

CLAIMS

1. A method for coherent beam combining (CBC) comprising:
 - generating a source optical beam, using a light source;
 - dividing the source optical beam into a MxN array of temporally coherent input optical beams and a reference optical beam;
 - generating MxN output optical beams corresponding to the MxN input optical beams such that the output optical beams propagate along a first propagation direction;
 - dividing each of the output optical beams such that a first portion of each of the output optical beams is directed towards the first propagation direction, all first portions of the output optical beams forming a combined output optical beam, and a second portion of each of the output optical beams is directed towards a second propagation direction and used as a sample optical beam;
 - directing the reference optical beam, such that the reference optical beam interferes with the sample optical beams, generating a plurality of corresponding optical interference signals;
 - providing a plurality of MxN optical detectors, each being positioned and configured to measure intensity of a respective optical interference signal, and generate a power output value, indicative of the overall intensity of the respective optical interference signal;
 - automatically and separately changing a phase of each of the input optical beams, while comparing the measured power output value of its corresponding optical interference signal with at least one previously measured power output value generated by the respective optical detector, wherein the changing of the phase of each input optical beam is carried out directly based on the measured power output values of its respective optical interference signals, without calculating or estimating the correct phase and/or without producing any other signal associated therewith;

locking the phase of the input optical beam when reaching an extremum power output value of its respective optical interference signal, and

wherein the generating of the optical interference optical signals, measuring of the power output values of the multiple optical detectors and phase locking are carried out continuously and simultaneously for all MxN input and output optical beams and optical interference signals.

2. The method of claim 1, wherein the changing of the phase of each input optical beam is carried by using MxN phase shifters (PSs), each PS being configured to change the phase of a respective input optical beam,
and MxN control modules (CMs), each CM being associated with a different PS and a corresponding optical detector and configured to iteratively transmit control commands to its associated PS, based on the power output value received from the respective optical detector.
3. The method of claim 2, wherein the control commands for each input PS are indicative only of an increase or decrease direction of the respective phase, such that each PS increases or decreases the phase of the respective input optical beam by predefined and/or controllable phase shift span $\Delta\phi$.
4. The method of any one of claims 1 to 3, wherein the step of generating the output optical beams is carried out using an array of MxN collimating elements for separately collimating each of the input optical beams.
5. The method of any one of claims 1 to 4 further comprising controlling one or more characteristics of a wave-front of the combined output optical beam.
6. The method of claim 5, wherein the one or more characteristics the wave-front of the combined output optical beam comprises one or more of:
 - far field (FF) distribution of the wave-front;
 - FF position of a central lobe formable by the combined output optical beams;
 - central lobe focusing characteristics;
 - wave-front spatial configuration;
 - environmental optical aberrations corrections.
7. The method of any one of claims 5 to 6, wherein the controlling of the one or more wave-front characteristics is carried out by controlling direction of a wave-front of the reference optical beam.

8. The method of claim 7, wherein the controlling of the wave-front of the reference optical beam is carried out by:
 - mechanically moving of an output end of an optical waveguide from which the reference optical beam is outputted; and/or
 - mechanically changing a relative positioning between an output end of an optical waveguide, from which the reference optical beam is outputted, and a focusing lens located within a pathway of the reference optical beam.
9. The method of any one of claims 5 to 6, wherein the controlling of the one or more wave-front characteristics is carried out by using an MxN array of phase controlling modules (PCMs), each PCM positioned and configured to control the phase of a different portion of the reference optical beam interfering with a respective sample optical beam.
10. The method of claim 9, wherein the MxN array of PCMs are electronically and/or digitally controllable.
11. The method of claim 10, wherein the MxN array of PCMs comprise a MxN array of spatial light modulators.
12. The method of any one of claims 5 to 11, wherein the controlling of the one or more characteristics of the wave-front of the combined output optical beam is done according to a FF position of a target.
13. The method of any one of claims 1 to 12 further comprising controlling polarization of each of the input optical beams, based on the measured power output value of its respective optical interference signal.
14. The method of claim 13, wherein the controlling of the polarization of each of the input optical beams comprises the steps of:
 - automatically, and separately changing the polarization of each of the input optical beams, while comparing the measured power output value of the respective optical interference signal with at least one previously measured power output value from the respective optical detector; and
 - locking the polarization of each respective input optical beam when reaching an extremum power output value from the respective optical detector,

wherein the changing of the polarization of each input optical beam is carried out directly based on the measured power output values of its respective optical interference signals, without calculating or estimating the correct polarization and/or without producing any other signal associated therewith.

15. The method according to any one of claims 1 to 14 further comprising a controllably focusing of the combined output optical beam, using a controllable output beam collimating device.

16. A system for coherent beam combining (CBC) comprising:

- a light source, generating a source optical beam;
- a beam splitting mechanism, configured to divide the source optical beam into an array of $M \times N$ temporally coherent input optical beams and a reference optical beam;
- an array of $M \times N$ collimating elements, configured to direct each of the input optical beams through a separate collimating element, generating $M \times N$ output optical beams corresponding to the input optical beams passed through the collimating elements, such that the output optical beams are parallel to one another, defining a first propagation direction;
- a beam splitting element, configured to divide each of the output optical beams such that a first portion of each of the output optical beams is directed towards the first propagation direction, all first portions of the output optical beams forming a combined output optical beam and a second portion of each of the output optical beams is directed towards a second propagation direction and used as a sample optical beam;
- an array of $M \times N$ optical detectors, each being positioned and configured to measure intensity of a respective optical interference signal and output a power output value that corresponds to the overall intensity of the respective optical interference signal;
- a control subsystem, configured to continuously receive measured power output values from each of the optical detectors, change a phase of each of the input optical beams, while comparing the measured power output value of the respective optical interference signal with at least one previously measured power output value from the

respective optical detector, and lock the phase of the input optical beam when reaching an extremum power output value of its respective optical interference signal,

wherein the changing of the phase of each input optical beam is carried out directly based on the measured power output values of its respective optical interference signals, without calculating or estimating the correct phase and/or without producing any other signal associated therewith,

wherein the generating of the optical interference optical signals, measuring of the outputs of the multiple optical detectors and phase locking are carried out continuously and simultaneously for all MxN input and output optical beams and optical interference signals.

17. The system of claim 16, wherein the control subsystem comprises one or more of:

- MxN phase shifters (PSs), each PS being configured to change the phase of a different input optical beam; and
- MxN processing modules (PMs), each PM being configured to receive power output value of a different optical detector and control a PS associated therewith, in an iterative manner.

18. The system of any one of claims 16 to 17 further comprising one or more of:

- a reference optical fiber for guiding the reference beam, the optical fiber having an input end for inputting light from the light source and an output end from which the reference beam is emitted; and
- a reference beam collimator positioned such as to collimate the reference optical beam before interfering with the sample optical beams.

19. The system of any one of claims 16 to 18 further comprising a wave-front control mechanism, configured to control one or more characteristics of a wave-front of the combined output optical beam.

20. The system of claim 19, wherein the one or more characteristics of the wave-front of the combined output optical beam comprises one or more of:

- far field (FF) distribution of the wave-front;
- FF position of a central lobe formable by the combined output optical beams;

- central lobe focusing characteristics;
 - wave-front spatial configuration;
 - environmental optical aberrations corrections.
21. The system of any one of claims 19 to 20, wherein the wave-front control mechanism is configured to control a relative positioning between the reference optical fiber output end and the reference beam collimator, for steering control of the combined output optical beam.
22. The system of any one of claims 19 to 20 further comprising an MxN array of phase controlling modules (PCMs), each PCM positioned and configured to control the phase of a different portion of the reference optical beam interfering with a respective sample optical beam.
23. The system of claim 22, wherein the MxN array of PCMs are electronically and/or digitally controllable by the control subsystem or by a separate controller.
24. The method of claim 23, wherein the MxN array of PCMs comprise a MxN array of spatial light modulators (SLMs).
25. The system of any one of claims 19 to 24, wherein the controlling of the one or more characteristics of the wave-front of the combined output optical beam is done according to a FF position of a target.
26. The system of any one of claims 16 to 25 further comprising MxN polarization controllers (PCs) each PC being associated with a different PM and configured to control polarization of each of the input optical beams, based on the measured power output value of its respective measured power output value.
27. The system of claim 26, wherein the controlling of the polarization of each of the input optical beams comprises:
- automatically, and separately changing the polarization of each of the input optical beams, while comparing the measured power output value of the respective optical interference signal with at least one previously measured power output value of the respective optical interference signal; and
 - locking the polarization of each respective input optical beam when reaching an extremum power output value of its respective optical interference signal,

wherein the changing of the polarization of each input optical beam is carried out directly based on the measured power output values of its respective optical interference signals, without calculating or estimating the correct polarization and/or without producing any other signal associated therewith.

28. The system of any one of claims 16 to 27 further comprising a focusing device, configured and positioned to controllably focus the combined output optical beam.
29. The system of any one of claims 16 to 28 further comprising an array of MxN optical waveguides, each being configured to guide therethrough a different input optical beam and/or an output optical beam.
30. The system of claim 29, wherein the optical waveguides are: optical fibers, fiber amplifiers, doped fibers.
31. A method for coherent beam combining (CBC) comprising:
 - providing a MxN array of temporally coherent input optical beams;
 - providing a reference optical beam;
 - generating MxN output optical beams corresponding to the MxN input optical beams such that the output optical beams propagate along a first propagation direction;
 - dividing each of the output optical beams such that a first portion of each of the output optical beams is directed towards the first propagation direction, all first portions of the output optical beams forming a combined output optical beam and a second portion of each of the output optical beams is directed towards a second propagation direction and used as a sample optical beam;
 - directing the reference optical beam, such that the reference optical beam interferes with the sample optical beams, generating a plurality of optical interference signals;
 - providing a plurality of MxN optical detectors, each being positioned and configured to measure intensity respective of each optical interference signal of the plurality of optical interference signals and generate a power output value that corresponds to the overall intensity of the respective optical interference signal;
 - automatically and separately changing a phase of each of the input optical beams, while comparing the measured power output value of the respective optical interference

signal with at least one previously measured power output value generated by the respective optical detector; wherein the changing of the phase of each input optical beam is carried out directly based on the measured power output value of its respective optical interference signal; and

locking the phase of the input optical beam when reaching an extremum power output value of its respective optical interference signal,

wherein the generating of the optical interference optical signals, measuring of the outputs of the multiple optical detectors and phase locking are carried out continuously and simultaneously for all MxN input and output optical beams and optical interference signals.

32. A system for coherent beam combining (CBC) comprising:

- an array of MxN temporally coherent input optical beams;
- a reference optical beam;
- an array of MxN collimating elements, configured to direct each of the input optical beams through a separate collimating element, generating MxN output optical beams corresponding to the input optical beams passed through the collimating elements, such that the output optical beams are parallel to one another, defining a first propagation direction;
- a beam splitting element, configured to divide each of the output optical beams such that a first portion of each of the output optical beams is directed towards the first propagation direction, all first portions of the output optical beams forming a combined output optical beam and a second portion of each of the output optical beams is directed towards a second propagation direction and used as a sample optical beam, directed such as to interfere with the reference optical beam, generating a plurality of optical interference signals;
- a plurality of optical detectors, each being positioned and configured to measure intensity of a respective optical interference signal and output a power output value that corresponds to the overall intensity of the respective optical interference signal; and

- a control subsystem, configured to continuously receive measured power output values from each of the optical detectors, change a phase of each of the input optical beams, while comparing the measured power output value of the respective optical interference signal with at least one previously measured power output value from the respective optical detector, and lock the phase of the input optical beam when reaching an extremum power output value of its respective optical interference signal, wherein the changing of the phase of each input optical beam is carried out directly based on the measured power output value of its respective optical interference signal, wherein the generating of the optical interference optical signals, measuring of the outputs of the multiple optical detectors and phase locking are carried out continuously and simultaneously for all $M \times N$ input and output optical beams and optical interference signals.