Per-channel nonlinear-frequency conversion in optical poling of isotropic medium

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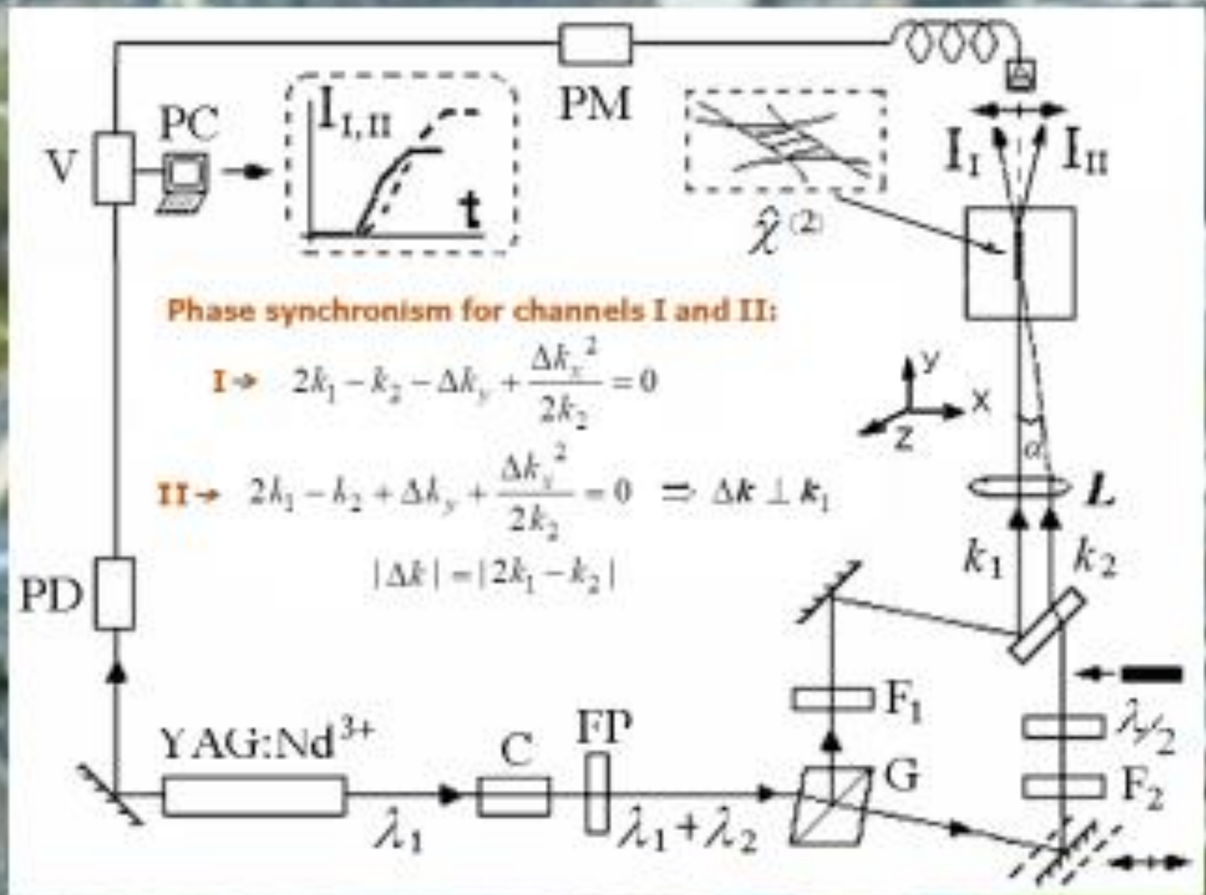
The signal multi-channel optical sources are important for the investigations of the different micro-objects and for the applications in areas of the modern optoelectronics and bio-photonics. For example, the various light micro-sources are necessary for the observation of high spatial resolutions and also for the steady-stable coherent control in real-time during the process of the organization of the high-ordered molecular systems. Experimental technique of the optical poling wherein gives possibilities for creation in isotropic media of the optically micro-structured elements with various properties which can used for the transformations and redistributions of pulsed light signals. In this work using the example of considering the nonlinear optical process of doubling the frequency of the pulsed laser radiation in case of the optical poling of an isotropic medium it's shown the possibility for the simultaneous and phase-matched separation of the output signals of light over the paired distribution channels. The optimal conditions for the selection of the beams of light signals are analyzed and the spatial and other characteristics of the channel-by-channel transformation are studied. The work was carried out as the part of tasks of the Russian State Project FWGW-2021-0012.



Experimental set-up for investigations of per-channel nonlinear-frequency conversion in volumetric all-optical poling

Calculated per-channel signals of optical fields for nonlinear process of frequency doubling by volumetric all-optical poling

$$E_{I,II}(r) = \frac{A\exp[-d_1(2k_1-k_2\mp\Delta k_y+\Delta k_x^2/(2k_2))^2]}{\sqrt{f_1 f_2}\sqrt[4]{(1+D_1^2)(1+D_2^2)}}\exp[ik_2 y]\exp[-\frac{z^2}{4f_1(1+D_1^2)}-\frac{z^2}{4f_2(1+D_2^2)}]\times$$

$$\times\exp[-\frac{x(y\pm x\Delta k_x/k_2)(f_3(f_2)-f_3^2k_2^2)}{4f_2(1+D_2^2)}]\exp[-ik_2(\frac{xf_3(2f_2)+(y\pm x\Delta k_x/k_2)f_3^2(8f_2^2)}{1+D_2^2})]\times$$

$$\times\exp[\frac{iz^2D_1}{4f_1(1+D_1^2)}+\frac{ix^2D_2}{4f_2(1+D_2^2)}]\exp[-i\,\mathrm{arctg}(\frac{\sqrt{(1+D_1^2)(1+D_2^2)}+D_1D_2-1}{D_1+D_2})],$$

$$A = \frac{(\tilde{\chi}^{(3)}_{yzx}E_1E_2)ik_2\pi^2a_1^2e^{-i\omega t}}{2\sqrt{8}\pi e_1\sin\alpha},\; f_1 = \frac{a_1^2}{12}+\frac{d_1}{k_1}(2k_1-k_2\mp\Delta k_y+\frac{\Delta k_x^2}{2k_2}),\; f_2 = f_1+d_1(d_1\mp\frac{\Delta k_x}{k_2})^2,$$

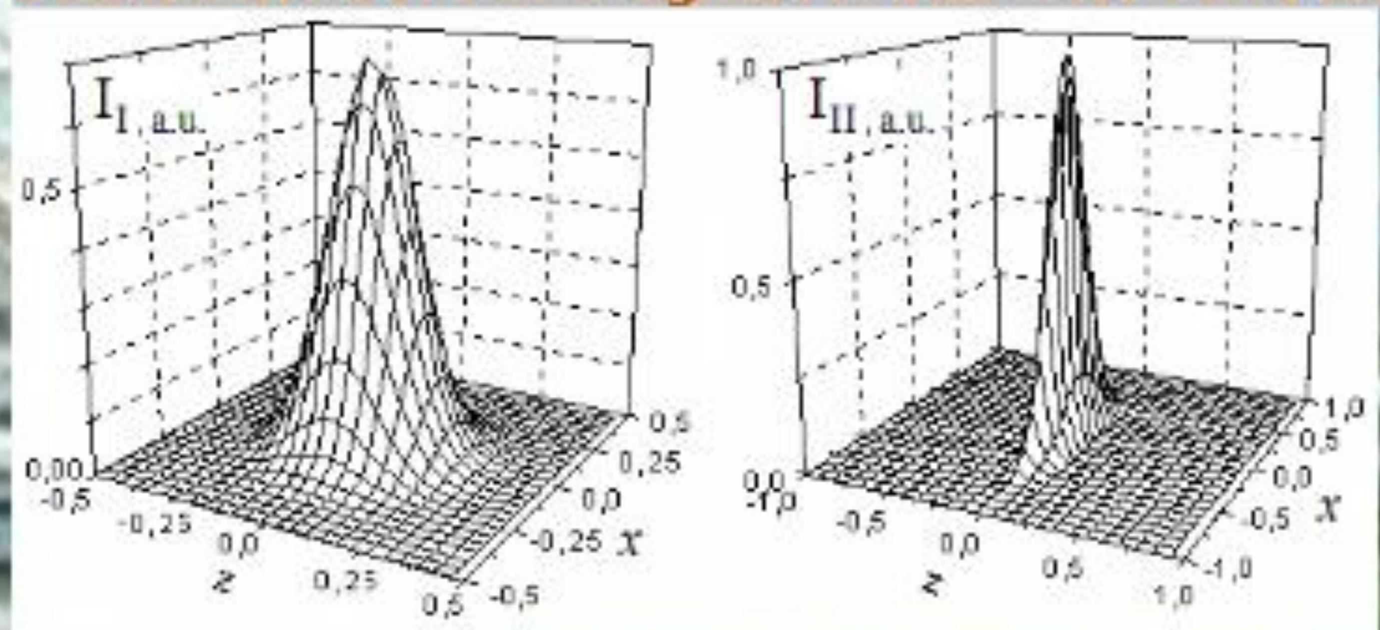
$$f_3 = \frac{2d_1}{k_2}(d_1\mp\frac{\Delta k_x}{k_2})(2k_1-k_2\mp\Delta k_y+\frac{\Delta k_x^2}{2k_2}),\; D_1 = \frac{y}{2k_2f_1},\; D_2 = \frac{y}{2k_2f_2},\; d_1 = \frac{3a^2}{8\sin^2\alpha},\; d_2 = \frac{\sin\alpha}{3},$$

$$y = y(1-\frac{\Delta k_x^2}{2k_2^2}-\frac{\Delta k_x^4}{8k_2^4})\mp x\frac{\Delta k_x}{k_2},\quad x = x(1-\frac{\Delta k_x^2}{2k_2^2})\pm y\frac{\Delta k_x}{k_2},\quad \tilde{\chi}^{(3)}_{yzx} = \chi^{(3)}(E_1\delta_{yz}+2E_1\delta_{yx}).$$

Nonlinear conversion efficiency for channels I and II:

$$\eta_{I,II} \approx \frac{24\pi^6}{b_{I,II}n_1^2n_2}\frac{1}{c}(\frac{\chi^{(3)}E}{\lambda_1}L)^2\frac{P_1}{\pi a_1^2},\quad b_I = \sqrt{3},\; b_{II} = 3,\; L \approx \frac{a_1(\sqrt{2}+2)}{\sin\alpha}.$$

Distributions of beam signals in channels I and II:



Exp. results: signal in channel II has more big value but 2D-distribution has asymmetrical view, tensoral characteristics are coincident with theory.

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