

Enhancement of Efficiency Extracavity Conversion of Radiation to Harmonics - A Method of Spatial Walk-Off Compensation in Crystals KTP and LBO

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Experimentally demonstrated is, that the spatial compensation of the second harmonics radiation walk-off with respect to beam of initial frequency, in the process of conversion into the third harmonics within sequentially placed LBO crystals, enables to increase conversion efficiency into the third harmonic - more than 3 times.

At third harmonic generation important is the ratio between radiation intensity at the initial frequency and one at the second harmonic. For effective transformation of radiation into the third harmonic this ratio should satisfy $I(\omega)/I(2\omega)=2/1$, where $I(\omega)$ and $I(2\omega)$ - intensities of radiation of the initial frequency and of the second harmonic, correspondingly. Thus it is necessary to control conversion rate of the initial radiation into the second harmonic and residual portion of intensity of initial radiation. This relation directly depends on efficiency of transformation of radiation in nonlinear medium, and also on quality of nonlinear elements, spatial & power performance of laser radiation (beam quality, polarization).

At present, nonlinear crystals KTP and LBO have one of the best performance for transformation of radiation into harmonics, however, in the traditional optical scheme of extracavity transformation they were not able to provide required efficiency of transformation for low energy pulses. Efficiency of the second harmonic generation was maximum of 22% at pulse frequency 20 kHz for laser generation in range some hundreds mWs. Peak efficiency of conversion of radiation into the third harmonic thus was 1.5%.

Because of nonlinear crystals (specifically biaxial crystal KTP) at transformation into the second harmonic yield walk-off of the second harmonic beam with respect to initial one, that affects third harmonic generation, which efficiency of transformation is sensitive to all parameters of radiation of the initial and second harmonics. The method of transformation in sequentially placed crystals with spatial compensation of the walk-off enables to solve, partly, the problem of spatial dispersion of media. Its essence is that for non-axial components of radiation the phase difference between two waves resulted in the first crystal may be compensated in the second one which is turned around the axis of radiation at 180° .

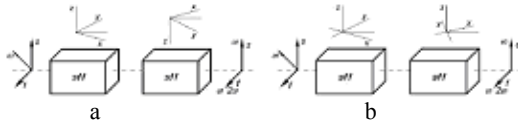


Fig. 1. Optical scheme of interaction in sequentially placed biaxial crystals.

angle of 180° (Fig. 1.a). In this arrangement axes z of crystalloptic coordinate systems of both crystals are directed oppositely, similar to a case of the single-axis crystals. In the second variant (Fig. 1.b) the axis of the first crystal is oriented with respect to direction of phase synchronism at an angle φ , and in the second crystal - at an angle $(-\varphi)$. Here, axes z of both crystals are codirectional.

Application of the method of spatial walk-off compensation in nonlinear elements KTP and also in crystals LBO was proposed and is experimentally demonstrated at transformation of radiation into the third harmonic. In the optical scheme of radiation frequency conversion the second crystal KTP and LBO turned with respect to the first one at an angle of 180° according to Fig. 1a. In the case of two KTP crystals system, conversion efficiency into the second harmonic increased 2 times. Use of the proposed method for system of crystals LBO enabled to increase efficiency of the third harmonic generation more than three times. As a result efficiency of radiation conversion into the second harmonic at modulation frequency of 20 kHz and pulse duration of 5 ns was 55%, and into the third 5%.

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