Theory and modelling of strong-field QED in the transition regime

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Research into QED phenomena taking place in ultra-strong electromagnetic fields has attracted considerable attention in the recent years [1]. This regime, called "strong-field QED" (SFQED) is characterized by QED acquiring non-perturbative features. The interest in SFQED is mostly driven by the increasing availability of ultra-high intensity multi-PW class laser facilities worldwide, and because it was realized that SFQED effects are to drastically alter collective plasma dynamics at already available intensities on the order of 10^{23} W/cm^2, leading to a QED-plasma physics regime at high laser intensity. Moreover, dedicated high-precision experiments for studying fundamental SFQED interactions are being planned and conducted at LUXE [2] and SLAC E-320.

As a quantum field theory, SFQED naturally makes statements about the transitions amplitudes between asymptotic in and out states. However, in order to simulate SFQED effects in the context of plasma physics it is necessary to obtain local rates for the SFQED processes. In this talk I will present several approximation frameworks for obtaining such rates, and discuss their intricacies and shortcomings [1]. The locally constant crossed field approximation (LCFA) is widely used and implemented in many particle-in-cell codes. However it lacks some essential features of the particle spectra, prohibiting its application in the transition regime between perturbative and non-perturbative physics [2]. Corrections to the LCFA [3], as well as complementary approaches will be discussed, focusing especially on locally monochromatic approximation [4] and time-frequency-analysis methods.

References

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