**Relativistic Quantum Photonics – fundamental science with ultrahigh intensity lasers**

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Ultrahigh intensity lasers have become a key new technology over the last two decades. Growing from Terawatt to Petawatt peak powers and poised to grow further, they are potential drivers for both fundamental physics research as well as applied science and technology. We have used ultra-intense lasers to reach into the regime of relativistic plasmas, emulate astrophysical situations in the laboratory and are poised to tackle non-perturbative quantum physics and even beyond standard model physics. Applications being investigated range from compact accelerators and light sources to material science, energy science and medical imaging and diagnostics.

Our lasers here at the Center for Relativistic Laser Science now reach peak power levels of ~4 Petawatt and intensities beyond 1023 W/cm2 on target. At those intensities the interactions are not only highly relativistic but semi-classical approximations are insufficient and quantum effects have to be taken into account. Currently, there are no successful non-perturbative, dynamic quantum field theories, which are necessary to calculate quantum effects in the presence of strong classical potentials. While effects like quantum emission of hard gamma rays via radiation reactions, pair creation and vacuum polarization are predicted by many codes and models, non have been experimentally validated so far. With our two beam, 4PW – 1 PW laser system we are now for the first time in a position to experimentally test those theories and directly measure effects like e.g. direct relativistic laser-ion acceleration or nonlinear Compton scattering and pair creation.