# Supplementary information: Fano interference of photon pairs from a metasurface

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### Supplementary Note 1: Metasurface Fabrication

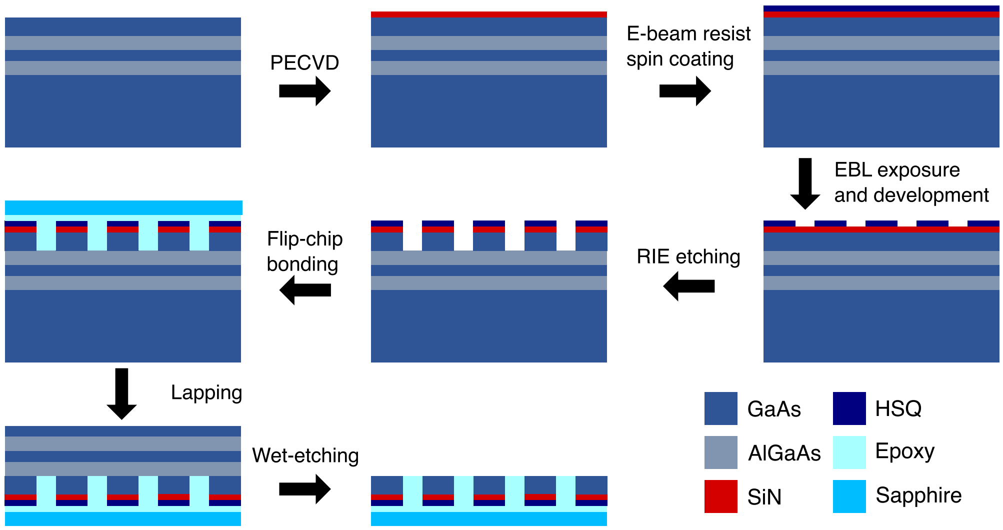


FIG. S1. **Fabrication process.** Fabrication process for [110]-oriented GaAs metasurface.

### Supplementary Note 2: Dimensions of the metasurfaces

| **Metasurfaces** | **Cube length, a (nm)** | **Notch width, w (nm)** | **Notch length, l (nm)** | **Period (nm)** |
|---|---|---|---|---|
| QOM-A | 376 | 118 | 196 | 795 |
| QOM-B | 351 | 107 | 175 | 714 |

TABLE S1. Dimensions of the metasurfaces

## Supplementary Note 3: Experimental Setups

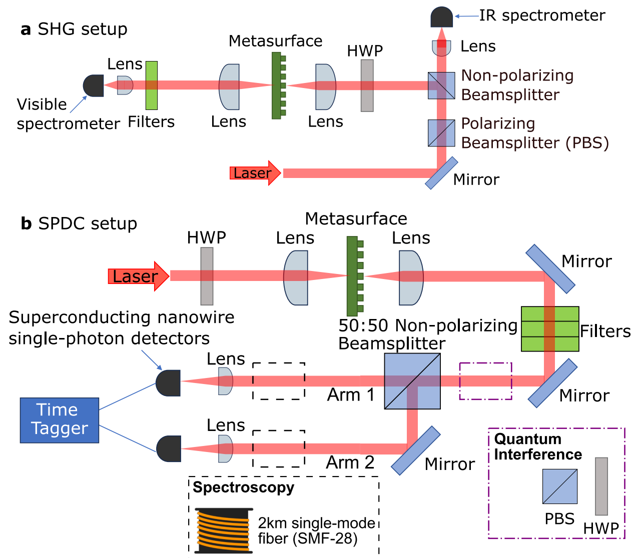


FIG. S2. **Schematics of experimental setups.** **a** Schematics of SHG setup. A pulsed laser (350 fs, 1MHz) pumps the GaAs metasurfaces from the air side. The emitted SHG radiation is filtered off the pump laser using a shortpass filter, and measured with visible spectrometer. The transmission port of the non-polarizing beam splitter (90% transmission, 10% reflection) is used to record the pump intensity in an infrared (IR) spectrometer. **b** Schematics of SPDC setup. A continuous-wave laser centered at 788.4 nm pumps the GaAs metasurfaces from the substrate side. The emitted SPDC radiation is filtered off the pump laser using a combination of longpass filters, and then sent to a Hanbury-Brown-Twiss-like interferometer for further analysis and detection. For spectroscopic measurements 2km single-mode fibers are added at the positions indicated with dashed boxes, and for quantum interference measurements additional optical components are further added at the position indicated with dash-dotted box.

**Supplementary Note 4: Fitting Lorentzian Functions to Experimental Data for Quantum Interference**

To capture the fundamental indistinguishability of biphotons according to Feynman's indistinguishability criterion, we employed the modulus square of the combined amplitudes of two Lorentzian functions, which can be expressed mathematically as follows:

$$I(\lambda) = \left| \frac{A_1 \left(\frac{\Gamma_1}{2}\right)^2}{\pi \left( (\lambda - \lambda_1)^2 - \left(\frac{\Gamma_1}{2}\right)^2 \right)} - e^{i\phi} \frac{A_2 \left(\frac{\Gamma_2}{2}\right)^2}{\pi \left( (\lambda - \lambda_2)^2 - \left(\frac{\Gamma_2}{2}\right)^2 \right)} \right|^2, \tag{S1}$$

where fitting parameters $A_{1,2}$, $\lambda_{1,2}$ and $\Gamma_{1,2}$ are amplitudes, center wavelengths and full-widths at half-maximum of two Lorentzian functions corresponding to the qBIC and the in-plane Mie mode, respectively, and $\phi$ is the phase between them. $\phi$ from the fit, which is shown as the blue dashed curve in Figure 4c, is precisely $\pi$ and other fitting parameters are shown in Table S2.

| Modes | Center Wavelength (nm) | Full-width half-maximum (nm) | Amplitude (a.u.) |
|---|---|---|---|
| qBIC | 1581.1 ± 0.2 | 14.2 ± 0.9 | 33 ± 2 |
| In-plane Mie mode | 1450 ± 40 | 400 ± 60 | 380 ± 80 |

TABLE S2. Fitting parameters for the blue dashed curve in Figure 4**c**.

**Supplementary Note 5: SPDC spectra with varied pump polarization while maintaining photon distinguishability**

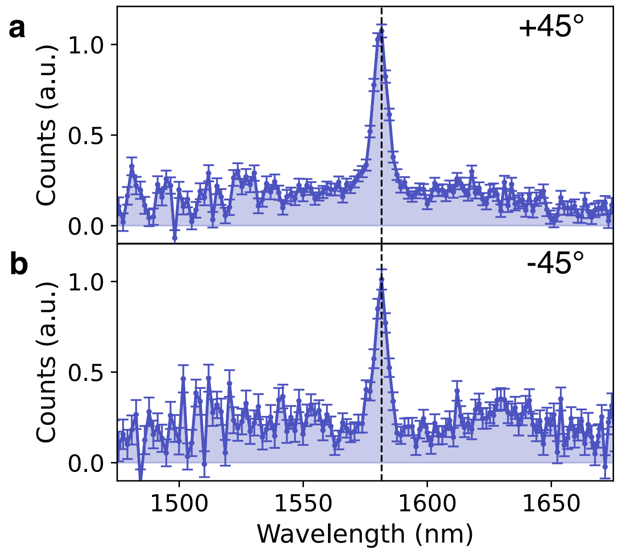


FIG. S3. **SPDC spectra of distinguishable biphotons.** **a** Measured SPDC spectra from QOM-A when the linear polarization of the pump beam was rotated 45° and **b** -45° with respect to that in Figure 3**c**, where the pump polarization was selected to optimize the nonlinear interaction. Changing the polarization of the pump beam also changes the ratio between the contributions from qBIC and in-plane Mie resonances but still preserves the distinguishability of the photon polarizations. Therefore, unlike in Figure 4**c**, the Fano contour, with a clear dip approaching zero, cannot be observed in the SPDC spectra. Black dashed lines indicate double the wavelength of the pump beam.