Comment on "Dispersion-Independent High-Visibility Quantum Interference in Ultrafast Parametric Down-Conversion"

Recently Atatüre *et al.* claimed to "recover" high-visibility quantum interference in femtosecond pulse pumped type-II spontaneous parametric down-conversion (SPDC) using neither spectral postselection nor a thin nonlinear crystal [1]. We show in this Comment that the interpretation of experimental data as well as the theory presented in Ref. [1] are incorrect and discuss why such a scheme cannot be used to recover high-visibility quantum interference.

Let us first discuss the theory presented in Ref. [1]. Equation (8) is incorrect and, consequently, so is Eq. (10). According to Eq. (10), the coincidence counting rate should have a $\sin^2(\theta_1 + \theta_2)$ modulation with 100% visibility for *arbitrary angles of* θ_1 *and* θ_2 when $\tau = 0$. As we shall see in our experiment, this is not so. This is because, for arbitrary θ_1 and θ_2, there should be two more terms, i.e., $\cos(\pi/4 - \theta_1)\sin(\pi/4 - \theta_2)[\mathcal{A}(t_1, t_2 + \tau) - \mathcal{A}(t_2 + \tau, t_1)] - \sin(\pi/4 - \theta_1)\cos(\pi/4 - \theta_2)[\mathcal{A}(t_1 + \tau, t_2) - \mathcal{A}(t_2, t_1 + \tau)]$, which cannot be ignored in Eq. (8). These two terms have no overlap if $\tau = 0$. This will reduce the visibility of the polarization correlation at arbitrary θ_1 and θ_2, except at the H and V settings of the analyzers.

To demonstrate that Eq. (10) in Ref. [1] is incorrect, we performed an experiment which is identical to Fig. 1 in Ref. [1] in which the polarization correlation is measured. When $\theta_1 = 90°(H)$ or $0°(V)$, high-visibility modulation is observed as θ_2 is varied [see Fig. 1(a)]. This is what Atatüre *et al.* observed in Ref. [1]. However, at $\theta_1 = 45°$, the visibility is immediately reduced to 16% [Fig. 1(b)].

This means that the "X-Y delay" at $\tau = 0$ does not recover the quantum interference as the authors expected. In fact, one can observe the same interference pattern when the X-Y delay is absent. To show this, we removed the X-Y delay from the setup, set $\theta_1 = 90°$, and varied θ_2. The "visibility" is $\approx$100% [see Fig. 1(c)]. By setting $\theta_1 = 45°(H)$ and varying θ_2 again, as evident from Fig. 1(d), the visibility is as low as 16%. This demonstrates that the X-Y delay has no net physical effect when $\tau = 0$. This also shows that what is observed in Ref. [1] is not quantum interference. It simply shows that the signal is V polarized and the idler is H polarized.

These data clearly show that $|V\rangle|H\rangle$ has not been transformed to $|X\rangle|X\rangle - |Y\rangle|Y\rangle$, as the authors claim [Eq. (10)]. In fact, such a "cascaded transformation of the two-photon state" cannot occur unless proper longitudinal compensation is made first [2]. Therefore, it is obvious that this type of scheme cannot be used to recover quantum interference. We also note that Fig. 3 in Ref. [1] might lead to confusion since readers might mistakenly consider it to show space-time interference. In fact, only polarization correlation measurement is observed in Ref. [1] at a fixed angle $\theta_1 = 0°$.

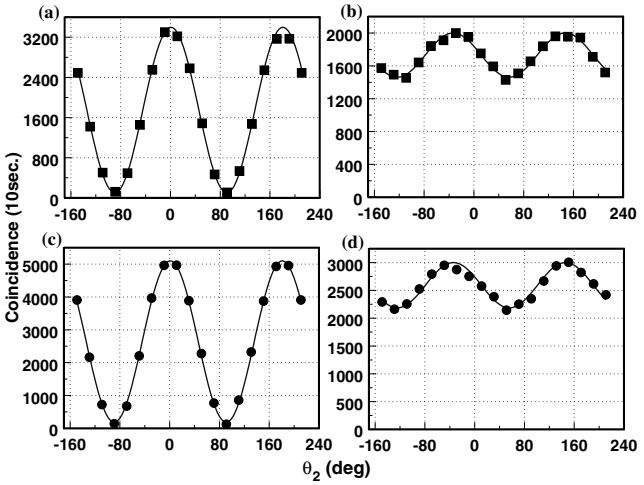

FIG. 1. Experimental data. With X-Y delay ($\tau = 0$): (a) $\theta_1 = 90°$, (b) $\theta_1 = 45°$. Without X-Y delay: (c) $\theta_1 = 90°$, (d) $\theta_1 = 45°$.

It is true that Atatüre *et al.* made some type of polarization state transformation of biphotons. Certainly these transformations are related to τ and the pump pulse duration (for a general description of polarization transformation of biphotons, see Ref. [3]). It, however, has nothing to do with the "recovery" of quantum interference as they claim.

In conclusion, we have experimentally and theoretically shown Atatüre *et al.*'s claim to be in error. Neither the experimental data nor the correct theory support their claim. Finally, we would like to mention that we have recently developed a new method of generating entangled photon pairs pumped by femtosecond pulses which shows true high-visibility quantum interference [4].

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[1] M. Atatüre, A. V. Sergienko, B. E. A. Saleh, and M. C. Teich, Phys. Rev. Lett. **84**, 618 (2000).
[2] M. H. Rubin, D. N. Klyshko, Y. H. Shih, and A. V. Sergienko, Phys. Rev. A **50**, 5122 (1994).
[3] A. V. Burlakov and D. N. Klyshko, JETP Lett. **69**, 839 (1999).
[4] Y.-H. Kim, S. P. Kulik, and Y. H. Shih, Phys. Rev. A **62**, 011802(R) (2000); quant-ph/0007067.

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