum kinetic calculation) in momentum space.*

References

[1] C. Kohlfürst and R. Alkofer, Phys. Lett. B **756** (2016) 371

[2] C. Kohlfürst, arXiv:1708.08920 [quant-ph]