Reply to Comment on "Generation of 10^{11} contrast 50 TW laser pulses"

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Received July 31, 2006; accepted July 31, 2006;
posted July 31, 2006 (Doc. ID 73592); published September 25, 2006

We show that the Comment of Albert *et al.* [Opt. Lett. **31**, 2990 (2006)], although being only marginally relevant to the content of the original paper [Opt. Lett. **31**, 1456 (2006)], misinterprets our results and leads to a wrong conclusion: that the rotation of the second crystal in the double-crystal scheme is unimportant. On the contrary, it follows from the Comment itself as well as from our experiment that the crystal rotation is the main factor in improving the efficiency. © 2006 Optical Society of America

OCIS codes: 140.7090, 140.3280, 140.3590, 320.1590, 320.5540, 230.5440.

We begin our response to the Comment by Albert *et al.*[1] pointing out that a detailed investigation of the nature of the improved efficiency of the two-crystal arrangement of XPW generation in comparison with a single-crystal arrangement was never a subject of the original Letter[2] (only ~2% of the Letter's text is on this matter). The following are the main results of the Letter.

"We demonstrate what we believe to be the highest-contrast (10^{11}), multiterawatt, chirped-pulse amplification (CPA) Ti:sapphire laser by applying the modified cross-polarized-wave (XPW) generation method. This method produces a contrast improvement of 3 orders of magnitude using microjoule input energy. Microjoule energy can be achieved by direct amplification without the complications of a double CPA system. The 10^{11} contrast is sufficient for experiments on high-damage-threshold solid targets with focused intensities up to 10^{22} W/cm^2….

In conclusion, we have demonstrated that pulse cleaning based on XPW generation in two BaF_2 crystals yields a 10^{11} contrast ratio for a 50 TW laser system. Dispersion compensation and direct amplification of the oscillator output are necessary for efficient XPW generation using only microjoule energy. Two BaF_2 crystals placed in series increase the XPW conversion efficiency by a factor of 3 compared with a single crystal, yielding 3 orders of magnitude of contrast improvement."

Of these results, the claimed improvement of efficiency of the two-crystal configuration compared with a single crystal is the only one that has anything to do with the content of the Comment. We suggested in the Letter that a possible explanation for experimentally observed improvement of efficiency when we rotate the second crystal relative to the first one could be a compensation of experimentally observed rotation of polarization ellipse in the first crystal. The angle of ellipse rotation in the conditions of our experiment was experimentally measured to be about 10°. This value is higher than 4°, which the authors of the Comment claim the maximum value should be. (They are not consistent on this claim: in Fig. 2 of the Comment they rotate the second crystal by 7.5° to maximize the efficiency!) Rotation by 10° is quite enough to affect the efficiency, according to the efficiency curve published previously by the authors of the Comment themselves.[3] By rotating the second crystal (by the same angle as the rotation of the ellipse in the first one), the orientation of the second crystal relative to the polarization ellipse is optimized for the highest efficiency.

The authors of the Comment are also not consistent on the issue of whether the crystal rotation improves the efficiency. For example, at the beginning they state that "polarization rotation does not contribute to the XPW generation," and later that "rotation is not the main decisive factor that influences the double-crystal efficiency" and that adjustment of the optimal distance is of prime importance. As a matter of fact, it follows even from their explanation (Fig. 2 of the Comment) that the rotation provides most of the efficiency increase (>100% at 6 cm separation), while simply changing the distance at the same angle for both of the crystals (curve with 22.5°) gives only an ~10% increase in efficiency.

We did not discuss the optimal distance issue in the Letter. It is quite obvious that there is an optimal distance if crystals are placed on both sides of the focus. The simplest explanation of that is that if the crystals are too far from the focus the intensity becomes too low for efficient generation of light with perpendicular polarization. If they are too close to the focus, then the crystals could be damaged, or undesirable effects (such as white-light generation) will limit the efficiency. The complicated explanation for the existence of optimal distance offered by the authors of the Comment is not likely to hold and here is why.

The authors of the Comment "assumed" in their analysis of the Letter that the distance between two crystals in our experiment was ~0.75 mm, which was placed at a point (in Fig. 1 of the Comment) that matches their results for the optimal distance; however, our experimental distance was 4 mm. It follows from their own analysis (Ref. 2 of the Comment) that if the distance between the crystals exceeds the optimal distance calculated by them by a factor of

0146-9592/06/202993-2/$15.00

4/0.75–5.3 there should be no improvement of efficiency, and there could be even a reduction.

Without knowing all the details of the calculations it is hard to pinpoint the discrepancies of the proposed theory. One of the obvious problems in Ref. 2 of the Comment is a neglect of the effect of the fundamental wave on the XPW through cross-phase modulation as well as other nonlinear phenomena.

In conclusion, we do not agree with the Comment for the following reasons:

1. The rotation is the major factor affecting the efficiency—this follows not only from our results but from Fig. 2 of the Comment.

2. The value of ellipse rotation is significant: the rotation angle (10°, as we measured experimentally, or even 7.5°, used by the authors of the Comment in their calculation in Fig. 2 is significantly larger than the "maximum" value of 4° that the authors of the Comment claim it should be less than.

3. The explanation of the improved efficiency in our experiment offered by the authors of the Comment is wrong because in their analysis of our experiment they assumed a wrong value for the separation distance.

4. The whole subject is only marginally relevant to the content of the original paper.

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References

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