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PISTIL interferometry diagnosis on a 61 channels coherent beam combining digital laser

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Coherent beam combining (CBC) opens the way to a new paradigm in laser architecture [1]. The quest to high peak and average power indeed faces several fundamental limitations (transverse amplified spontaneous emission in wide amplifiers, thermal management issues) which can be addressed when relying on numerous smaller scale reliable lasers coherently combined. Achieving CBC for a large number of amplifiers will not only rely on the use of an efficient phase-locking scheme but also on fiber management inside the laser head (such as accurate angular and lateral positioning, at μm or mrad levels), optics, and amplifiers management as well as laboratory environment control. An accurate diagnosis of the laser array is mandatory in order to get significant feedback on its design, and potentially improve or stabilize its behavior, either in phase-locked loop or in free run.

To this end, we propose a diagnosis route for CBC laser sources led by a PISTIL (PISton and TILt) segmented wavefront analyzer [2,3]. We had the opportunity to test out the method onto the XCAN laser [4], a femtosecond digital CBC-type laser made of 61 “pixels” (fiber amplifiers). This 61 collimated “pixels” laser pupil is sampled by a 99/1 beamsplitter and propagates through the PISTIL interferometer, a lateral-shearing based architecture which makes neighboring elements of the pupil interfere. The resulting figure, called a pistilogram, is thus constituted of many fringe patterns that only depend on the phase differences that exist between each channel, whose phases are retrieved via Fourier-transform and general inversion based processes.

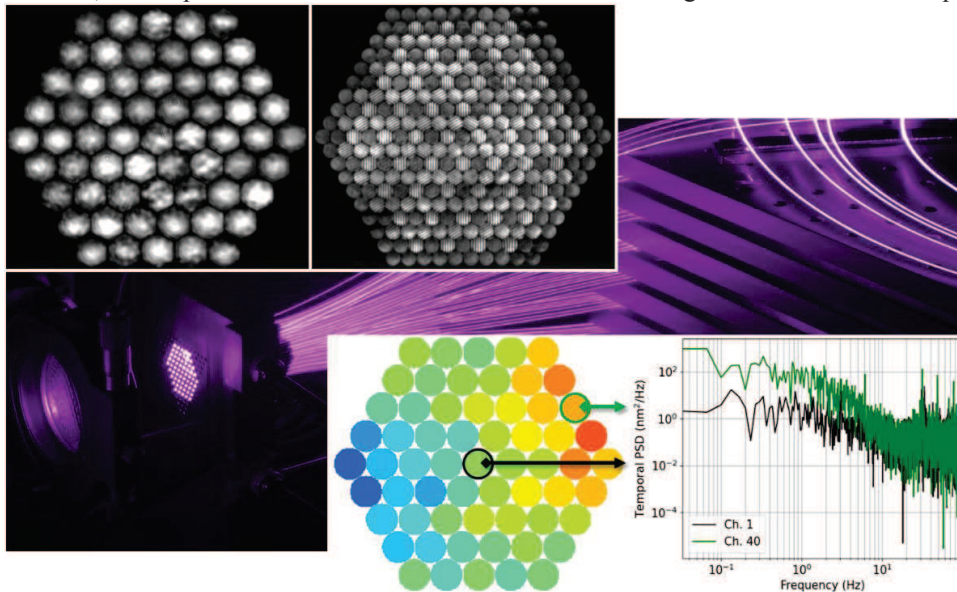


Fig. 1 Top left panel: Typical XCAN laser pupil and an associated pistilogram. Bottom right panel: a reconstructed segmented wavefront from the pistilogram analysis and an example of temporal power spectral densities comparison between two channels in the array. Background: The XCAN fiber laser array and its laser head.

Exploitation of the data recorded (Figure 1) allows tracking the phase evolution during phase-locked sequences, as well as open loop sequences (phase divergence). Therefore, both can be characterized. Frequency information can be extracted fiber by fiber via power spectral and cross spectral densities. Beam jitter can be estimated via a global tip-tilt projection of the retrieved segmented wavefront and modal extension is proposed for further studies. Aside from signal processing data mining, real time analysis is being developed to support end users of those new laser systems.

References

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