Contribution ID: **51** Type: **Oral Presentations**

Using structured light for controllable splitting and coherent beam recombining of intense femtosecond beams/pulses

Ultra-short laser pulse generation, along with extreme nonlinear processes such as high-harmonic generation, are extensively studied and actively evolving areas in modern photonics. Since their discovery, researchers have been addressing challenges like spectral broadening, filamentation, pulse and beam diagnostics, pulse amplification, and coherent beam recombination.

A key application that deserves special focus is the spectral broadening of intense femtosecond pulses, essential for their subsequent temporal compression. At high intensities, beams can become unstable, a challenge that can be mitigated by controllably splitting the beam into sub-beams. However, this approach is only viable if there is a reliable method to coherently recombine the sub-beams after spectral broadening, allowing for pulse compression just before they enter the laser-matter interaction zone.
Meanwhile, singular optics is another rapidly advancing field, focused on shaping laser beams by embedding phase singularities within them. In this work we implement known objects from the area of singular optics, like optical vortex arrays in the fields of ultra-short laser pulses in attempt to solve the problem of beam splitting and their subsequent coherent recombining.

We will present our recent advances in addressing spectral broadening and temporal compression of high-energy femtosecond pulses by controllable splitting and coherent beam recombining of femtosecond beams/pulses using structured light, more precisely optical vortex lattices. This controllable and reversable beam reshaping technique known from the field of singular optics is the key feature in the presented approach. Using fused silica vortex phase plates, etched with square-shaped optical vortex lattices we achieved an experimental realization of controllable beam splitting, followed by nonlinear spectral broadening (both in ambient air and in fused silica substrate) and a final coherent beam recombination. Moreover, the compression in time (down to the Fourier transform limit) of the spectrally broadened pulses is demonstrated as well. In our view, the results confirm the feasibility of the proposed idea and provide strong motivation for further optimization and investigation serving as potential alternative to the established methods for coherent beam recombining.

We acknowledge funding of the Bulgarian National Science Fund (project КП-06-Н78/6). The work was also supported by the Bulgarian Ministry of Education and Science as a part of National Roadmap for Research Infrastructure, project ELI ERIC BG. L.S. and A.D. were also supported by the European Union NextGenerationEU through the "National Recovery and Resilience Plan of the Republic of Bulgaria, project BG-RRP-2.004-0008-C01". L.S. would like to gratefully acknowledge the Return Grant awarded by the Alexander von Humboldt Foundation.

Primary authors: Dr STOYANOV, Lyubomir (Department of Quantum electronics, Faculty of Physics, Sofia University "St. Kliment Ohridski"); ZHANG, Yinyu (Institute of Optics and Quantum Electronics, Friedrich Schiller University, Jena, Germany and Helmholtz Institute Jena, Jena, Germany); DREISCHUH, Alexander; PAULUS, Gerhard (Institute of Optics and Quantum Electronics, Friedrich Schiller University, Jena, Germany and Helmholtz Institute Jena, Jena, Germany)

Presenter: Dr STOYANOV, Lyubomir (Department of Quantum electronics, Faculty of Physics, Sofia University "St. Kliment Ohridski")