



HAL
open science

Coherent Beam Combining and Telecom Modulation: Reciprocal Impact

Pierre Pichon, Bastien Rouzé, Mathilde Gay, Laurent Bramerie, Laurent Lombard, Anne Durecu

► **To cite this version:**

Pierre Pichon, Bastien Rouzé, Mathilde Gay, Laurent Bramerie, Laurent Lombard, et al.. Coherent Beam Combining and Telecom Modulation: Reciprocal Impact. CLEO EUROPE 2023, Jun 2023, Munich, Germany. 10.1109/cleo/europe-eqec57999.2023.10232366 . hal-04264957

HAL Id: hal-04264957

<https://hal.science/hal-04264957v1>

Submitted on 10 Nov 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Coherent beam combining and telecom modulation: reciprocal impact

Pierre Pichon¹, Bastien Rouz  ¹, Mathilde Gay², Laurent Bramerie², Laurent Lombard¹ and Anne Dur  cu¹

1. DOTA, ONERA, Universit   Paris Saclay- 91120 Palaiseau, France

2. Institut Foton, CNRS UMR 6082, Universit   de Rennes – 22300 Lannion, France

There is a growing interest in ground-to-satellite optical communication to go beyond their radio-frequency (RF) counterparts and especially tackle the issue of RF bands saturation [1]. Nevertheless, laser systems used as transmitter in optical feeder links require relatively high power (typically 500 W [2]) but also a high beam quality and wavefront control to maximize transmission through atmospheric turbulences. These specifications are yet difficult to achieve at the same time with this type of high-power laser. Coherent Beam Combining (CBC) enables to achieve power scaling of several laser amplifiers in master-oscillator-power-amplifier (MOPA) configuration preserving a safe operating regime [3]. CBC could thus be a solution for the development of the next generation of high-power emitters for telecom applications.

To the best of our knowledge, CBC, when used at the transmitter side, has never been studied when carrying a telecom signal. In this work, we feed a three-arms tiled-array CBC setup in MOPA configuration with a 10.66 Gb/s telecom signal at 1545 nm. The information on the signal relies on either amplitude modulation or phase modulation, respectively with Non-return to Zero (NRZ) or Differential-Phase-Shift-Keying (DPSK). The phase of each arm is locked via the LOCSET technique (locking of optical coherence by single-detector electronic-frequency tagging [4]) by tagging the phase of two laser arms respectively at 26 MHz and 28 MHz with electro-optics modulators (EOM). Here, we investigate the impact of the telecom signal on the quality of CBC and reciprocally, if the latter perturbs the data transmission. The study relies on measurements of the bit error rate (BER) and eye diagram to qualify the telecom signal but also measurements of residual phase noise and power-in-the-bucket (PIB) to qualify CBC performances. The experimentation has been led under laboratory conditions.

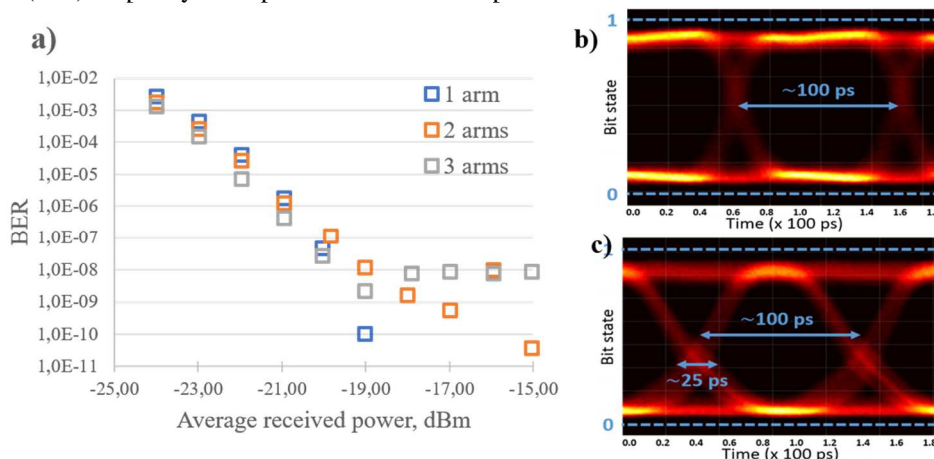


Fig. 1 a) BER measurements for 1 (reference), 2 and 3 laser arms (CBC ON) with an NRZ amplitude modulation. Eye diagrams for 1 (b) and 2 (c) laser arms.

When only two arms are active, an In-phase and Quadrature (IQ) interferometer enables to measure a CBC stability of $\lambda/150$ without telecom signal, which respectively drops at $\lambda/125$ and $\lambda/70$ for DPSK and NRZ modulations respectively. Hence, the presence of a telecom signal has an impact on the absolute value of the CBC stability, which however remains extremely good for a CBC system [3]. With three arms activated without telecom modulation, the PIB is 36%. With NRZ amplitude modulation this value slightly drops to 34.5% (33.1% for DPSK phase modulation). Hence, the telecom signal does not prevent phase locking. We also investigated the BER in NRZ (Fig. 1.a) and DPSK leading to a plateau limiting the BER in the 10^{-8} - 10^{-9} range. It is attributed to a residual path difference between arms (of a few mm) which after combination leads to spectral filtering and intersymbol interferences (See eye diagrams on Fig. 1.b and c). The effect of the amplifier power (up to 3 W) and of the frequency tagging amplitude on the BER will also be presented.

This work opens the route to high power CBC-Telecom laser sources for optical feeder links

References

- [1] A. Le Kernec, L. Canuet, A. Maho, M. Sotom, D. Matter et al., "The H2020 VERTIGO project toward tbit/s optical feeder links," in Proc. SPIE 11852, International Conference on Space Optics, ICSO 2020.
- [2] A. Billaud, F. Gomez, D. Allieux, N. Laurenchet, P. Jian, O. Pinel, G. Labroille, "Optimal Coherent Beam Combining Based on Multi-Plane Light Conversion for High Throughput Optical Feeder Links," in 2019 IEEE International Conference on Space Optical Systems and Applications (ICSOS), 2019.
- [3] B. Rouz  , L. Lombard, H. Jacqmin, A. Lim  ry, A. Dur  cu, and P. Bourdon, "Coherent beam combination of seven 1.5 μm fiber amplifiers through up to 1 km atmospheric turbulence: near- and far-field experimental analysis," Appl. Opt. 60, 8524-8533 (2021).
- [4] T. Shay, V. Benham, J. Baker, A. Sanchez, D. Pilkington and C. Lu, "Self-Synchronous and Self-Referenced Coherent Beam Combination for Large Optical Arrays," IEEE Journal of Selected Topics in Quantum Electronics 13, 480 (2007).