Simulation of the quantum kinetic equation for pair production

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The videos in this folder show the density of produced pairs $f(\vec{p},t)$ as solutions of the quantum kinetic equation for particle production[1]

$$\frac{\mathrm{d}f(\vec{p},t)}{\mathrm{d}t} = \frac{1}{2}\lambda(\vec{p},t)\int\limits_0^t \mathrm{d}t'\lambda(\vec{p},t')\Big[1-2f(\vec{p},t)\Big]\cos\Big(2\big[\Theta(\vec{p},t)-\Theta(\vec{p},t')\big]\Big)\,.$$

Where $\omega(\vec{p},t) = \sqrt{\epsilon_\perp^2 + \big(p_\shortparallel - eA(t)\big)^2}$, $\epsilon_\perp = \sqrt{m^2+p_\perp^2}$ and

$$\Theta(\vec{p},t) = \int\limits_0^t \mathrm{d}t'\omega(\vec{p},t')\,, \quad \lambda(\vec{p},t) = \frac{eE(t)\epsilon_\perp}{\omega^2(\vec{p},t)}\,.$$

The electric field $E(t)$ is assumed homogenous and directed along the z-axis. This integro-differential equation is equivalent to a system of three coupled differential equations (suppressing the function arguments)

$$\begin{aligned}\dot{f} &= \frac{1}{2}\lambda u\,,\\ \dot{u} &= \lambda(1-2f) - 2\omega v\,,\\ \dot{v} &= 2\omega u\,.\end{aligned}$$

The E-field is chosen as a simple sine, and the A-field accordingly

$$E(t) = E_0\sin(\nu t)\,, \qquad A(t) = \frac{E_0}{\nu}\cos(\nu t)\,,$$

with $\nu = 2\pi/T$ and the laser wavelength T. The simulations were done for a variety of the parameters λ and E_0, with $p_\perp$ ranging from 0 to $3m$ and $p_\shortparallel$ from $-3m$ to $3m$.

[1]S. Schmidt et al, Int. J. Mod. Phys. E **07**, 709 (1998).