Far field energy distribution control using a coherent beam combining femtosecond digital laser

Coherent Beam Combining (CBC) of fiber lasers is a promising technique to scale-up peak and average powers of laser systems with beam shaping capabilities, targeting a wide range of industrial and societal applications [1,2]. In this context, we have built XCAN [3,4,5] a CBC femtosecond fiber digital laser based on 61 tiled channels stacked in a hexagonal arrangement and operating in both high peak and average power regimes (see image below). Tiled aperture offers incontestably high agility in terms of far field beam shaping as each channel is seen as an individual pixel where amplitude and phase are controlled independently. However, the periodic intensity distribution of the array beams in the near field gives rise, when a flat phase is applied to all beams ($\varphi = 0$), to six similar low-intensities side-lobes surrounding a high intensity main lobe. Thus, the combined beam corresponds only to the main lobe of the far field pattern. The combining efficiency η_{CBC} is defined as the average power in this central lobe divided by the overall average power in the far field.

The aim of this internship is to explore different phase, intensity and polarization patterns as a tool for far field shaping on demand and to further improve the efficiency achievable with tiled aperture CBC. In particular, the candidate will investigate patterns capable of re-steering the maximum of energy into the main lobe. He will develop codes for CBC numerical simulation. To this end, iterative computing approaches like the Gerchberg-Saxton (GS) algorithm, deep learning, neural network and genetic algorithms allow computing the required phase and intensity modulation to be applied on the near field to produce a predefined target far field distribution. Experimental demonstration on XCAN shall be performed.

Continuation via a thesis is entirely conceivable if the trainee demonstrates an appetite for research in this field. A thesis focusing purely on laser physics or partly on applications (filamentation, for example) could be envisioned and set up at the end of the internship.

Key words: fiber lasers and amplifiers, beam combining, computing approaches.

Skills:

- Optics and laser physics: modeling and experimentation.
- Development tools: Python, Matlab and LabView

References:

[1] A. Brignon, (ed.) Coherent Laser Beam Combining, Wiley-VCH, (2013).

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[3] I. Fsaifes, L. Daniault, S. Bellanger, M. Veinhard, J. Bourderionnet, C. Larat, E. Lallier, E. Durand, A. Brignon, and J-C. Chanteloup, “Coherent beam combining of 61 femtosecond fiber amplifiers,” Optics Express 28(14), 20152–20161 (2020).

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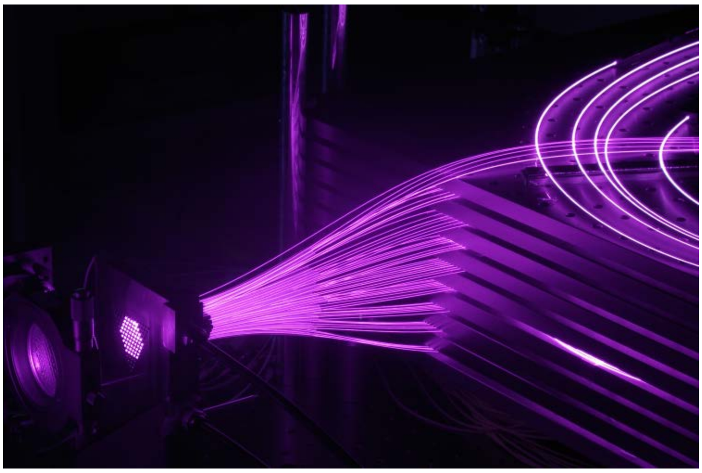

Contacts :

Laboratoire LULI, Ecole Polytechnique

Ihsan Fsaifes, ihsan.fsaifes@polytechnique.edu

Jean-Christophe Chanteloup, jean-christophe.chanteloup@polytechnique.edu