CLAIMS

1. A method comprising:

forming an array of atoms in a first array state, wherein said forming comprises:

exciting a crystal with a plurality of discrete adjustable acoustic tone frequencies,

passing a laser through the crystal to create a plurality of confinement regions, wherein each acoustic tone frequency corresponds to an individual confinement region for a single atom,

trapping at least two atoms in at least two of said plurality of confinement regions,

correlating the discrete adjustable acoustic tone frequencies to identify the confinement regions that contain the trapped atoms, and

adjusting a spacing between at least two of the trapped atoms by sweeping at least one correlated adjustable acoustic tone frequency;

evolving the plurality of atoms in the first array state into a plurality of atoms in a second array state by subjecting at least some of the trapped atoms to photon energy to transition at least some of the trapped atoms into an excited state; and

observing the plurality of atoms in the second array state.

2. The method of claim 1, wherein the excited state is a Rydberg state.

3. The method of claim 1, wherein the plurality of atoms in the first array state comprises between 7 and 51 atoms.

4. The method of claim 1, wherein the evolving the plurality of atoms comprises preparing at least some of the atoms in the first array state into a Zeeman sublevel of the ground state before subjecting at least some of the atoms to photon energy.

5. The method of claim 4, wherein the preparing the atoms in the first array state into a Zeeman sublevel of the ground state comprises optical pumping in a magnetic field.

6. The method of claim 1, wherein the subjecting at least some of the atoms to photon energy comprises applying light having two different wavelengths, and wherein the transition of the at least some of the atoms into an excited state comprises a two photon transition.

7. The method of claim 6, wherein the two different wavelengths are approximately 420 nm and approximately 1013 nm.

8. The method of claim 6, further comprising applying a phase gate with a third wavelength.

9. The method of claim 8, wherein the third wavelength is approximately 809 nm.

10. The method of claim 1, wherein the subjecting the at least some of the atoms to photon energy comprises applying two half-pi pulses.

11. The method of claim 10, wherein the subjecting the at least some of the atoms to photon energy further comprises applying a pi pulse between the two half-pi pulses.

12. The method of claim 1, wherein the trapping the at least two at least two atoms comprises trapping at least two atoms from a cloud of atoms and dispersing atoms from the cloud of atoms not trapped in one of said plurality of confinement regions.

13. The method of claim 1, wherein the crystal and laser comprise a first control acousto-optic deflector (AOD), and wherein the trapping the at least two atoms comprises trapping atoms from a hold trap array having at least three traps spaced apart in two dimensions.

14. The method of claim 13, wherein the hold trap array is generated by at least one of at least one hold AOD, a spatial light modulator (SLM), and an optical lattice.

15. The method of claim 13, further comprising a second control AOD configured in a crossed relationship with the first control AOD, and wherein:

the correlating the discrete adjustable acoustic tone frequencies to identify the confinement regions that contain the trapped atoms comprises correlating with discrete adjustable acoustic tone frequencies of the first control AOD and the second control AOD, and

the adjusting the spacing between the at least two of the trapped atoms comprises sweeping at least one correlated adjustable acoustic tone frequency of the first control AOD or the second control AOD.

16. The method of claim 15, wherein the adjusting the spacing between the at least two of the trapped atoms further comprises adjusting the position of multiple atoms in a row.

17. The method of claim 1, further comprising :

forming a second array of atoms in a third array state adjacent to the first array of atoms, wherein said forming comprises:

exciting a second crystal with a plurality of second discrete adjustable acoustic tone frequencies,

passing a second laser through the second crystal to create a plurality of second confinement regions, wherein each second acoustic tone frequency corresponds to an individual second confinement region for a single atom,

trapping at least two second atoms in at least two of said plurality of second confinement regions,

correlating the second discrete adjustable acoustic tone frequencies to identify the second confinement regions that contain the trapped atoms, and

adjusting a spacing between at least two of the trapped second atoms by sweeping at least one second correlated adjustable acoustic tone frequency;

wherein the evolving the plurality of atoms in the first array state into a plurality of atoms in a second array state by subjecting at least some of the trapped atoms to photon energy to transition the at least some of the trapped atoms into the excited state further comprises evolving the plurality of second atoms in the third array state into a plurality of second atoms in a fourth array state by subjecting at least some of the second trapped atoms to photon energy to transition at least some of the second trapped atoms into an excited state; and

wherein the observing the plurality of atoms in the second array state further comprises observing the plurality of second atoms in the fourth array state.

18. The method of claim 1, wherein:

the adjusting the spacing between at least two of the trapped atoms by sweeping at least one correlated adjustable acoustic tone frequency comprises encoding a quantum computing problem;

the evolving the plurality of atoms in the first array state into the plurality of atoms in the second array state produces a solution to the quantum computing problem; and

the observing the plurality of atoms in the second array state comprises reading out the solution to the quantum computing problem.

19. The method of claim 18, wherein the quantum computing problem comprises at least one of an Ising-problem and a maximum independent set (MIS) optimization problem.

20. A system comprising:

a confinement system for arranging an array of atoms in a first array state, the confinement system comprising:

a crystal,

an adjustable acoustic tone frequency application source configured to selectively apply a plurality of discrete adjustable acoustic tone frequencies to the crystal, and

a laser source arranged pass light through the crystal to create a plurality of confinement regions, wherein each acoustic tone frequency corresponds to an individual confinement region,

a source of an atom cloud, the atom cloud capable of being positioned to at least partially overlap with the plurality of confinement regions;

an excitation source for evolving at least some of the plurality of atoms in the first array state into a plurality of atoms in a second array state, the excitation source comprising at least one source of photon energy;

an observing system for observing the plurality of atoms in the second array state.

21. The system of claim 20, wherein the excitation source is configured to excited at least some of the plurality of atoms in the first array state into a Rydberg state.

22. The system of claim 20, wherein the plurality of atoms in the first array state comprises between 5 and 51 atoms.

23. The system of claim 20, wherein the excitation source is configured to excited at least some of the plurality of atoms in the first array state into a Zeeman sublevel of the ground state before subjecting at least some of the atoms to photon energy.

24. The system of claim 23, the excitation source further comprises an optical pumping system and a magnetic field generator.

25. The system of claim 20, wherein the at least one source of photon energy comprises light sources having a first wavelength and a second wavelength for producing a two photon transition of the at least some of the plurality of atoms in the first array state.

26. The system of claim 25, wherein the two different wavelengths are approximately 420 nm and approximately 1013 nm.

27. The system of claim 25, wherein the at least one source of photon energy comprises a source having a third wavelength for applying a phase gate.

28. The system of claim 27, wherein the third wavelength is approximately 809 nm.

29. The system of claim 28, wherein the excitation source is configured to apply two half-pi pulses.

30. The system of claim 29, wherein the excitation source is configured to apply a pi pulse between the two half-pi pulses.

31. The system of claim 20, wherein the confinement system is a first control acousto-optic deflector (AOD), and wherein the system further comprises a hold trap array having at least three traps spaced apart in two dimensions, the hold trap array being generated by a hold trap source.

32. The system of claim 31, wherein the hold trap source comprises at least one of at least one hold AOD, a spatial light modulator (SLM), and an optical lattice.

33. The method of claim 31, further comprising a second control AOD in a crossed relationship with the first control AOD, wherein the first control AOD controls deflection of light beams in a first direction, and the second control AOD controls deflection of light beams from the first AOD in a second direction different from the first direction.

34. The method of claim 20, wherein the confinement system is a first control acousto-optic deflector (AOD), and wherein the system further comprises a second control AOD in a stacked relationship with the first control AOD, wherein the first control AOD is configured to produce a plurality of confinement regions in a first array having a first direction, and the second control AOD controls is configured to produce a plurality of confinement regions in a second array that is substantially parallel to the first direction.