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Thesis Topic Proposal

Institute of Physics, Czech Academy of Sciences
ELI Beamlines laser center

Degree Level: MSc
Starting date: October 1st 2022

Theoretical study of high-intensity laser-plasma interactions

Topic Characteristics/Abstract:

The thesis will study the quantum electrodynamical (QED) phenomena in interaction of ultra-strong laser pulses with plasma targets. The better understanding of strong field QED processes in laser-plasma interactions is crucial for planning and interpreting the results of experiments on the new generation of high power laser facilities, such as ELI Beamlines.

When an electron moves in a strong electromagnetic field, it radiates. Emitted hard photon interacting with a strong field can in turn create electron-positron pair. Besides, the radiation back reaction influences the trajectory of charged particles.

In particular, the thesis will focus on theoretical and numerical investigation of the setups, when not only QED phenomena, but also collective plasma effects play an important role, such as coherent photon emission by multiple plasma electrons, generation of a strong macroscopic magnetic field and its back reaction on plasma or particle acceleration.

Scope:

At the moment very limited number of laser facilities in the world are capable to investigate strong field QED effects, however, several new lasers with unprecedented power up to 10 petawatt (including ELI Beamlines L4 laser) are on the final stage of construction.

Therefore, the theoretical and numerical study of strong field QED phenomena arising in interaction of ultra-strong laser pulses with matter is very timely and important. In particular, it will help to design flagship experiments on these unique facilities and find the potential applications.

Methodology/Approach:

The student will first explore the topic through a detailed bibliographic study of existing reviews and articles. The collaborations already established with international colleagues working on the topic will also be an important source of knowledge for the project.

The student will use the existing PIC codes with implemented QED processes, such as EPOCH or SMILEI for numerical simulations of laser-plasma interaction. Using the results of simulations he/she will develop analytical models to describe physical processes.

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