



DEVELOPMENT AND SCIENTIFIC AND PRACTICAL SIGNIFICANCE OF LASER TECHNOLOGIES

Tuyboyev Fazliddinjon Faxriddin ugli

Teacher of the Department of Physics and Astronomy, Navoi State University

e-mail: fazliddinto91@gmail.com

Today, laser devices and their practical application are of particular importance in the development of medicine, high technology, information transmission and processing, optical communication systems, agriculture, and many other areas of science and technology.

As is known, the concept of forced radiation was introduced into science by A. Einstein in 1916. Developing the physical phenomena based on this concept, N.G. Basov, A.M. Prokhorov and Ch. Towns stated that it is theoretically possible to create quantum generators for wavelengths in the optical range. The first quantum generator in the optical range was discovered in 1960 by the American physicist T. Meiman. After that, generators in the optical range with forced radiation - lasers - were created using various active media and methods. In recent years, due to the development of science and technology, lasers operating on the basis of quantum-scale physical phenomena have been discovered and put into practice.

Lasers are devices that produce coherent light of a specific wavelength. First developed in the 1960s, laser technology is now used in many fields, including medicine, engineering, materials science, and chemistry. In chemistry, lasers play a crucial role in a variety of applications, including molecular analysis, reaction initiation, and material processing.

Lasers work on the principle of stimulated emission, which is the use of forced transitions that can occur in atoms and molecules. When an atom or molecule is excited by a high-energy photon, it emits this energy at a specific wavelength, producing coherent light. Since then, the science of optics has recognized that there are three possible processes that can occur when atoms and molecules interact with electromagnetic waves: absorption, spontaneous emission, and stimulated emission.

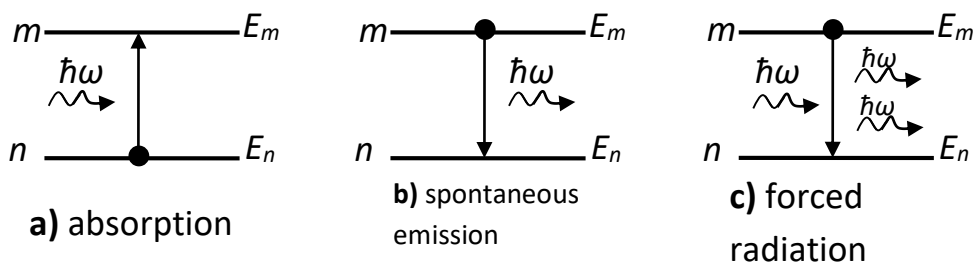


Figure 1. A quantum system with two energy states, illustrating absorption, spontaneous, and stimulated emission.

where: a) - absorption of a photon and transition of an electron from one energy level to another.

b) - spontaneous emission of light by an electron excited by the absorption of a photon.

c) - emission of light by an electron excited by the absorption of a photon and the collision of another electron with another electron, when the electron moves from a higher energy level to a lower energy level.

Laser light offers great advantages in applications requiring precision in chemical and physical processes, as it is high-intensity, focused, and monochromatic. Today, laser technology is contributing to a variety of fields, including widespread use in medicine. The convenience of laser light lies in its coherence and monochromaticity.

Coherence is the temporal correlation of several oscillations or wave processes in physics, which manifest themselves when they are added together.

Monochromatic light is an electromagnetic wave with a specific and fixed frequency.

Typical laser image

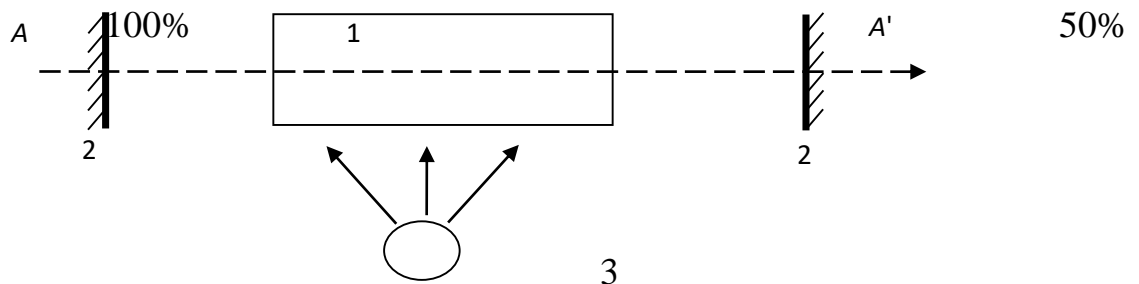


Figure 1. Functional diagram of a laser.

where: 1 is the active element, 2 is the optical resonator (parallel mirrors), 3 is the pumping system. The axis AA' perpendicular to the mirrors is called the optical axis of the laser, and the laser light propagates along this axis.

To obtain laser light of different wavelengths, we can use an additional element, i.e. a modulator, in the center of the active element and the resonator.

As follows

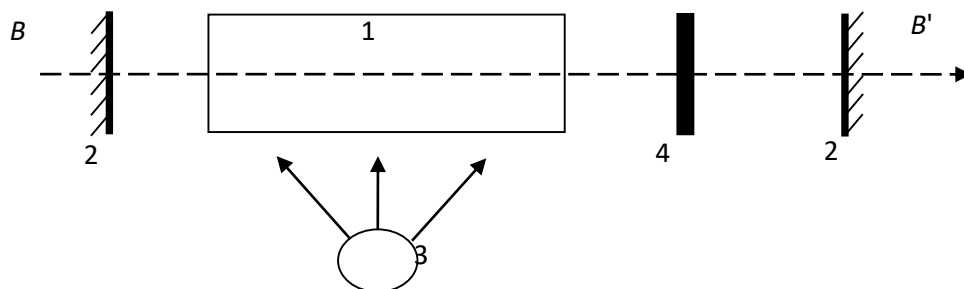


Figure 2. Functional diagram of the laser.

where: 1 is the active element, 2 is the optical resonator (parallel mirrors), 3 is the pumping system, 4 is the additional elements that can be placed inside the resonator (modulator). The axis BB' , perpendicular to the mirrors, is the optical axis of the laser.

1. Interdisciplinary connection – Laser technology is closely related to the fields of physics, chemistry and engineering. Lasers are widely used to analyze chemical processes, study the structure of substances and create new materials.

2. Spectroscopy and analysis methods – Lasers are used in infrared, ultraviolet and Raman spectroscopy. These methods are important in the in-depth study of the composition of substances and their properties.

3. Industrial and practical applications – Lasers are used to control reaction kinetics in chemical processes, process materials (cutting, welding, engraving) and analyze drugs in the pharmaceutical industry.

4. Medicine and biotechnology – Laser technologies are used in medicine in diagnostics, therapy and surgery, as well as in biochemical analysis. Students in the chemistry field can contribute to the field of biomedicine by understanding these technologies.

5. Research and Innovation – Laser technology plays an important role in modern scientific research. For chemical researchers, lasers have a wide range of applications in areas such as the synthesis of new materials, nanotechnology, and environmental technologies.

List of used literature:

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2. Sendhil, K., Vijayan, C., and Kothiyal, M.P. (2006) Low-threshold optical power limiting of cw laser illumination based on nonlinear refraction in zinc

tetraphenyl porphyrin. *Opt. Laser Technol.*, 38 (7), 512–515.

3. Kondratenko, T.S., Ovchinnikov, O. V., Grevtseva, I.G., and Smirnov, M.S. (2016) The formation and luminescent properties of hybrid associates of colloidal Ag₂S quantum dots with J-aggregates of trimethinecyanine dye. *Nanotechnologies Russ.*, 11 (1–2), 85–91.