[00388] What is claimed is:

CLAIMS

1. An apparatus configured for frequency doubling of optical radiation, the apparatus comprising at least two sequential nonlinear crystals (NLCs):

   - a first NLC configured to receive a fundamental beam, at a fundamental frequency (F_F), and to emit a weak second harmonic beam, at a second harmonic frequency (F_H) together with a strong residual beam, at the fundamental frequency (F_F); the power ratio between the weak second harmonic beam and the fundamental beam is smaller than 5×10^{-3} to 1, respectively; and

   - at least one second NLC, configured to receive a residual beam, at the fundamental frequency (F_F), and a second harmonic beam, at the second harmonic frequency (F_H), of a previous NLC, and to emit a strong frequency doubled beam, at the second harmonic frequency (F_H), together with a residual beam, at the fundamental frequency (F_F); the power ratio between the strong frequency doubled beam and the fundamental beam is larger than 0.3 to 1, respectively.

2. The apparatus of claim 1, further comprising at least one phase mismatch compensator (PMC), configured to correct a phase relationship between a residual beam, at the fundamental frequency (F_F), and a second harmonic beam, at the second harmonic frequency (F_H), prior to being received by the second NLC.

3. The apparatus of claim 2, further comprising at least one feedback and control system, configured to sample the strong frequency doubled beam and accordingly to adjust the PMC to allow maximum power for the strong frequency doubled beam.

4. The apparatus of claim 3, wherein the feedback and control system comprising: at least one measuring element, at least one processing element, and at least one adjusting element configured to adjust the PMC.

5. The apparatus of claim 1, further comprising at least one oven, each configured to adjust temperature of an NLC.

6. The apparatus of claim 1, wherein the length (L_S) of the first NLC equals to 10% or less of the length (L_D) of the second NLC ($L_S \leq 0.1\ L_D$).

7. The apparatus of claim 6, wherein the second NLC comprises LBO and its length (L_D) of is greater than 40 *mm*.

8. The apparatus of claim 1, wherein the fundamental frequency (F_F) comprises a property of infra-red (IR) light (λ_F=1064*nm*), therefore second harmonic frequency (F_H) comprises property of visible light (λ_H=532*nm*).

9. The apparatus of claim 1, wherein each of the NLCs is configured with a fundamental beam polarization along a crystallographic axis thereof or with a fundamental beam polarization at 45^0 to the crystallographic axis thereof.

10. The apparatus of claim 1, each of the NLCs comprises at least one material selected from the group consisting: BBO, KTP, LBO, CLBO, DKDP, ADP, KDP, LiIO3, KNbO3, LiNbO3, AgGaS2, AgGaSe2.

11. The apparatus of claim 1, wherein dimensions of lateral area of each of the NLCs is larger than the dimensions of its received input beams.

12. The apparatus of claim 1, further comprising at least one converging element, configured to focus a beam into an NLC.

13. A method for frequency doubling of optical radiation, the method comprising:
- providing a nonlinear crystal (NLC) with a fundamental beam, at a fundamental frequency (F_F), and a weak second harmonic beam, at a second harmonic frequency (F_H);
- thereby emitting via the NLC a strong frequency doubled beam, at the second harmonic frequency (F_H), together with a residual beam, at the fundamental frequency (F_F);

  wherein the power ratio between the provided weak second harmonic beam and the fundamental beam is smaller than 5×10^{-3} to 1, respectively;

and wherein the power ratio between the emitted strong frequency doubled beam and the fundamental beam is larger than 0.3 to 1, respectively.

14. The method of claim 13, wherein the providing further comprises phase mismatch compensating between the fundamental and the weak second harmonic beams; and wherein the method further comprises controlling the PMC to allow maximum power for the strong frequency doubled beam.

15. An apparatus configured to double frequency of an input of optical radiation and to provide an output beam comprising a second harmonic frequency, the apparatus comprising:

- at least two sequential nonlinear crystals (NLCs); each NLC, configured to receive a first beam at a fundamental frequency (F_F), and optionally a second beam at a second harmonic frequency (F_H) from a previous NLC, and to emit a strong frequency doubled beam, at the second harmonic frequency (F_H), together with a residual beam, at the fundamental frequency (F_F);

- at least one phase mismatch compensator (PMC), positioned between the two NLCs; the PMC is configured to correct a phase relationship between a residual beam, at the fundamental frequency (F_F), and a second harmonic beam, at the second harmonic frequency (F_H), prior to being received by the following NLC; and

- a motorized rotation device per each the PMC, configured to actively rotate the PMC and therefore actively adjust the correction of the phase relationship between the residual beam and the second harmonic beam.

16. The apparatus of claim 15, further comprising at least one feedback- and control-system, configured to sample the strong frequency doubled beam and accordingly to tilt the PMC, via the motorized rotation device, to allow maximum power for the strong frequency doubled beam.

17. The apparatus of claim 16, wherein the feedback and control system comprising: at least one beam splitter, at least one measuring element, at least one processing

element, and at least one control element configured to control the motorized rotation device.

18. The apparatus of claim 15, wherein the PMC comprises an optically transparent window exhibiting chromatic dispersion, such that the distance through which the beams must pass through the window varies relative to its rotation angle.

19. The apparatus of claim 15, wherein the motor is configured to rotate the PMC in a step-wise and/or a continuous motion.

20. The apparatus of claim 19, wherein the motor is further configured to rotate the PMC in a Dither form bounded between upper- and lower- values.

21. The apparatus of claims 16 and 20, wherein feedback- and control- system is configured to use the Dither form to provide at least one of the following:
    a. minimize back-conversion in the following NLC, thereby maximize power of the output beam;
    b. maximize back-conversion in the following NLC, thereby minimize power of the output beam;
    c. adjust the power of the output beam to a predetermined value between the maximum and the minimum, optionally while operating conditions are dynamic or static.

22. The apparatus of claim 15, wherein the motor is configured to rotate the PMC in a toggle mode, between maximum and minimum harmonic conversion states, such that the output beam is turned ON and OFF respectively.

23. The apparatus of claim 22, wherein the motor is configured to rotate the PMC to provide flat-topped pulses of controlled rise and fall times, and of controllable duration.

24. The apparatus of claim 15, wherein the motor is configured to rotate the PMC in accordance with look-up tables, and therefore to provide shaped harmonic pulses.

25. The apparatus of claim 15, further comprising at least one dichroic beam splitter configured to separate at least part of the residual beam out of the output beam.

26. The apparatus of claim 15, the power ratio between the emitted strong frequency doubled beam and the emitted fundamental beam is larger than 0.3 to 1, respectively.

27. The apparatus of claim 15, further comprising at least one oven, each configured to adjust temperature of the NLCs.

28. The apparatus of claim 27, wherein the active control of the PMC is configured to minimize power variations caused by variations in the temperature of the ovens housing the NLCs.

29. The apparatus of claim 15, wherein the fundamental frequency (F_F) comprises a property of infra-red (IR) light (λ_F=1064*nm*), therefore second harmonic frequency (F_H) comprises property of visible light (λ_H=532*nm*).

30. The apparatus of claim 15, wherein each of the NLCs is configured with a fundamental beam polarization along a crystallographic axis thereof or with a fundamental beam polarization at 45^0 to the crystallographic axis thereof.

31. The apparatus of claim 15, each of the NLCs comprises at least one material selected from the group consisting: BBO, KTP, LBO, CLBO, DKDP, ADP, KDP, LiIO3, KNbO3, LiNbO3, AgGaS2, AgGaSe2.

32. The apparatus of claim 15, wherein dimensions of lateral area of each of the NLCs is larger than the dimensions of its received input beams.

33. The apparatus of claim 15, further comprising at least one achromatic converging element, configured to focus the fundamental and harmonic beams into an NLC.