# 2020 HGF – OCPC – Programme

## for the involvement of postdocs in bilateral collaboration projects

**Title of the project:**

Numerical modeling of few-cylce laser sources via post-compression of picosecond pulses

**Helmholtz Centre, division/group:**

DESY, FS/FS-LA

**Project leader:**

Dr. Christoph Heyl

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**Description of the project** (max. 1 page)**:**

Few-cycle laser pulses are nowadays employed for a variety of applications including attosecond physics, light-wave electronics as well as particle acceleration. Such laser pulses can easily undergo nonlinear interactions if sufficiently high intensities are reached. Nonlinear interactions form the basis of modern laser technology and are essential for pushing laser technology to the few optical cycle regime, a regime, which can be reached e.g. via optical parametric processes. As an alternative to parametric sources, the combination of ultrafast high-power lasers followed by pulse post-compression has recently attracted much attention, evoked by a new scheme, which can be used for post-compression starting in the picosecond range. The scheme employs a resonator-like light guiding concept, which provides completely new degrees of freedom for controlling nonlinear light matter interactions. By utilizing such light guiding schemes, new parameter regimes for ultrafast laser sources will be reached within the next years, opening up new possibilities for various applications within extreme nonlinear optics. Its in-depth exploration is waiting.

The here proposed project builds up on our multi-pass post compression efforts, which recently allowed us to post-compress picosecond laser pulses all the way down to four optical cycles, for the first time [Balla et. at., submitted for publication (2020)]. **The main focus of this project will be the numerical investigation and optimization of extreme-scale post-compression schemes, aiming at expanding these schemes towards the single-cycle limit and towards pulse energies exceeding the**

**100 mJ regime.** In addition, the project aims at exploring multi-pass cell-based frequency mixing concepts.

The planned numerical simulations will be carried out using one of several available nonlinear pulse propagation codes which enable high-speed 3D calculations performed using our in-house computer cluster facility. **The anticipated efforts will be closely linked to ongoing experiments which focus on the development of novel laser systems for particle acceleration and free electron laser science at DESY in Hamburg.** Depending on the candidate's interest, the projects brings along opportunities to also get involved in our experimental efforts. The candidate will work in close collaboration with experts on ultrafast laser technology within the group of Dr. Ingmar Hartl. Theory support will be available both in-house as well as via external collaborations.

## **Description of existing or sought Chinese collaboration partner institute** (max. half page)**:**

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## **Required qualification of the post-doc:**

- PhD in Physics or Electrical Engineering
- Experience with numerical modelling of nonlinear optical processes. Highly desirable: experiences with nonlinear pulse propagation methods
- Additional skills in parallel CPU and/or GPU programming using Python, C/C++ or Matlab are beneficial
- Language requirement: good written and oral English skills