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Conversions of optical angular momentum in the processes of sum-frequency and second-harmonic generation from the surface of the isotropic chiral medium with nonlocal nonlinear response.

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Optical angular momentum (AM) has been a hot topic of investigation since early nineties [1]. Conventionally, the AM of a paraxial light beam is separated into two parts: spin and orbital. The first one is an intrinsic feature of a light field related to its polarization state, while the second is a more extrinsic one and originates from the transverse flow of the Poynting vector of the beam and the vortices of this flow. As a rule, nonlinear optical processes of frequency conversion are achieved when the input and output beams have well defined polarization state and mainly the orbital angular momentum conversions is studied. However, it has been repeatedly shown that, for example, sum-frequency and second-harmonic generation can be performed even in isotropic chiral medium in the case when its optical response is nonlocal in space. It was shown in [2] that the interplay between spin and orbital parts of the AM of input beams plays a key role in this kind of processes. The paper [2] only considered the part of nonlinear signal which was generated during the propagation of the input beams in the bulk of the medium, leaving the surface effects out of the scope of investigation. The present research is an attempt to account for the surface effects in these processes and to see how the AM of the light beams is transformed in them.

We considered the geometry of normal incidence of the input beams. All mentioned nonlinear processes were earlier shown to be forbidden in plane wave approximation in a given geometry. However, real laser beams, especially tightly focused ones, have a longitudinal components of their electric field as well. The interaction of transverse and longitudinal fields provides a sum-frequency generation even in the case when all the signal comes from the bulk response of the medium. We have shown analytically that the reflected signal beam consists of the modes, the angular momentum of which is strictly related to the AM of the input beams. Neither sum spin momentum, nor sum orbital momentum projections on the normal to the medium surface are conserved, but only the total AM (the sum of spin and orbital) is. These rules are not broken even if we take into account the surface response of the medium, the symmetry of which is much lower in comparison with its bulk. The very same rules are applicable for the process of second-harmonic generation driven by the nonlocal response of the medium, which, in its turn, also has more complicated form of its material tensor.

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References

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