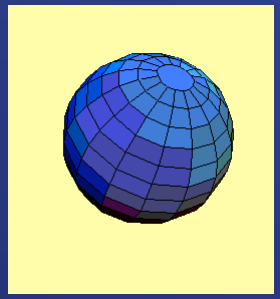
How Things Work II (Lecture #31)



Instructor: Gordon D. Cates
Office: Physics 106a, Phone: (434) 924-4792
email: cates@virginia.edu

Course web site available through COD and Toolkit
or at http://people.virginia.edu/~gdc4k/phys106/spring07

April 13, 2007

Announcements

- The correct time and date for the final exam are May 4th, from 9AM to 12 noon.
- There will be a quiz Wednesday, April 18th.
- I will post a new homework this evening, and it will be due on Tuesday April 17th, i.e. before the quiz.
- Homework #5 should be viewed as at least a partial study guide for the quiz.
- In addition to my normal office hours on Monday, I will also hold office hours Monday evening, and at some point on Tuesday.

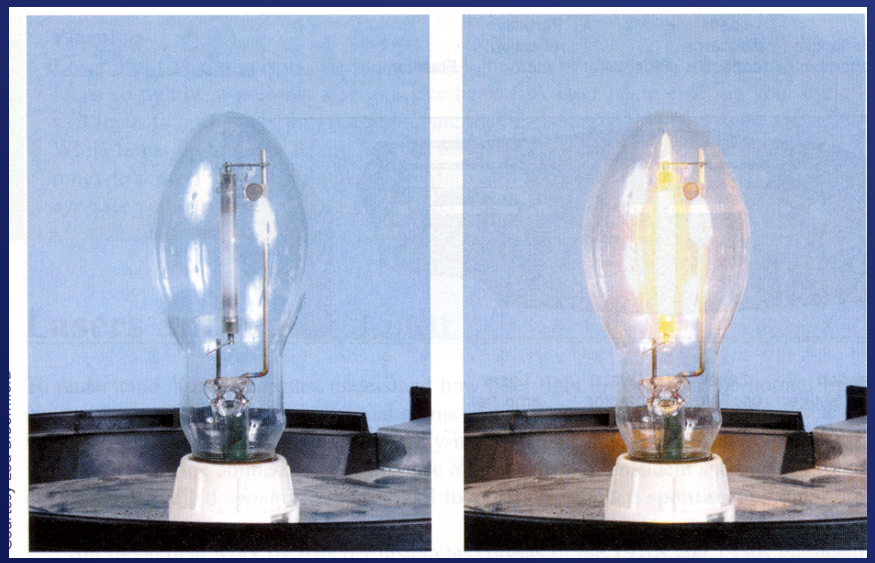
Gas Discharge Lamps

- There are several familiar varieties:
  - Neon signs
  - Fluorescent lamps
  - Mercury, metal-halide, and sodium lamps
- All these lamps share some common features:
  - The light they produce is NOT thermal in nature, and is not a blackbody spectrum.
  - In all cases light is initially produced by a "discharge", the phenomenon of an electric current passing through a gas.

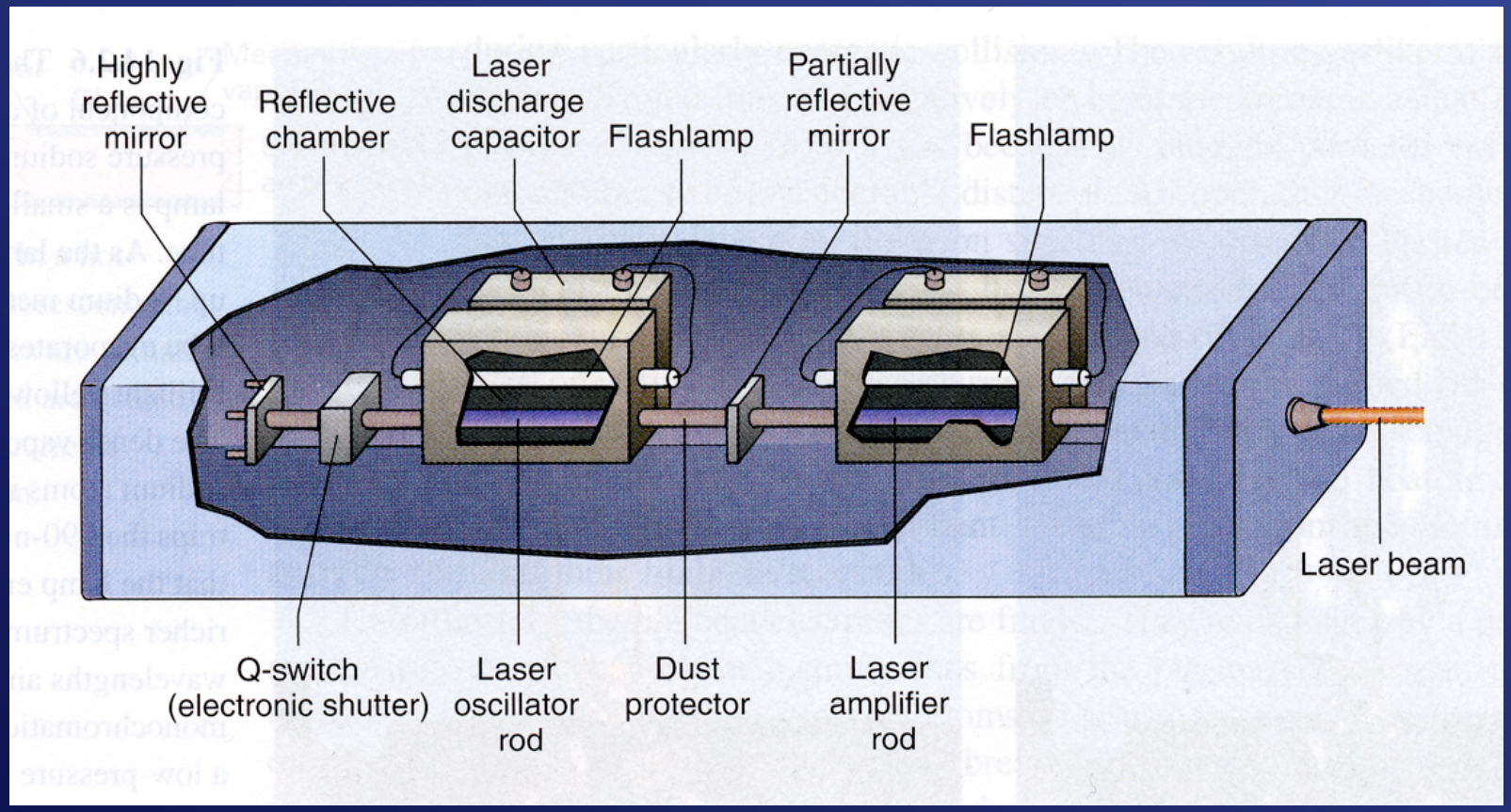
High-pressure mercury, metal-halide and sodium lamps

- Contains a high pressure of either mercury or sodium.
- In either case, the pressure of mercury or sodium is so high that most of the light emitted is not at the primary wavelength which is reabsorbed. This effect is called radiation trapping.
- High pressure mercury lamps can also contain metal-halide compounds such as sodium iodide, thallium iodide, indium iodide and scandium iodide. These additional compounds add additional light at new wavelengths and can make the light a warmer color than a pure high-pressure mercury lamp.

A high-pressure sodium lamp.

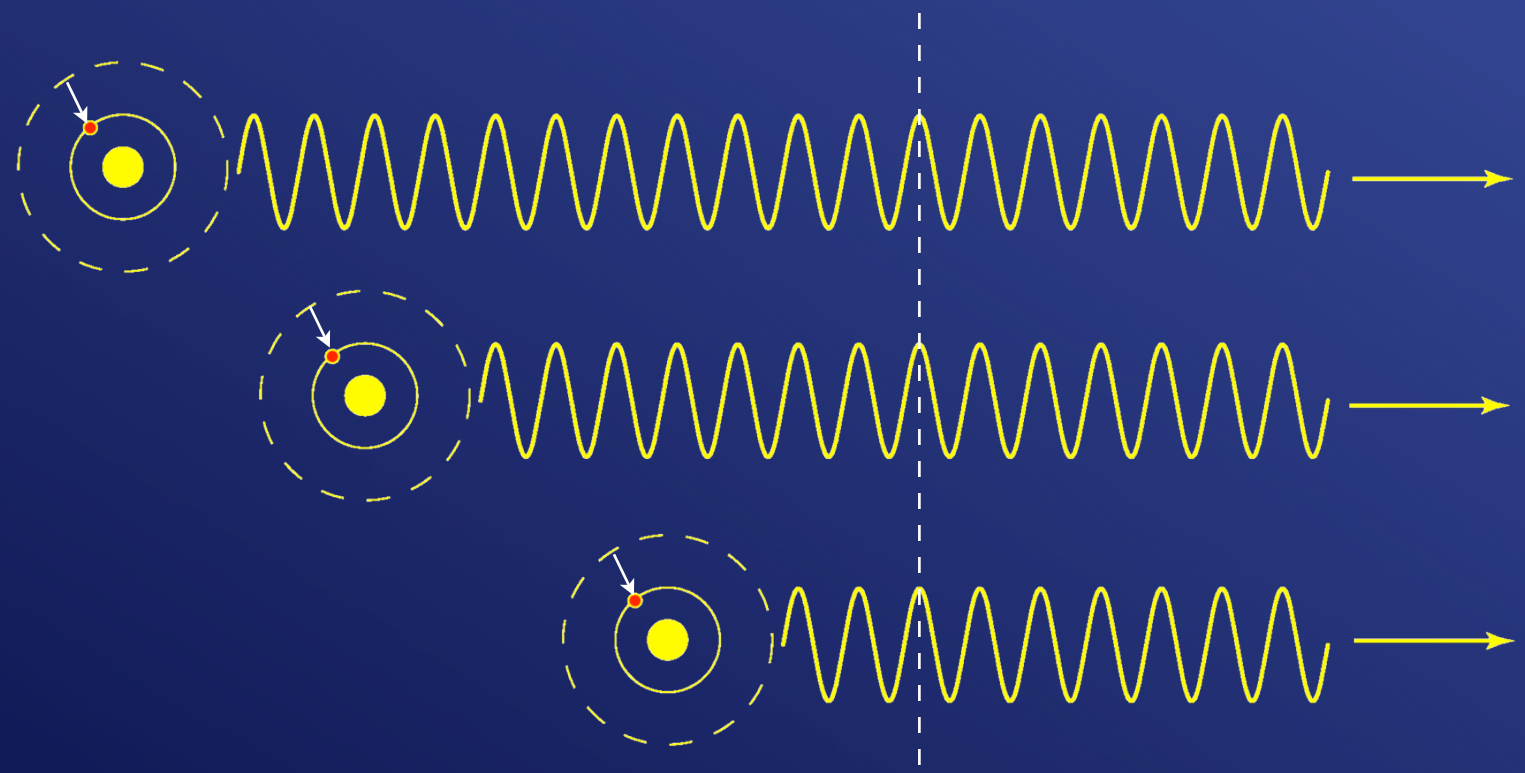


Lasers



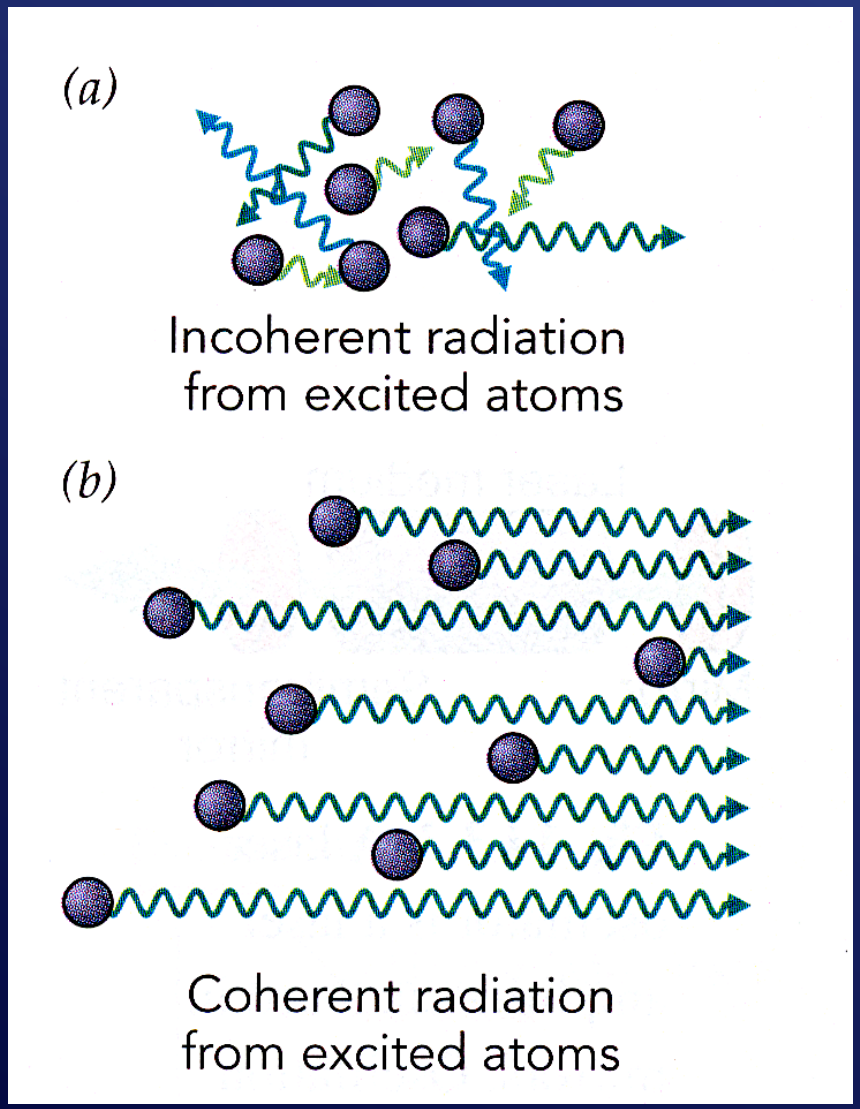
Lasers also use light that is generated when atoms undergo a particular transition, but the way in which those transitions is induced is very different than in a discharge lamp.

Spontaneous emission and Stimulated emission



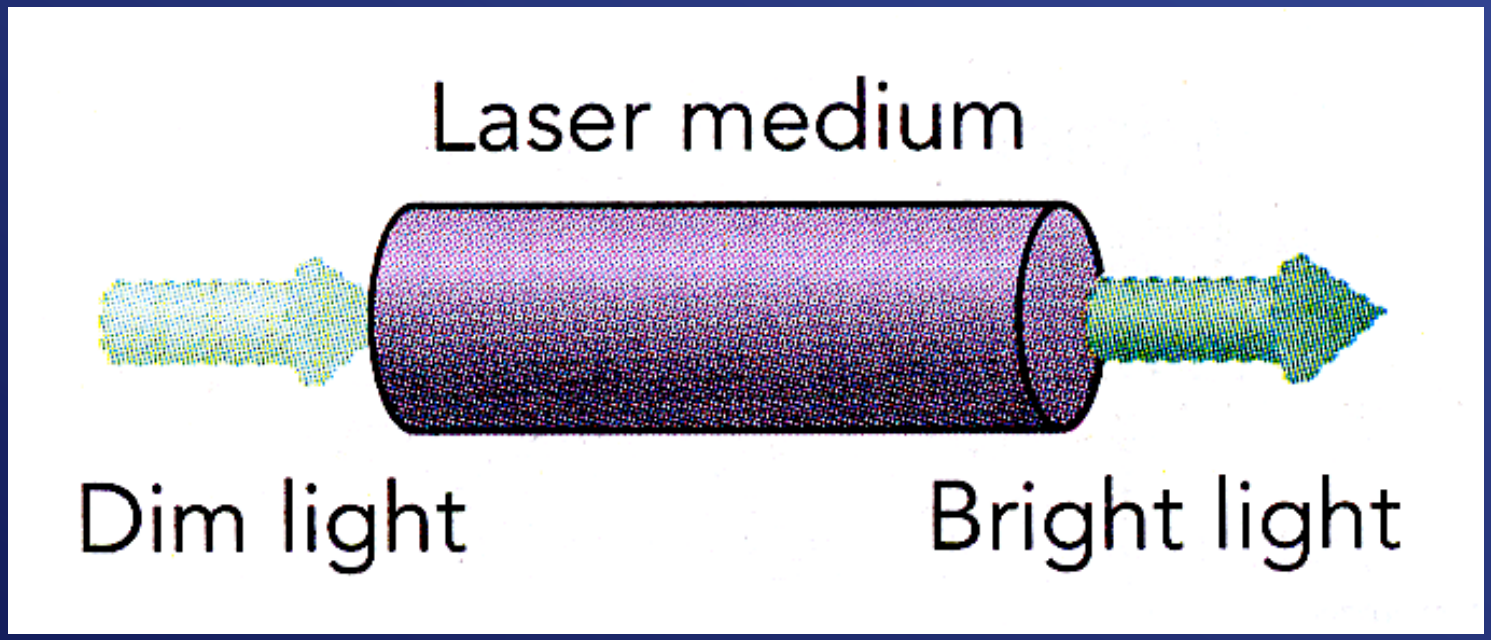
- In spontaneous emission, an atom randomly makes a transition to a lower energy state and emits a photon.
- In stimulated emission, an atom feels the oscillation of an electromagnetic wave and is stimulated to emit a photon that will be in phase with the stimulating radiation.

Stimulated emission in response to coherent light



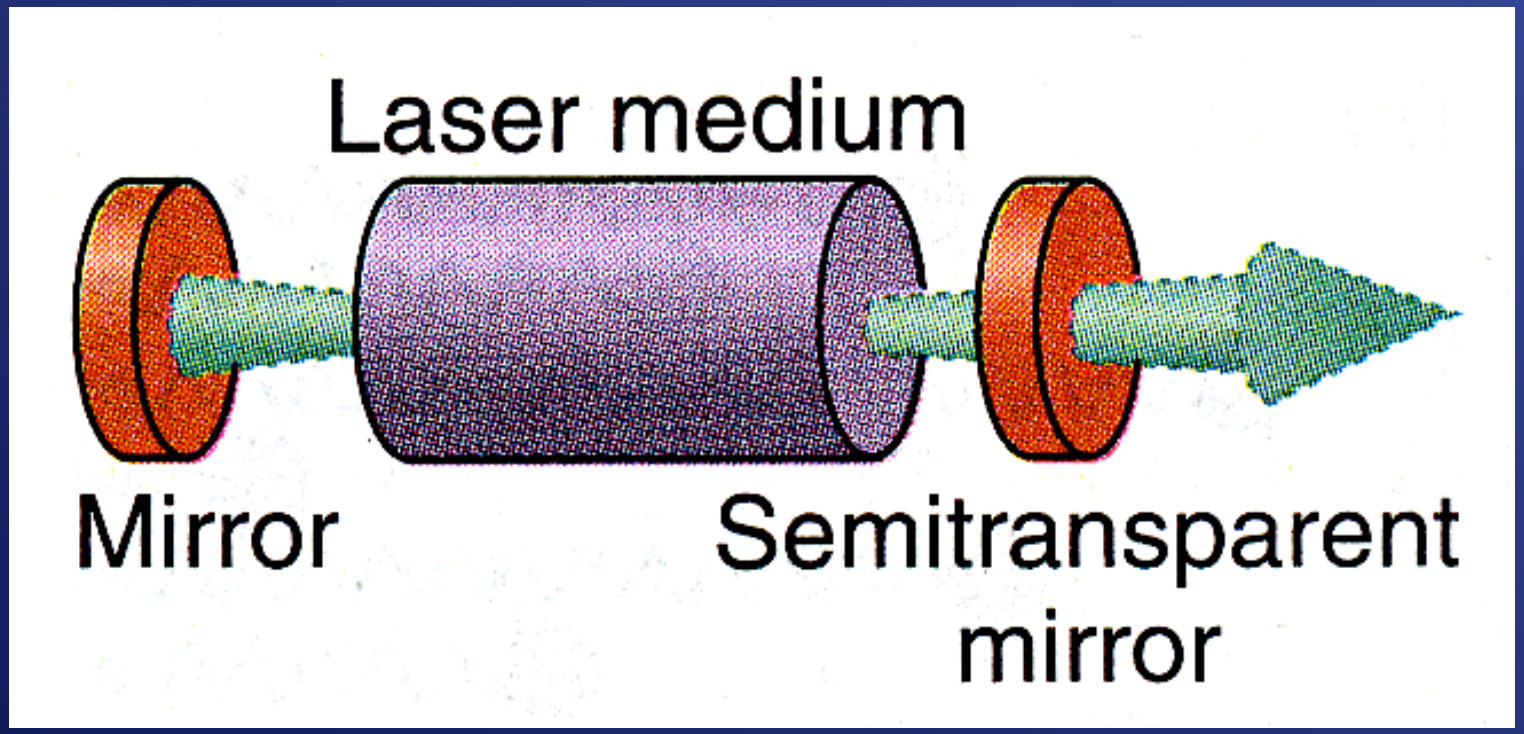
- If atoms are left to themselves, or even exposed to resonant but incoherent light, they will emit light in random directions.
- If atoms are exposed to coherent light, however, that is resonant with a possible transition, they will emit coherent radiation.

Lasers amplifier



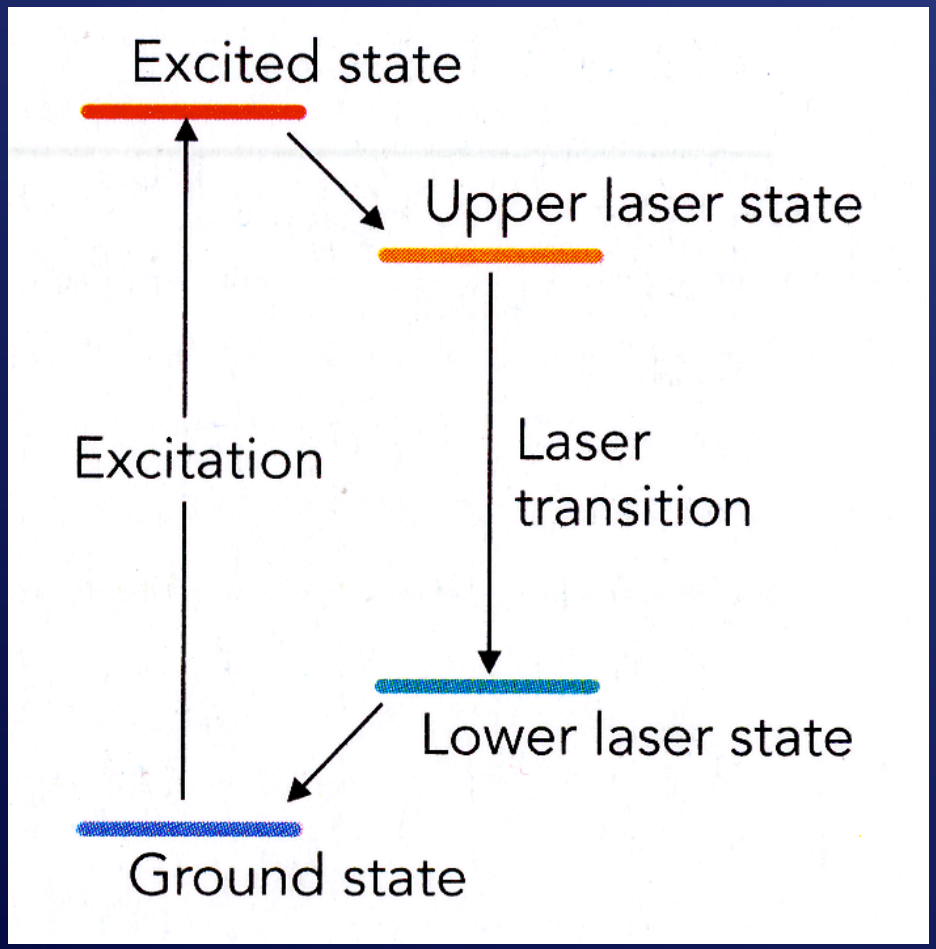
- The laser medium contains many atoms in an excited state that can undergo a transition corresponding to the frequency of the incoming light.
- Dim coherent light enters the laser medium.
- Through stimulated emission, the incoming photons cause many more photons of the same color and of the same phase to be produced.

Laser oscillator, or simply, a laser



- A laser oscillator, or in more common terminology, simply a laser, is a laser amplifier enclosed by two mirrors that reflect back upon themselves.
- Coherent light travels back and forth between the mirrors, getting amplified during each round trip.
- A fraction of the light is extracted during each round trip through a semi-transparent mirror.

Why population inversions are critical



- In addition to stimulated emission, there is an equally likely process called stimulated absorption.
- Thus, if a photon of the right color encounters an atom in the lower energy state of the transition in question, the photon can be absorbed.
- For the laser medium to amplify light, you need more atoms in the upper level of the lasing state than in the lower level.
- Such a situation is called a "population inversion", and it is critical to the function of a laser.
- For this reason, most lasers involve three or four level systems.