First-Principle Modeling of QED Processes in High-Intensity Optical- and X-Ray Laser Fields

U Hernandez Acosta[1], K Steiniger[1], A Reinhard[1], S Ehrig[1], and M Bussmann[1]

[1] *Center for Advanced Systems Understanding, Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany*
Contact Email: u.hernandez@hzdr.de

The European X-ray Free-Electron Laser (EuXFEL [1]) is one of the most advanced light sources currently available and marks the leading edge for instruments providing highly energetic, ultra-intense laser light. On the one hand, this type of next-generation light source enhances the investigations made in various probe experiments in material science and warm-dense matter research. On the other hand, the EuXFEL enables fundamental-physics experiments measuring novel phenomena and non-linear structures in the interaction of electromagnetic fields and matter. This is especially true if the EuXFEL is combined with highly intense optical lasers, for example, the ReLaX system [2] in the HED-HIBEF experiments. Then pure non-linear phenomena emerge, for instance, vacuum birefringence [3] to give a famous example.

In a nutshell, the EuXFEL makes it possible to do particle-physics-like experiments using a laser.

A key ingredient for the exploitation of the full potential of the EuXFEL is the understanding of the underlying physical theory, where the precision of the estimate needs to meet the quality of the machine. To explore this regime, where strong fields meet high frequencies, we present a novel approach for a numerical modeling tool, QED.jl [4], which inherently uses exact strong-field QED descriptions. This combines our recent developments in the theory [5,6] with the technique of Monte-Carlo event generation to provide precise predictions for recent laser experiments.

References

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