Nd : YAG LASER FOR HOLOGRAPHY

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ABSTRACT

Different possibilities to use photonics, holography and optical processing for nuclear physics has been investigated in our works (1-4). The paper presents the results of the study of time and spatial coherence of Nd:YAG laser (5) and application in holography.

The yttrium-aluminium garnet laser doped with neodynium ions Nd:YAG, the wavelength 1.06 microns operating with gigantic pulses at high harmonics opens up new perspectives in holography due to the use of controllable transparents in data processing systems. The laser can operate at a very high frequency of pulses repetition with Q-modulation, upto 50 KHz, due to a high thermal conductivity of yttrium-aluminium garnet. Power of the gigantic pulses may reach about 100MW with a quality factor as high as 1.5 percent, that is an order of value higher than for a ruby laser.

Coherence properties of the radiation are the basic criterion in applying a laser in holography. The object of the study was a serial laser that allowed us to obtain gigantic radiation pulses in the second harmonic at the length of the wave 0.53 microns at an energy E = 5mJ, length 25 nsec and discrepancy 6mrad (power 200 kW for λ = 0.53 mkm and 1 MW for λ = 1.06 mkm, pulses repetition frequency up to 100 Hz).

Both time and spatial coherence of the radiation has been studied by means of the Michelson interferometer. Generation spectrum width has been measured simultaneously using the Fabry-Perot interferometer. The laser beam passing through a collimator entered the Michelson interferometer with a variable length of one of its arms. It allowed us to vary relative delay from 0 to 100 cm. The interference pattern was recorded either photometrically or by a photomultiplier with the point diaphragm scanned normally to the direction of the interference friges.

The coherence degree $/\gamma/$ was determined by measuring the interference pattern contrast. Although photometering of the interference pattern photos is known to be the simplest technique, nonlinearity of the photoemulsion sensitivity and inaccuracy in measuring the density of the film by the microphotometer result in more than 50 percent error. Direct photometering of the interference pattern by the photodetector is certain to be more occurate. In the experiment, use was made of the storing oscillograph operating in a storage mode to detect maximum and minimum intensities, the interference pattern intensity being averaged by a large number of pulses. The interference pattern shifted due to vibrations and the areas, differing in intensities from pulses to pulses, were detected by the photomultiplier with the diaphragm. Thus, we could see on the oscillograph a generation pulse with a blurred peak whose upper edge represents the maximum and the lower one -- the minimum of the interference pattern.

In Fig.1 the coherence degree $/\gamma/$ is plotted against relative delay of the interfering beams for energies of the pulse 0.5 and 1.5 mJ. For these energies the length of the coherence radiation reduces from 4 to 1 cm. The complicated appearance of the plot of the contrast versus relative delay is due to generation of a large number of longitudinal modes (up to 50), their interference and the effect on the spectrum of an additional resonator with a low Q. The maximum of the contrast corresponding to a double length of the resonator as shown in Fig.1, to the right from the break on the abscissa. The dotted line represents a computed dependence of the interference pattern contrast versus relative delay for the energy in the pulse 1.5 mJ. For the calculations the size of the laser resonator is chosen 50 cm long, the distance between the rear side of the rod and the front mirror is 12.5 cm.

The degree of the spatial coherence was measured by the Michelson interferometer using the technique advanced by Gerke R.R., Denisyuk Yu.N. and Lokshin V.I. /6/. One of the mirrors of the Michelson interferometer being replaced by an angular reflector, the wave from one arm of the interferometer is superimposed with the mirror-reflected wave outcoming from the second arm. Waves emitted at the same angle interfere on the axis of the reflector. Measuring contrast of the interference pattern allows a degree of the spatial coherence to be determined. In Fig.2 the module of the spatial coherence degree plotted versus distance from the axis of the interference pattern is given for three cases : 1 - energy of the pulse 1 mJ, spot intensity distribution is Gaussian ; 2 - energy is 3 mJ, spot intensity is the same ; 3 - energy 3.2 mJ, uniform spot intensity distribution. The dotted line shows the boundary of the image of the rear-side of the rod. The laser can easily be tuned to one of the transverse mode, including the mode 00, that enabled us to obtain a spatial coherence degree, practically equal 1. It is illustrated by curves 1 and 2 where the reduction of the spatial coherence degree up to 0.7 is observed at the periphery of the spot.

Thus, we may draw a conclusion that the laser radiation possesses high spatial energy-independent coherence and energy-dependent time coherence. The length of the time coherente at small energies is sufficient to create holograms of three-dimensional scenes. In case of high energies it is necessary that the relative delay of the reference and signal beams should be reduced to 1 cm. In can easily be accomplished in creating hologram of flat transparents.

The Nd : YAG laser operating in the second harmonic with Q-modulation can successfully be used in holography, for example, in holographic data processing, in particular.

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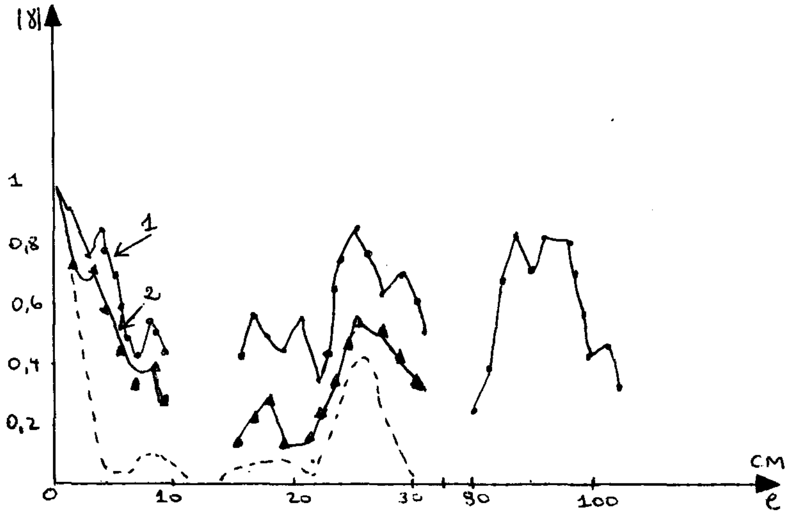

Fig.1.

Time coherence of the Nd:YAG laser

1. $E_p = 0.5$ mJ ; 2. $E_p = 1.5$ mJ.

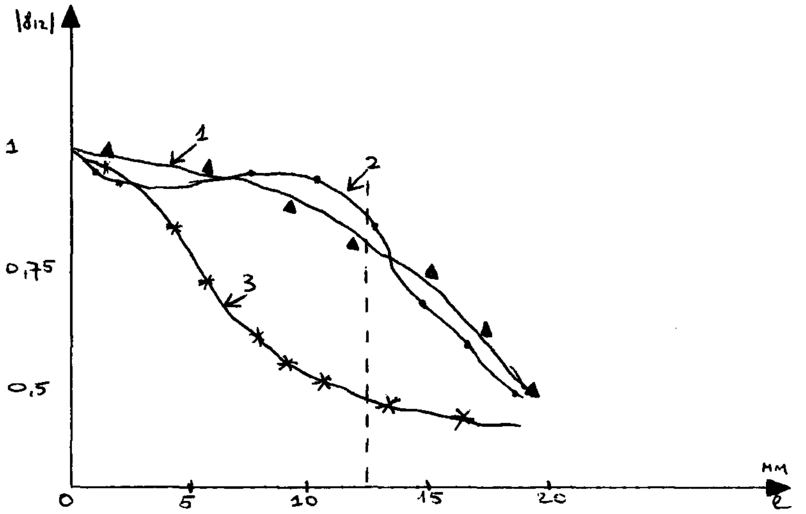

Fig.2.

Spatial coherence of the Nd:YAG laser

1. $E_p = 1$ mJ ; 2. $E_p = 3$ mJ ; 3. E = 3.2 mJ - uniform intensity distribution.