AAPPS-DPP 2018 Plenary speaker Name: Prof. Bjorn Manuel Hegelich

Affiliation: Center for Relativistic Laser Science, Institute for Basic Science

Rationale: Prof. Hegelich is a leading researcher and world-renowned expert in the physics of ultrahigh intensity lasers and their interaction with matter. He has pioneered laser ion acceleration and written a large number of very influential papers on ultrahigh intensity laser-matter interactions and technology, including three papers in Nature/Nature Physics. Four of his papers have more than 400 citations with the top paper having over 700. Prof. Hegelich co-authored more than 120 peer-reviewed publications that have garnered a total of almost 7000 citations (Google scholar). His accomplishments include the first demonstrations of mono-energetic laser ion acceleration [1] and neutron sources, of relativistic transparency [2,3] coherent synchrotron radiation [4]. Prof. Hegelich was one of the first scientists to realize the importance of ultrahigh contrast for high intensity laser-matter interactions and developed and pioneered the required technology on the LANL Trident laser, demonstrating for the first time relativistic transparency and opening up this regime for detailed study and use in applications. It has now become the most efficient regime for laser ion sources and laser neutron sources. As a key investigator at the Texas Petawatt laser he initiated and oversaw its contrast and intensity upgrade, realizing the new physics potential at the intensity frontier [5] and pushing achievable intensities towards 10^{23} W/cm^2 and the quantum radiation regime and has been spear heading the development of an effective field theory to predict specific observables for future experiments [6,7]. His recent appointment as associate director of the Center for Relativistic Laser Science and its 4PW laser, currently the most intense in the world, will allow testing of those theories and enable a rigorous research program looking for quantum effects in strong classical potentials.

Talk Title: Relativistic Quantum Photonics – fundamental science and applied engineering with ultrahigh intensity lasers

Short abstract: 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. Existing lasers now reach peak power levels of ~5 Petawatt and intensities beyond 10^{23} W/cm^2 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 the two beam, 4PW – 1 PW laser system at the Center for Relativistic Laser Science 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.

List of related published papers

[1] B.M. Hegelich, B.J. Albright, J. Cobble, K. Flippo, S. letzring, M. Paffett, et al., Laser acceleration of quasi-monoenergetic MeV ion beams, Nature. 439 (2006) 441–444. doi:10.1038/nature04400.

[2] S. Palaniyappan, B.M. Hegelich, H.-C. Wu, D. Jung, D.C. Gautier, L. Yin, et al., Dynamics of relativistic transparency and optical shuttering in expanding overdense plasmas, Nat Phys. 8 (2012) 763–769. doi:10.1038/nphys2390.

[3] B.M. Hegelich, I. Pomerantz, L. Yin, H.C. Wu, D. Jung, B.J. Albright, et al., Laser-driven ion acceleration from relativistically transparent nanotargets, New Journal of Physics. 15 (2013) 085015. doi:10.1088/1367-2630/15/8/085015.

[4] B. Dromey, S. Rykovanov, M. Yeung, R. Hörlein, D. Jung, D.C. Gautier, et al., Coherent synchrotron emission from electron nanobunches formed in relativistic laser--plasma interactions, Nat Phys. 8 (2012) 804–808. doi:10.1038/nphys2439.

[5] B.M. Hegelich, G. Mourou, J. Rafelski, Probing the quantum vacuum with ultra intense laser pulses, Eur. Phys. J. Spec. Top. 223 (2014) 1093–1104. doi:10.1140/epjst/e2014-02160-8.

[6] O.Z. Labun, Effective field theories for quantum chromo- and electrodynamics, arXiv. hep-ph (2016).

[7] B.M. Hegelich, L. Labun, O.Z. Labun, Finding quantum effects in strong classical potentials, Journal of Plasma Physics. (n.d.) 1–21.