Laser (biophysics)

Laser

A laser is an optical device that emits **highly coherent light**, i.e. light that has a common wavelength, phase and direction of propagation. The name is an abbreviation of the English term **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation.

Internationally recognized laser radiation symbol.

History of the laser Laser

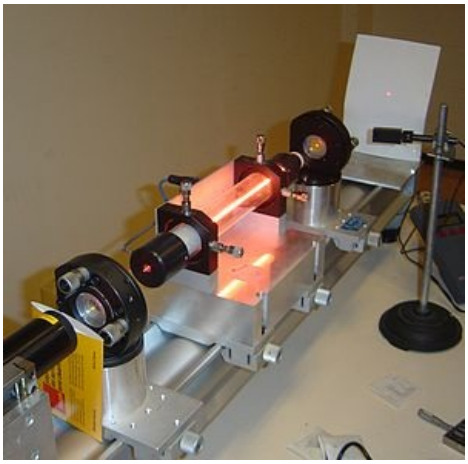
The predecessor of the laser was the maser, a device that works on the same principle but generates microwave radiation. The first maser was built by Charles Townes, J. P. Gordon and H. J. Zeiger in 1953. This prototype was unable to operate continuously.

In 1960, Theodore H. Maimanin the USA demonstrated a working laser for the first time. He used a ruby crystal as the active medium using three energy levels; the laser could only operate in pulsed mode.

In 1964, Charles Townes, Nikolai Basov and Alexander Prokhorov were jointly awarded the Nobel Prize in Physics for "fundamental research in quantum electronics which led to the design of oscillators and amplifiers based on the principles of masers and lasers".

The principle of laser

If a substance contains particles in excited states, then irradiation of the substance with photons of energy equal to the difference in energy levels between the excited and ground states will cause the excited particles to transition to a lower energy state, associated with the emission of radiation with the same wavelength, phase and direction of propagation as the radiation that caused the emission. The particle, most often a photon, strikes the excited electron very sharply, and therefore the primary photon of energy h. ν continues on and is joined by the photon generated by the electron transition, also of energy h. ν. From this point on, the two photons continue. These will knock 2 more excited electrons into the ground state, 4 photons will continue, these will knock 4 more electrons, 8 photons will continue ... The process thus described is called **stimulated emission**.


Helium-Neon laser demonstration at the Kastler-Brossel Laboratory at Paris VI: Pierre et Marie Curie. The glowing ray in the middle is a discharge tube (akin to that of a neon light), it is *not* the laser beam. The laser beam crosses the air and marks a red point on the screen to the right.

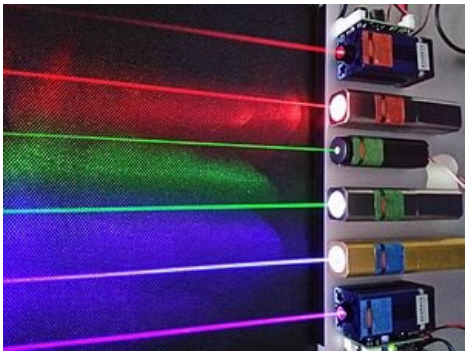
The **electron shells** of atoms and molecules exist only in certain quantum states (energy levels Ei). When transitioning between two energy states, an atom (molecule) emits radiation at a frequency where fnm = frequency of emitted quantum radiation, En = higher energy level, Em = lower energy level, h = **Planck's constant**.

In the **ground state**, **atoms** have the lowest energy where they can only absorb electromagnetic radiation. Under the influence of external radiation, atoms can enter **excited states** from which they can transition to the ground state spontaneously (independent transitions, incoherent radiation) or forced (due to external electromagnetic radiation, emitted radiation has the same frequency as the external radiation).

Types of lasers

Lasers are classified according to the medium they contain.

- Gaseous lasers - (e.g. Argon laser, Excimer laser)
- liquid-medium lasers - (lasers with liquid blood dye)
- solid-state lasers - (ruby, glass...)


Six commercial lasers in operation, showing the range of different colored light beams that can be produced, from red to violet. From the top, the wavelengths of light are: 660nm, 635nm, 532nm, 520nm, 445nm, and 405nm. Manufactured by Q-line.

Effects

- Thermal, impact, free radical generation (dependent on radiation wavelength, pulse length, radiation intensity and properties of the biological object)

Applications

- Communication technology, computer backbone networks (light source for optical fibres)
- medicine (ophthalmology, dermatology, surgery)
- particle acceleration (mainly electrons - point source of X-rays)
- laser ablation (ablation = removal)

Links

Related articles

- Laser (hygiene)
- Laser

Source

- KUBATOVA, Senta. *Biofot* [online]. [cit. 2011-01-31]. <https://uloz.to/!CM6zAi6z/biofot-doc>.

- MACH, Petr. *Výkonové součástky a technologie* - Předmět ČVUT - A1B13VST, AD1B13VST

References used

ČERNOHORSKÝ, P. Jandera: *Atomová spektroskopie*, Univerzita Pardubice, Pardubice (1997)

http://fyzika.jreichl.com/