

## Two-photon interference from a quantum emitter in hexagonal boron nitride

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### Influence of the post-selection on the HOM visibility

It is well known that dephasing degrades the visibility of two-photon interference when the time difference between coincidences is larger than the dephasing time [33-35]. Time postselection of photon detection events, allowed by suitable detector resolution, can thus increase the Hong-Ou-Mandel (HOM) visibility and has been used to boost the fidelity of quantum protocols based on HOM interference – at the price of a lower count rate [3,4]. In this section, we calculate the evolution of the HOM visibility upon modification of the post-selection time window based on numerical integration of the master equation.

Our system is modeled by a two-level system with computational states  $|g\rangle$  and  $|e\rangle$ , and is described in the rotating frame, in the absence of coherent laser drive. As a consequence, the time evolution is purely dissipative, governed by the Lindblad master equation  $\dot{\rho} = \sum_{c_i} c_i \rho c_i^\dagger - \frac{1}{2} \{c_i^\dagger c_i, \rho\}$ , with  $c_i$  the relevant collapse operators. The dissipation terms are spontaneous emission at rate  $\Gamma_{\text{sp}}$  and pure dephasing at rate  $\gamma^*$ . The corresponding collapse operators read, respectively,  $\sqrt{\Gamma_{\text{sp}}}\sigma^-$  and  $\sqrt{\gamma^*/2}\sigma_z$  (in the convention where  $\gamma^* = 1/T_2^*$  [32]), where  $\sigma_z = |e\rangle\langle e| - |g\rangle\langle g|$ , and  $\sigma^- = |g\rangle\langle e|$ . The effect of the non-resonant laser pulse is accounted for by taking  $|e\rangle$  as the initial state. In the far field, the field operators are locked to the source operators [36], such that  $a(t) \propto \sigma^-(t - r/c)$ , with  $a(t)$  the photon annihilation operator. The field observables are therefore expressed in terms of source operators in the following.

The HOM visibility can be expressed as a function of the first- and second-order coherence of the light field [37]:

$$g_{\text{HOM}}^{(2)}(0) = \frac{1}{2}g_{\text{HBT}}^{(2)}(0) + \frac{1}{2} \left( 1 - \frac{1}{N^2} \int \int dt dt' |G^{(1)}(t, t')|^2 \right)$$

with  $G^{(1)}(t, t') = \langle \sigma^+(t)\sigma^-(t') \rangle$ ,  $N$  a normalization factor  $N = \int dt \langle \sigma^+(t)\sigma^-(t) \rangle = \int dt \langle \sigma_{ee}(t) \rangle$  and  $g_{\text{HBT}}^{(2)}(0) = 0$  for an ideal single-photon source.

$G^{(1)}(t, t')$  is numerically calculated based on the quantum regression theorem using the Qutip toolbox [38,39]. To account for the temporal post-selection, the integrals run over  $t, t' \in [0, \Delta t]$ , where  $\Delta t$  is the post-selection window size.  $g_{\text{HOM}}^{(2)}(0)$  is calculated as a function of  $\Delta t$  for various values of  $\gamma^*$ .

Figure 1 shows the result of the calculation for six values of  $\gamma^*$ . It can be seen that the visibility  $V_{\text{HOM}} = 1 - 2g_{\text{HOM}}^{(2)}(0)$  decays with increasing  $\Delta t$ . The decay time depends on the dephasing, and is plotted as a function of  $\gamma^*$  in main text figure 3b. The visibility for  $\Delta t \approx 0$  is always high since the photons are always indistinguishable at short delays [33], and decays faster for larger dephasing rates. The long-time asymptote, corresponding to integration of all detection events, coincides with the bare (non-postselected) indistinguishability  $T_2/2T_1 = \Gamma_{\text{sp}}/(\Gamma_{\text{sp}} + 2\gamma^*)$  [30].

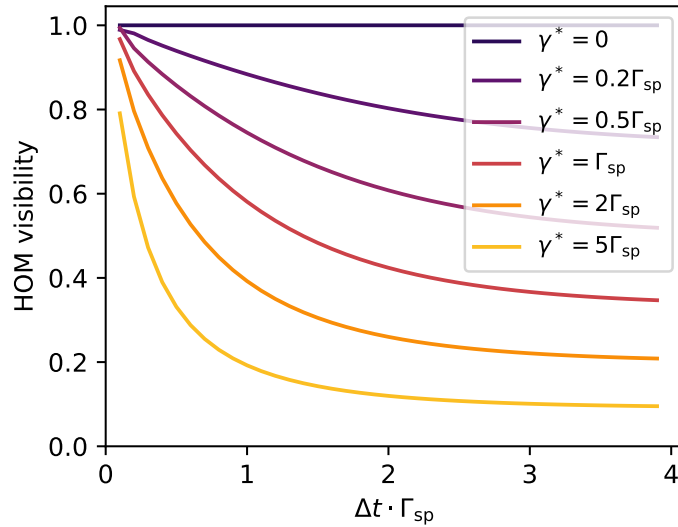


FIG. 1:  $V_{\text{HOM}}$  as a function of  $\Delta t$  for different values of  $\gamma^*$ .

### Influence of the Purcell factor on the HOM visibility

As mentioned in the previous section, the integrated HOM visibility (without any post-selection) for an ideal emitter is  $V_{\text{HOM}} = T_2/2T_1$  [30] – the ideal case  $T_2 = 2T_1$  providing  $V_{\text{HOM}} = 1$ . In a cavity, the Purcell effect modifies the lifetime according to  $T_1' = T_1/F_p$ , where  $F_p$  is the Purcell factor. Given our estimation of  $T_2^* = 2.4$  ns, an indistinguishability of 0.80 (resp 0.90) corresponds to  $F_p = 7$  (resp.  $F_p = 15$ ).

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