Peculiarities of second harmonics generation with linearly varying wave-number mismatch along a nonlinear crystal

K. Regelskis, J. Želudevičius, V. Žvirblytė
Department of Laser Technology
Center for Physical Sciences & Technology
Vilnius, Lithuania

Abstract—We investigated the second harmonics generation when a constant gradient of the wave-number mismatch was imposed along a nonlinear crystal. Behavior of the complex amplitude of the second harmonic signal was geometrically visualized by means of the Cornu spiral. Phase-matching bandwidths and conversion efficiencies of the second harmonics generation in low-conversion approximation with and without wave-number mismatch gradient are compared.

Keywords—Optical harmonic generation; Nonlinear optics; Nonlinear optical devices.

I. INTRODUCTION

Several theoretical and experimental studies have shown that in many nonlinear systems, the frequency conversion efficiency and bandwidth could be increased by varying the properties of the medium along the direction of wave propagation [1, 2]. In our previous work we have shown, both numerically and experimentally, that the spectral-bandwidth of the second harmonics (SH) generation can be significantly increased by imposing a constant temperature gradient along a nonlinear crystal [3]. In this contribution we further investigated peculiarities of second harmonics generation when a constant wave-number mismatch gradient is imposed along the nonlinear crystal.

II. RESULTS AND DISCUSSION

In the low-conversion approximation for a monochromatic wave, the variation of the SH amplitude along the propagation direction $z$, when the constant wave-number mismatch gradient is imposed along a crystal, is proportional to the function

$$F(z) = -C(\zeta (p - z / L)) + i S(\zeta (p - z / L)),$$

where $S(x)$ and $C(x)$ are the sine and cosine Fresnel integrals, $|\zeta|$ is the Cornu spiral length, $L$ is crystal length. The simultaneous parametric plot of the real and imaginary parts of the function $F(z)$ is the Cornu spiral (Fig.1(a)). Starting from beginning of the nonlinear crystal ($z = 0$) the Cornu spiral starts to unwind by rotating around the center of the hole (C1) until it reaches the kink point ($p = z / L$), where perfect phase matching ($\Delta k(pL) = 0$) is achieved. After passing the kink point, it again starts to wind around the second centre (C2) of the hole. The displacement vector $M$ represents the length and direction of the shortest straight path from the initial to the any other position on the Cornu spiral. The length of the displacement vector is equal to $|F(z) - F(0)|$ and proportional to absolute value of the SH amplitude. When the conversion efficiency of the second harmonics generation remains constant, the ratio of the phase-matching bandwidths (without and with the constant wave-number mismatch gradient imposed along the crystal) is proportional to the length of Cornu spiral $|\zeta|$. In other words, the length of the crystal should be proportionally increased with extending of the phase matching bandwidth to remain constant conversion efficiency.

In the experiment, a custom-designed crystal oven with two independent heaters at opposite ends of the crystal was used [3]. The SH generation efficiency as a function of the crystal temperature was recorded by varying central temperature at the midplane of the 30 mm long LBO crystal with a fixed temperature difference between crystal end faces ($\Delta T = 20 ^\circ C$). Achieved experimental results were in agreement with theoretically estimated ones (Fig. 1(b)).

![Fig. 1. Cornu spiral (a); SH generation efficiency as a function of the crystal central temperature (b).](image)

REFERENCES

