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二周期PPLN導波路を用いた高効率偏光量子もつれ光子対生成

Efficient polarization-entangled photon generation using two-period PPLN waveguides 東北大学電気通信研究所¹,沖電気工業(株)研究開発センタ²

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Entangled photon sources are of essential importance in quantum info-communication technologies. The most established method so far used for the entangled photon generation is spontaneous parametric down-conversion (SPDC) in nonlinear crystals, such as LiNbO₃ (LN) and KTiOPO₄ (KTP). With the technique of quasi-phase matching together with waveguide structure, PPLN (periodically-poled LN) and PPKTP has been used as efficient sources of entangled photons at a telecom band. We developed a device for highly efficient entangled photon generation utilizing type-II PPLN having two poling periods in a single waveguide structure; the technique has recently been demonstrated in bulk PPLN [1]. The device consisted of ridge waveguides with two sequential poling periods (Λ_A and Λ_B) in each waveguide (Fig. 1). The first (second) part emits photons with the wavelength λ_1 in the H(V)-polarization and λ_2 in V(H). Thus, the generated state is polarization-entangled so that

$$\left|\psi\right\rangle = \frac{1}{\sqrt{2}} \left(\left|\mathcal{H}\right\rangle_{1}\right| \mathcal{V}_{2} + \mathcal{E}^{\theta} \left|\mathcal{V}_{1}\right| \mathcal{H}_{2}\right). \tag{1}$$

In the experiment, we used a waveguide with $\Lambda_A=8.65 \ \mu\text{m}$ and $\Lambda_B=8.72 \ \mu\text{m}$, which emits photons in $\lambda_1=1528 \ \text{nm}$ and $\lambda_2=1548 \ \text{nm}$ with a CW pump ($\lambda_p=796 \ \text{nm}$) at 42 °C. We observed the generation efficiency of 1×10⁷/pairs/mw/sec. After separating photons of λ_1 and λ_2 with a dichroic mirror and a pair of band-pass filters (FWHM=0.2 nm), we compensated the phase θ in Eq. (1) to $\theta=0$ with a Soleil-Babinet Compensator. The results of polarization correlation measurements for H-V and ±45° bases are shown in Fig. 2. We observed a high visibility (0.92) polarization correlation in both bases, indicating the high degree of entanglement in the generated state. We also carried out the state tomography of the generated polarization state, which exhibited the fidelity F=0.91 to the ideal Bell state. This work was supported by MIC SCOPE No. 121806010.

[1] W. Ueno et al., Opt, Exp. 20, 5508-5517 (2012)



Fig. 1. Sketch of the PPLN waveguide used in the experimentsa.



Fig. 2. Results of the polarization correlation measurement.