LASER IMPROVEMENTS

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Description of the main idea:

It is a well accepted, that an OPO based on a Ring oscillator is a preferable design that enables high energy with relatively good beam quality compared to linear OPO. Its geometry enables collinear pumping while significantly reducing optical damage risk to pump laser. However, the existing state of the art method that uses an oscillator (Ring) OPO together with a parametric amplifier , is limited in the sense of maximum beam quality that may be achieved at given signal power .

The reason for this limitation, is expressed in the following relation that connects signal beam M^2 (proportional to beam product parameter) to OPO cavity parameters:

$$M^2 = \frac{a_{cavity}^2}{\lambda_{signal} \cdot \sqrt{L_{cavity} f_{thermal}}}$$

Where a_{cavity} is the aperture of the OPO (effectively, **a** is pump beam diameter) λ_{signal} is the signal wavelength , L_{cavity} is the length of the OPO oscillator and $f_{thermal}$ is the thermal focal length. This effect occurs due to absorption of idler wavelength in the crystal (KTP, usually) where $f_{thermal} \propto \frac{1}{P_{abs}}$ and P_{abs} is proportional to signal power so that thermal focal length becomes smaller as signal energy increases. This at turn means, that higher signal energies correlate to larger M^2 value (higher beam products).

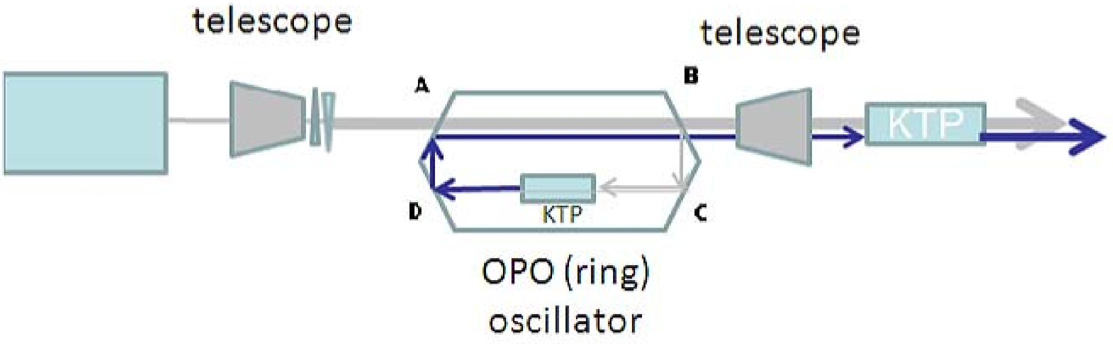
One may think to improve beam quality by decreasing pump beam diameter. This option is, however ,strongly limited by the damage threshold values of the nonlinear crystals. Its damage threshold generally, have the lowest values among all other components in the OPO .

Other option may be to try longer OPO cavity designs. As can be seen from equation1 large L_{cavity} also decreases M^2 and should improves beam quality while preserving beam quality. Although this solution reliefs the damage threshold problem, it does not change the actual working point dramatically , because to get a factor of two improvement in beam quality one needs a cavity four times longer, resulting in a less efficient OPO.

Generally , it seems that there is a strong limitation on beam product in case highly energetic signal pulse is required.

Some investigations were done with unstable OPO resonators, that show good beam product even in case of high signal pulse energy. However, this method seems to suffer from Opto-Mechanical sensitivities and therefore is not very suitable for military applications.

Therefore, what we suggest is a new scheme according to which the crystal within the OPO cavity is not directly exposed to highly energetic pump beam. Instead, it is placed at the OPO cavity at the branch not along the transmission of the pump beam (figure 1).



Explanation:

The laser pump source beam is de-magnified to obtain small diameter pump beam which is safe for the mirrors (usually the intensity safe for such components is around 1-2 GW/cm^2 (which is about four times larger than KTP damage threshold).

The OPO is comprised of input and output mirrors (A and B) and from reflective mirrors (C and D).

Usually, the output mirror is coated so as to enable maximum pump radiation go through the OPO to take part in the amplification process at the parametric amplifier.

At the same time ,parametric oscillation process is initiated at the OPO crystal (the crystal within the oscillator).

The main innovation in the following ,is the allocation of the OPO crystal, not in the AB branch which is in the same beam line as the laser pump beam (which jeopardizes the OPO crystal) and the parametric Amplifier crystal, but rather in the CD branch which is away from the main pump beam.

Nevertheless, for oscillation to begin some pump energy must be directed towards the OPO crystal. This is done simply by an appropriate dichroic coating that enable a given portion of the high intensity pump beam to be deflected by the output mirror B towards the OPO crystal. At the same instance , the rest of energy (which is generally much higher) is directed towards the Amplifier crystal. This realization has the following advantages on conventional OPO-OPA configurations:

1) Pump beam radius existing the OPO may be very small compared to conventional layouts. This is a result of the fact that the OPO crystal is not exposed to the full intensity of the beam, but to small portion of it. Such condition supports relatively high quality beams due to small $f_{thermal}$ and a_{cavity} which are a result of small pump beam diameter and energy, correspondingly.
2) Pump beam energy entering the Amplifier may be relatively higher than in conventional layouts, as beam quality is already fixed by the beam created in the OPO oscillator. Optical damage risk may be extensively removed by simply introducing a telescope which magnifies both signal and pump beam so as to impinge the Amplifier with intensity suitable for conversion but lower compared with damage threshold intensity.
3) The process is achieved with high efficiency due to the capability of selecting an oscillator which has low oscillation threshold (directing optimal pump power towards the Amplifier crystal.

The above described idea may be exploited in several realization including Laser Designators, Active illumination sources ,DIRCM etc.

The common demand for these applications is the need for efficient , high energy, high beam quality OPO process that may be realized in a military environment, which requires very good reliability and opto mechanical stability.