

WHAT IS CLAIMED IS:

1. An optical computation system comprising:
 - a light source configured to produce a pump beam;
 - an optical modulator configured to receive a modulation mask and to modulate the pump beam based on the modulation mask to generate a modulated beam;
 - a non-linear medium configured to convert a portion of the modulated beam to a second harmonic (SH) beam and to produce an output comprising the SH beam and an unconverted portion of the pump beam; and
 - a dichroic mirror configured to receive the output of the non-linear medium and to decouple the SH beam and the unconverted portion of the pump beam;
 - a detector configured to detect a first optical power of the unconverted portion of the pump beam and to detect a second optical power of the SH beam; and
 - a controller configured to generate an updated modulation mask based on the first and second optical powers for transmission to the optical modulator.
2. The optical computation system of claim 1, wherein the optical modulator comprises a spatial light modulator that is configured to modulate phases of wavelets of the pump beam to generate the modulated beam.
3. The optical computation system of claim 2, wherein the modulation mask is a random binary phase pattern.
4. The optical computation system of claim 2, wherein the spatial light modulator is configured to modulate phases of wavelets of the pump beam by encoding a phase of each one of the wavelets as either a first phase or a second phase based on the modulation mask, and
 - wherein the first and second phases are 180 degrees apart.
5. The optical computation system of claim 1, wherein the optical modulator comprises a digital micromirror device that is configured to modulate intensities of wavelets of the pump beam to generate the modulated beam.

6. The optical computation system of claim 1, further comprising:
a first lens configured to focus the modulated beam inside of the non-linear medium; and
a second lens configured to collimate the output of the non-linear medium onto the dichroic mirror.
7. The optical computation system of claim 1, wherein the detector comprises:
a first photodetector configured to detect the first optical power of the unconverted portion of the pump beam; and
a second photodetector configured to detect the second optical power of the SH beam, and
wherein the non-linear medium comprises a periodic-poled lithium niobate crystal.
8. The optical computation system of claim 1, wherein the modulation mask comprises a plurality of pixels, and
wherein the controller is configured to identify a cluster of the pixels based on the first and second optical powers, and to generate the updated modulation mask by inverting pixels of the cluster of the pixels.
9. A method of controlling an optical computation system to determine an approximate ground state of a system energy, the method comprising:
driving a light source to generate a pump beam;
generating a phase mask;
applying the phase mask to a spatial light modulator to modulate phases of wavelets of the pump beam to generate a modulated beam based on the phase mask;
and
receiving a first optical power of the pump beam and a second optical power of a second harmonic (SH) beam generated based on the pump beam from a detector,
wherein the generating the phase mask comprises:
identifying a cluster of the phase mask;
determining a current system energy based on the first optical powers;

determining whether to update the phase mask based at least on the system energy and a previous minimum system energy; and
in response to determining to update the phase mask,
updating the phase mask based on the cluster of the phase mask.

10. The method of claim 9, wherein the generating the phase mask further comprises:

in response to determining not to update the phase mask,
identifying a lesser of the current system energy and the previous minimum system energy as the approximate ground state.

11. The method of claim 9, wherein the generating the phase mask further comprises:

identifying a thermal energy;
calculating a change in system energy based on the current system energy and the previous minimum system energy; and
determining a boltzmann probability based on the change in system energy and the thermal energy, and
wherein the determining whether to update the phase mask is further based on the boltzmann probability.

12. The method of claim 9, wherein the determining whether to update the phase mask comprises:

determining that a feedback iteration count is less than a threshold;
determining to update the phase mask.

13. An optical computation system comprising:
a light source configured to produce a pump beam;
an optical modulator configured to receive a modulation mask and to modulate the pump beam based on the modulation mask to generate a modulated beam;
a non-linear medium configured to convert a portion of the modulated beam to a second harmonic (SH) beam and to produce an output comprising the SH beam and an unconverted portion of the pump beam; and

a dichroic mirror configured to receive the output of the non-linear medium and to decouple the SH beam and the unconverted portion of the pump beam;

a first camera configured to capture the unconverted portion of the pump beam and to generate a first intensity matrix;

a second camera configured to capture the unconverted portion of the pump beam and to generate a second intensity matrix; and

a controller configured to generate an updated modulation mask based on at least one of the first and second intensity matrices for transmission to the optical modulator.

14. The optical computation system of claim 13, wherein the optical modulator comprises a spatial light modulator that is configured to modulate phases of wavelets of the pump beam to generate the modulated beam, and wherein the modulation mask is a binary phase pattern.

15. The optical computation system of claim 14, wherein the spatial light modulator is configured to modulate phases of wavelets of the pump beam by encoding a phase of each one of the wavelets as either a first phase or a second phase based on the modulation mask, and wherein the first and second phases are 180 degrees apart.

16. The optical computation system of claim 13, wherein the optical modulator comprises a digital micromirror device that is configured to modulate intensities of wavelets of the pump beam to generate the modulated beam.

17. The optical computation system of claim 13, wherein the controller is configured to generate the updated modulation mask by:

determining a camera state as the first intensity matrix, the second intensity matrix, or a weighted sum of the first and second intensity matrices; and

determining the updated modulation mask based on the modulation mask and the camera state.

18. The optical computation system of claim 17, wherein the determining the updated modulation mask based on the modulation mask and the camera state comprises:

determining the updated modulation mask as a difference between the modulation mask and a multiplication of the camera state and a feedback step size.

19. The optical computation system of claim 18, wherein the pump beam comprises a gaussian pulse of a train of gaussian pulses generated by the light source, and

wherein the feedback step size corresponds to a periodicity of the train of gaussian pulses.

20. The optical computation system of claim 18, wherein the controller is configured to adaptively adjust the feedback step size prior to generating the updated modulation mask.

21. An optical computing system comprising:
an optical amplifier configured to generate a pump beam with a flat phase front;
a degenerate optical parametric amplifier configured to generate a signal of double wavelength in small wavelets based on the pump beam;
an optical filter configured to filter the pump beam from the signal;
an optical beam splitter configured to read out a fraction of the signal;
an nonlinear optical crystal configured to generate second-harmonic light based on the signal;
a first dual-band reflector configured to separate the signal and the second-harmonic light;
an optical receiver configured to couple the second-harmonic light into the optical amplifier; and
a second dual-band reflector configured to combine the signal and second-harmonic light into the degenerate optical parametric amplifier.

22. The optical computing system in claim 21, further comprising:

a first fourier lens configured to focus the signal into the nonlinear optical crystal for generation of second-harmonic light; and

a second fourier lens between the first and second dual-band reflectors and configured to defocus the signal.

23. The optical computing system in claim 21, wherein each of the first and second dual-band reflectors comprises a dichroic mirror or an optical filter.

24. The optical computing system in claim 21, wherein, as the signal continuously traverses the optical computing system, an optical gain of the optical amplifier is increased until optical parametric oscillation occurs.

25. The optical computing system in claim 21, further comprising a first optical modulator between the degenerate optical parametric amplifier and the nonlinear optical crystal and configured to modulate the signal prior to the signal reaching the nonlinear optical crystal to change an effective four-body interaction Hamiltonian of the optical computing system.

26. The optical computing system in claim 24, further comprising a second optical modulator between the nonlinear optical crystal and the optical receiver and configured to modulate the second-harmonic light to change an effective four-body interaction Hamiltonian of the optical computing system.

27. An optical computing system comprising:
an optical amplifier configured to generate an amplified signal with a flat phase front;

a nonlinear optical device configured to receive the amplified signal and to generate a pump beam through second-harmonic generation based on the amplified signal;

a degenerate optical parametric amplifier configured to generate a signal of double wavelength in small wavelets based on the pump beam;

an optical filter configured to filter the pump beam from the signal;

a first optical beam splitter configured to read out a fraction of the signal;

a second optical beam splitter configured to direct a first portion of the signal to an optical modulator for modulation of the portion of the signal and to direct a second portion of the signal to a dichroic mirror; and

an optical receiver configured to couple the modulated first portion of the signal into the optical amplifier to generate the amplified signal,

wherein the dichroic mirror is configured to combine the second portion of the signal with the pump beam into the degenerate optical parametric amplifier.

28. The optical computation system of claim 27, wherein the optical modulator comprises a spatial light modulator or a digital micromirror device, and

wherein the nonlinear optical device comprises a nonlinear optical crystal or an optical waveguide.