TOPOLOGICAL ERGODIC DYNAMICS OF OPTICAL SINGULARITIES IN LASER-INDUCED SPECKLE FIELD FOLLOWING “OPTICAL DAMAGE” OF PHOTOREFRACTIVE LINBO3: FE CRYSTAL

Marat Soskin, Vasiliy Vasil'ev

Institute of Physics, Ukraine

It's known that optical fields can possess optical singularities (OS) [1]. Elliptic polarized field possess left (right) optical vortices (OV) accompanied by right (left) polarized C points. OVs appear due to full destructive interference of surrounding virtual sources in a wave field. C points possess forms of star (S), monstar (M), lemon (L). They orient axes of surrounding ellipses. The surfaces of long/short axes of polarization ellipses possess form of direct (elliptics, E) and skew (hyperbolics, H) cones with Poincaré indices +1 (0) and common vertices in a C point. As a result, next six combinations exist: E(S), E(M), E(L), H(S), H(M), H(L) [2]. Illumination of photorefractive crystal LiNbO3:Fe by He-Ne laser initiates its "optical damage" which creates the developing generic elliptically polarized speckle-field full with optical singularities which are born and annihilate by pairs. Its regularities were investigated firstly by technique of high-speed stokes-polarimetry (20 ms for each component). Incident laser beam was blocked during all needed elements readjustments. 15s interval between cadres guaranteed detailed investigation of speckle-fields dynamics. To the end of one-hour illumination “optical damage” process was saturated practically.

It was shown that evolution of induced singularities proceeds mainly throw unlimited chain reactions which differ principally from nuclear and chemical chain reactions due to conservation of singularities total topological charge. Their space-time structure is strictly fixed. They consist from system of connected links with born moving and annihilated singularities pairs. Their space-time structure is strictly mandated by singular optics lows. The neighbor links are connected by trajectories of H(S) points only with alternating top and bottom positions in the links chain, what secures fulfillment of topological charges conservation low during reactions.

It exist simultaneously loop reactions in nearly tenth fraction of reactions. They start form C points pair as usually but annihilate shortly. Loop reactions don’t take part in development of induced singularities system and can be qualified as “topological impurities”.

Measured set of all possible combinations for C points forms allowed define probabilities of their realization. It appeared that they coincide completely in the errors limits with the values measured for stationary speckle-field [3] and theoretical calculated for speckle-fields with Gaussian statistics [4]. That witnesses the ergodicity of random Gaussian statistics speckle-fields induced by various techniques [5].

1. J.P. Nye, Natural Focusing and Fine Structure of Light (IOP Publ., Bristol, 1999).
5. P. Walters, An Introduction to Ergodic Theory (Springer, 1982)