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NEW TYPES OF LASER FIELDS FOR PROCESSING MATERIALS

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Introduction. The periodic structures are widely applied in modern physics. For their creation the periodic light fields are sometimes used. The most known and widely spread example of a periodic light field is the interferential picture as set of the parallel located light bands. This picture arises in the result of superposition of two coherent light waves propagating at some angle each to other. Light fields with cellular distribution of intensity are the fields with precisely expressed local light maxima of intensity having the final sizes and the certain form located in the certain order having in their cross-section. The maxima of intensity are not necessarily distributed periodically in a plane of cross section of a field, however, cross distribution of intensity, as a rule, has some symmetry. The possibility of using cellular fields in practice is determined by the arrangement of light maxima in a cellular field. In this work the method of formation of dynamic coherent light fields of a new types with cellular distribution of intensity ensuring an possibility of the structured influence on materials is described.

The method of shaping cellular fields with the third order axial symmetry. The fields with cellular distribution of intensity can be received by means of a superposition of three light waves (beams) propagating on the same angle to one axis. Optical scheme of the method showed in fig. 1.

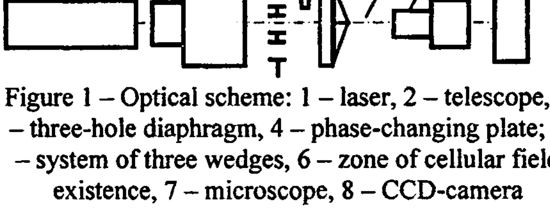
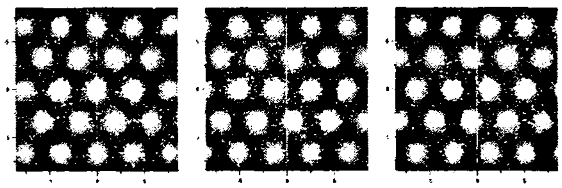


Figure 1 – Optical scheme: 1 – laser, 2 – telescope, 3 – three-hole diaphragm, 4 – phase-changing plate; 5 – system of three wedges, 6 – zone of cellular field existence, 7 – microscope, 8 – CCD-camera

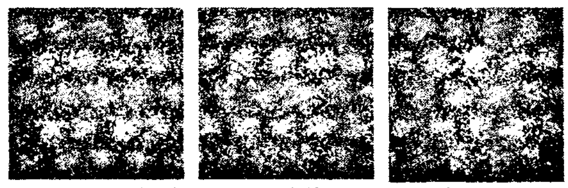
The mathematical model of three beam superposition has been developed and analyzed. It is founded that changing phase of one or more beams one can move cellular interference field in the certain direction. The calculated dynamic field with cellular intensity distribution moved by phase change of one beam with phase-changing unit 4 is presented in fig. 2 (sizes indicated in micrometers). Angle between beam propagation direction and scheme axis is of 10 degrees, wavelength of light is 0.633mkm. The beam phase changing of 360° corresponds to the pattern displacement equal to the one period of interference pattern.



0° и 360°   120°   240°

Figure 2 – Calculated cellular field intensity distribution dependence on phase incursion of one of three interfering beam.

In fig. 3 experimentally obtained field is shown in dependence on phase-changing plate declination angle.



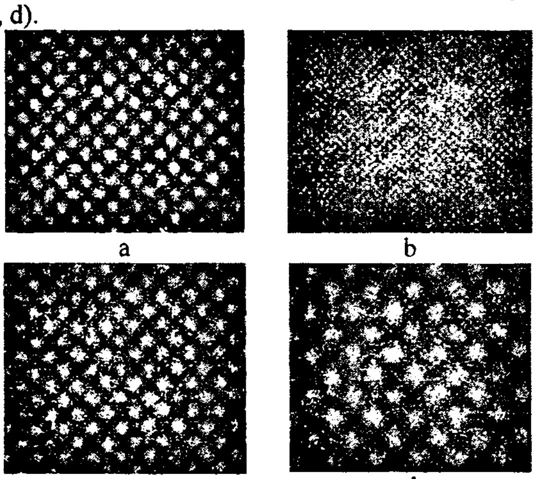
0.178° и 1,602°   0,534°   0,801°

Figure 3 – Intensity distribution in the experimentally realized cellular field

There are some real opportunities for practical application of cellular fields because of their mobility and symmetry. The moved cellular field can be applied for microparticle control and arrangement because of high gradient of the light field. With the help of dynamic cellular field it is possible to carry out laser massage of biological tissues carrying out selective influence on organelles with the certain parameters.

It is known, that therapeutic effect at laser influence is provided mostly by means of two mechanisms. Ones are polarizing and gradient. For strengthening of therapeutic effect by polarizing mechanism for laser massage it is necessary to apply not simply polarized radiation, but polarization rotating could be made. Also prophilometry of bodies having the axial symmetry profilometry and effective laser phoresis are possible with the such cellular fields.

Formation of cellular fields with the forth order axial symmetry. Using various quantity of interfering beams it is possible to shape cellular fields of various kinds. With the help of two crossed bibeams a periodic gradient cellular field, so called quadribeam is formed. In the case when angles at the basis of biprism are identical, the maxima-cells are located on tops of squares in the period. If use biprisms with various angles at the basis, the cellular fields with cells located periodically in the tops of rectangulars are formed. In the case of formation of quadribeam biprisms, crossed under direct angle, can be replaced by a glass pyramid with an angle at the basis, that equals to an angle at the basis of biprism.If collimated light beam incidents to the pyramid quadribeam is formed in the area which is two pyramids connected by their bases. For the first time the longitudinal distribution of intensity has been investigated in quadribeams depending on the divergence of initial light beam incident on the pyramidal optical element. It has been shown that from convergent initial beam, the converrgent quadribeam can be formed, in which size of cells of intensity and distance between them decrease, when longitudinal coordinate increases (fig. 4, a, b). The length of existence of convergent quadribeam is smaller than the length of existence of the quadribeam formed of collimated initial light beam. From the divergent initial beam there can be formed divergent quadribeam of infinite length, and sizes of the cells of intensity and distance between them increases proportionally to the longitudinal coordinate (fig. 4, c, d).



a b

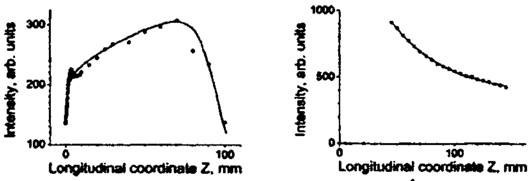
c d

10 mm 100 mm

Figure 4 – Intensity distribution in the converging (a,b) and diverging (c,d) quadribeam depending on the distance from the pyramid (enlarged)

Length of the existence area of the converging quadribeam is less than existence area of the quadribeam formed from collimated aperture-limited initial light beam (fig. 5, a). Existence area of the diverging quadribeam is very lengthy (fig. 5, b).

These features of divergent quadribeams make them very useful for laser probe of atmosphere and hydrosphere. There are some real possibilities for practical application of quadribeams, because of their symmetry.



a b

Figure 5 – Longitudinal distribution of average intensity in cross-sections of converging (a) and diverging (b) quadribeams

The first one is for formation of periodic microstructures, and also for their control. For example in the case, when the checked sample has the form of a plate with the periodically located apertures, and it is necessary to check presence and quality of apertures simultaneously on all surface. The period of cells of quadribeam then is selected to be equal or multiple to the period of controllable microstructure.

The second opportunity for application of cellular fields with periodically located cells in tops of rectangulars is laser prophilometry of outside and internal surfaces of products having the form of parallelepiped. Especially perspective looks prophilometry and control of the covering of internal surfaces of pipes rectangular (in the specific case square one) section.

Conclusion. The methods of formation of gradient light fields of a cellular type are investigated and developed. Due to the special configuration of distribution of intensity the given fields can be applied for creation of dynamic and static structures with the same configuration in various materials, and also for laser processing of materials. The special practical value can have the cellular fields representing the superposition of three and four light beams. They can be applied both for manufacturing of periodic microstructures, and for control of microparticle ansambles. Besides quadribeams are rather perspective for prophilometry of bodies in the form of parallelepiped. The dynamical light beams, formed with the help of rotating biprisms, may be rather useful for laser therapy or for thermal treatment of various materials including metals.

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