Soft Photon Approximation in a Laser Field

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In the present talk, we consider processes involving the emission of soft photons in the presence of a strong laser field. We demonstrate that the matrix element S for a process $\mathrm{i} \to \mathrm{f} + \gamma$, with a soft photon γ, can be expressed in terms of the matrix element S_0 for the process $\mathrm{i} \to \mathrm{f}$ through a simple multiplicative factor in the integrand over ϕ. This approximation enables a result that is exact in the phase and approximate in the prefactor to order $\mathcal{O}(\omega/\varepsilon_{\mathrm{char}})$, where ω is the frequency of the soft photon and $\varepsilon_{\mathrm{char}}$ is the characteristic energy of the $\mathrm{i} \to \mathrm{f}$ process.

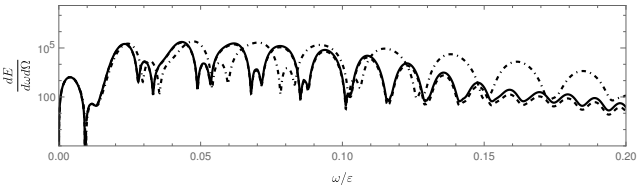

Figure 1: The Log-plot energy spectrum for nonlinear Compton scattering. Black line correspond to the exact result, dashed line correspond to the soft photon approximation result, dot-dashed line correspond to the classical result

It should be emphasized that this method fundamentally differs from the classical current approach, where soft photon emission is treated classically. Unlike the classical current method, my approximation achieves $\mathcal{O}(\omega/\varepsilon_{\mathrm{char}})$ accuracy for the photon emission spectrum. In contrast, the classical (non-quantum) result - except for a narrow frequency region near zero (whose width depends on the specific process and laser pulse profile)—yields completely incorrect predictions. This is clearly illustrated in Fig. 1.