Chapter I

Optical control of an individual Cr spin in a CdTe QD

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I.1 Optical pumping and spin dynamics in a Cr doped QD

I.1.1 Resonant optical pumping of the Cr spin

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Figure I.1: Resonant optical pumping experimental setup

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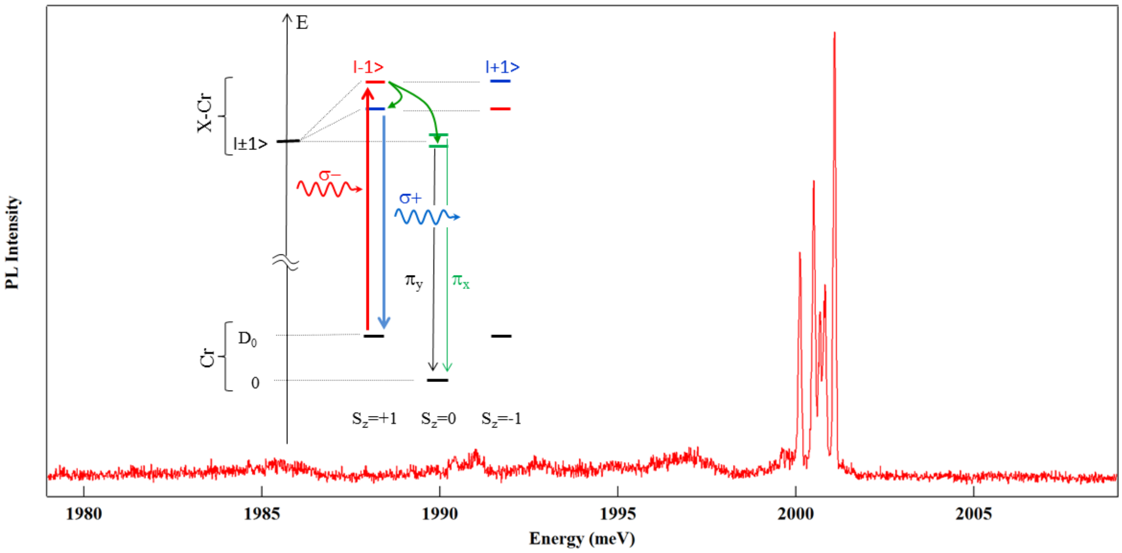

Figure I.2: Low temperature PL spectra of QD2 exciton in co-polarized excitation and detection for B = 0T. Inset: Schematic of the energy levels in a Cr-doped QD and configuration of excitation/detection for resonant optical pumping. The ground states $S_z = 0, \pm 1$ are split by the magnetic anisotropy $D_0 S_z^2$. In the excited state (X-Cr), the exchange interaction with the bright exciton ($|\pm 1\rangle$) split the states $S_z = \pm 1$. The higher energy Cr states, $S_z = \pm 2$, are not displayed.

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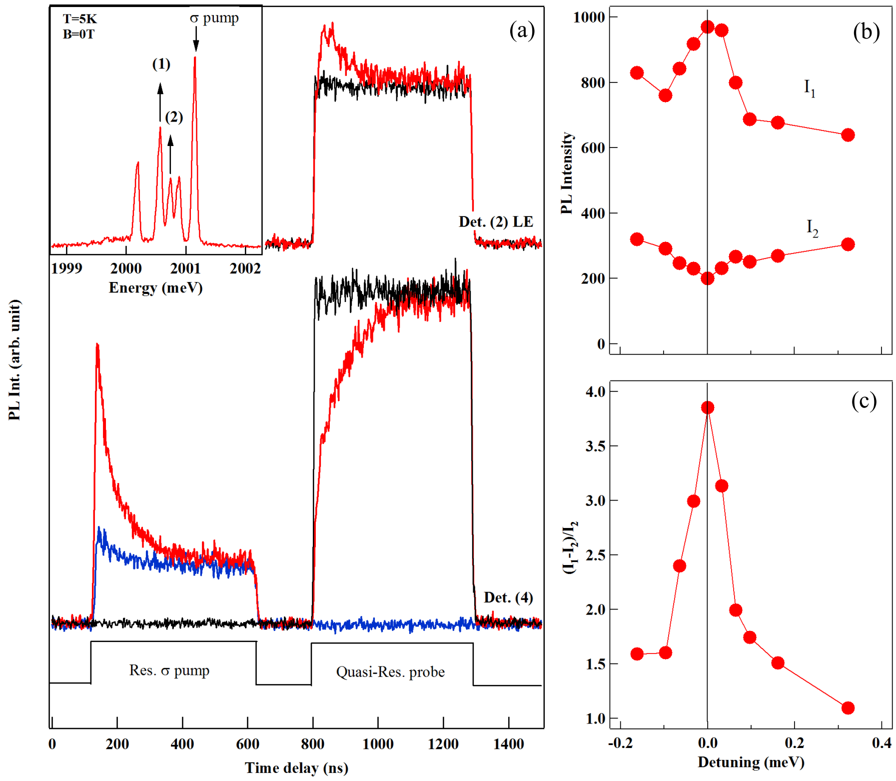

Figure I.3: (a) PL transients recorded in circular polarization on the low energy line of (2) and on line (3) (as defined in Chap. **??**) under the resonant (pump on (1)) and quasi-resonant (probe at $E_{exc.} \approx 2068$ meV) optical excitation sequences displayed at the bottom. Inset: PL of X-Cr and configuration of the resonant excitation and detection. (c) and (d): Energy detuning dependence of resonant PL intensity (I_1, at the beginning and I_2, at the end of the pump pulse) and of the corresponding normalized amplitude of pumping transient $(I_1 - I_2)/I_2$.

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Figure I.4: Continuous probe (heat), modulated pump

Figure I.5: Power variation of pump and probe

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Figure I.6: Heating in gap and far away from the dot

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I.1.2 Dynamics of the Cr spin under optical excitation

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To observe the time fluctuations of the Cr spin under CW optical excitation, we used the statistics of time arrivals of the photons emitted by a Cr-doped QD given by the second order correlation function $g^{(2)}(\tau)$ of the PL intensity. Fig. **??** shows $g^{(2)}(\tau)$ for the lines (1), (3) and (4) recorded in circular polarization. These signals are compared with the auto-correlation obtained for the PL of a non-magnetic QD which is characteristic of a single-photon emitter with a dip (anti-bunching) at short delays. The width of the anti-bunching is given by the lifetime of the emitter

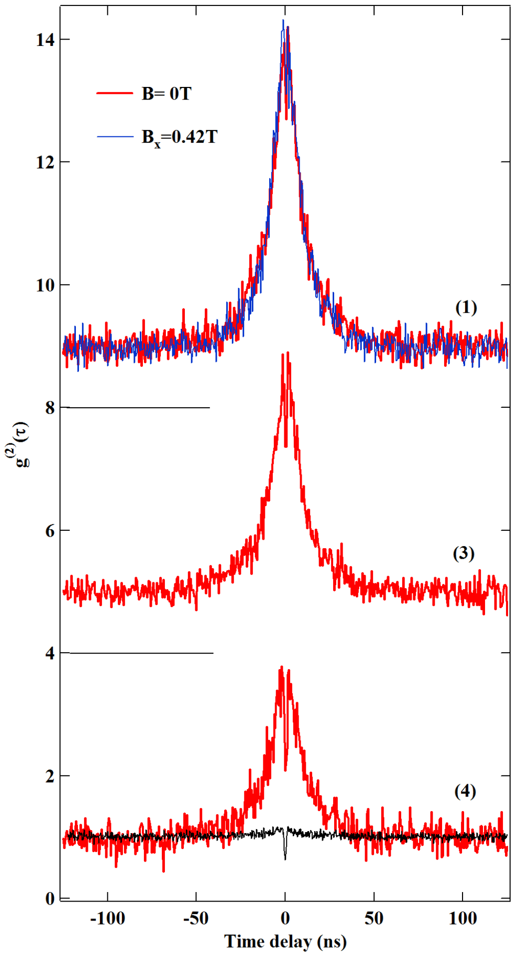

Figure I.7: Auto-correlation of the PL intensity collected in circular polarization on the X-Cr lines (1), (3) and (4) (as defined in Chap. **??**) and compared with the auto-correlation of the exciton in a non-magnetic QD (black line). The curves are shifted for clarity. For line (1), the auto-correlation is also recorded under a transverse magnetic field (blue line).

and the generation rate of excitons and its depth is limited by the time resolution of the HBT setup. As illustrated in Fig. **??**, typical non-magnetic CdTe/ZnTe QDs do not present any significant bunching induced by charge fluctuations [1, 2]. A similar auto-correlation on a X-Cr PL line still presents a reduced coincidence rate near zero delay, but it is mainly characterized by a large photon bunching with a full width at half maximum (FWHM) in the 20 ns range. This large bunching reflects an intermittency in the emission of a given line of the QD coming from fluctuations of the Cr spin in a 10 ns timescale as it will be confirmed by cross-correlation measurements.

The amplitude of the bunching reaches 5 for line (1) and is slightly weaker for the lower energy lines. In a simple picture of blinking where the selected QD line can be either in a state ON or OFF, the amplitude of the bunching is given by Γ_{OFF}/Γ_{ON}, ratio of the transition rates from OFF to ON, Γ_{ON}, and from ON to OFF, Γ_{OFF} [3]. An amplitude of bunching larger than 1 is then expected in a multilevel spin system where, after a spin relaxation, multiple spin-flips are usually required to come back to the initial state ($\Gamma_{ON} < \Gamma_{OFF}$). Let us finally note that the bunching signal is not affected by a weak transverse magnetic field ($B_x = 0.42$T in Fig. **??**). This confirms the presence of a large strain induced magnetic anisotropy D_0 which splits the Cr and X-Cr states and blocks their precession in a magnetic field.

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I.1.3 Spin relaxation in the dark

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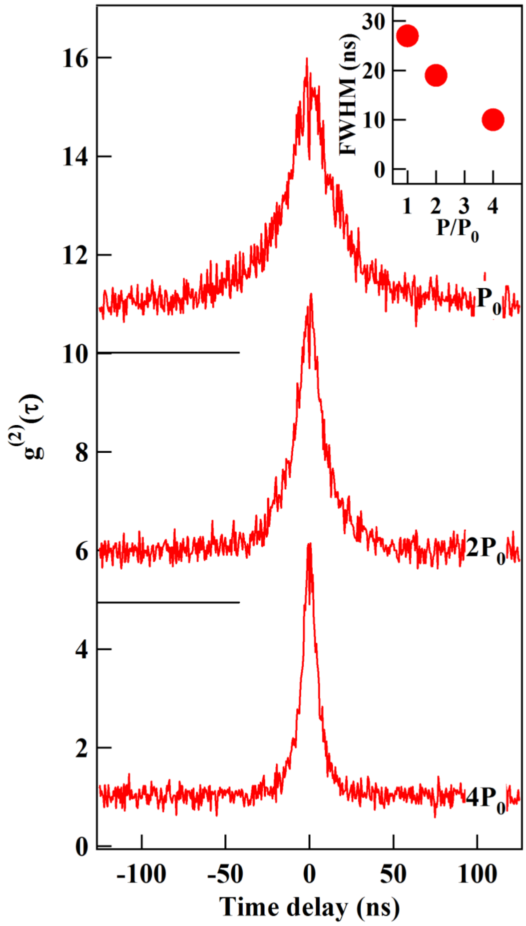

Figure I.8: Auto-correlation of the PL intensity recorded in circular polarization on the high energy X-Cr line (1) for different excitation powers. The inset shows the corresponding FWHM of the bunching signal versus excitation power.

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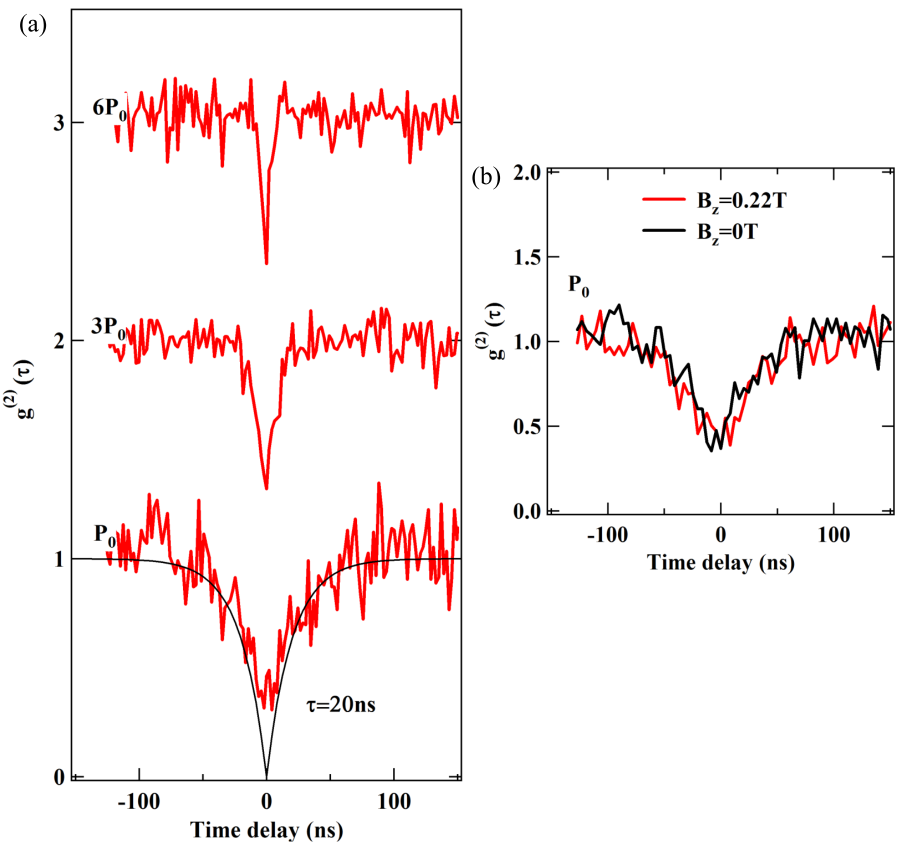

Figure I.9: (a) Correlation signal of the PL intensity of lines (1) and (3) recorded in the same circular polarization (cross-correlation) for three different excitation powers. The curves are shifted for clarity. The black line is an exponential fit with a characteristic time $\tau = 20$ ns. (b) Longitudinal magnetic field dependence of the cross-correlation signal obtained at low excitation power.

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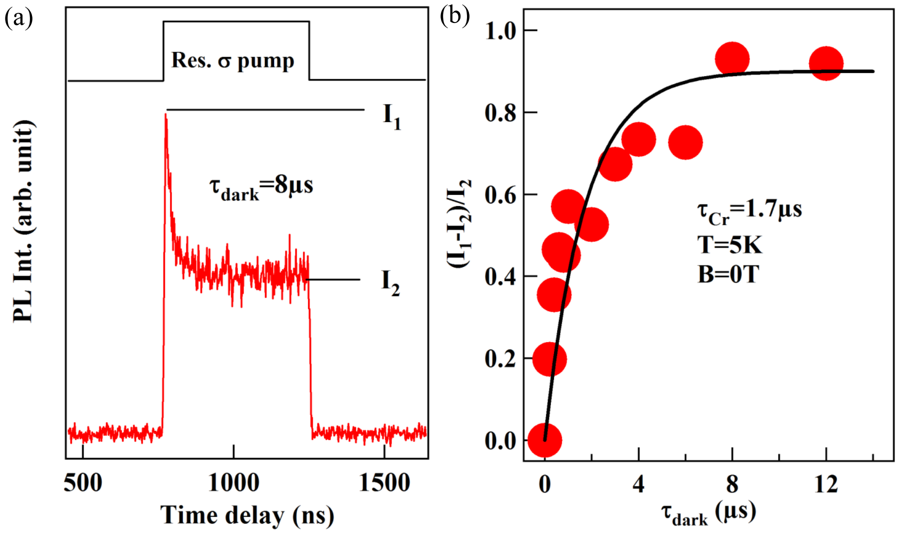

Figure I.10: (a) Time evolution of the PL intensity of line (3) of X-Cr under resonant excitation on line (1) with a circularly polarized excitation pulse. (b) Evolution of the amplitude of the pumping transient $(I_1 - I_2)/I_2$ as a function of the dark time between the excitation pulses. The black line is an exponential evolution with a characteristic time $\tau_{Cr} = 1.7\mu s$

Figure I.11: Configuration of relaxation exp with probe (heat) + graph comparing with and without probe

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I.2 Optical Stark effect on an individual Cr spin

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Figure I.12: Schema of the stark experiment with energy level (cf presentation)

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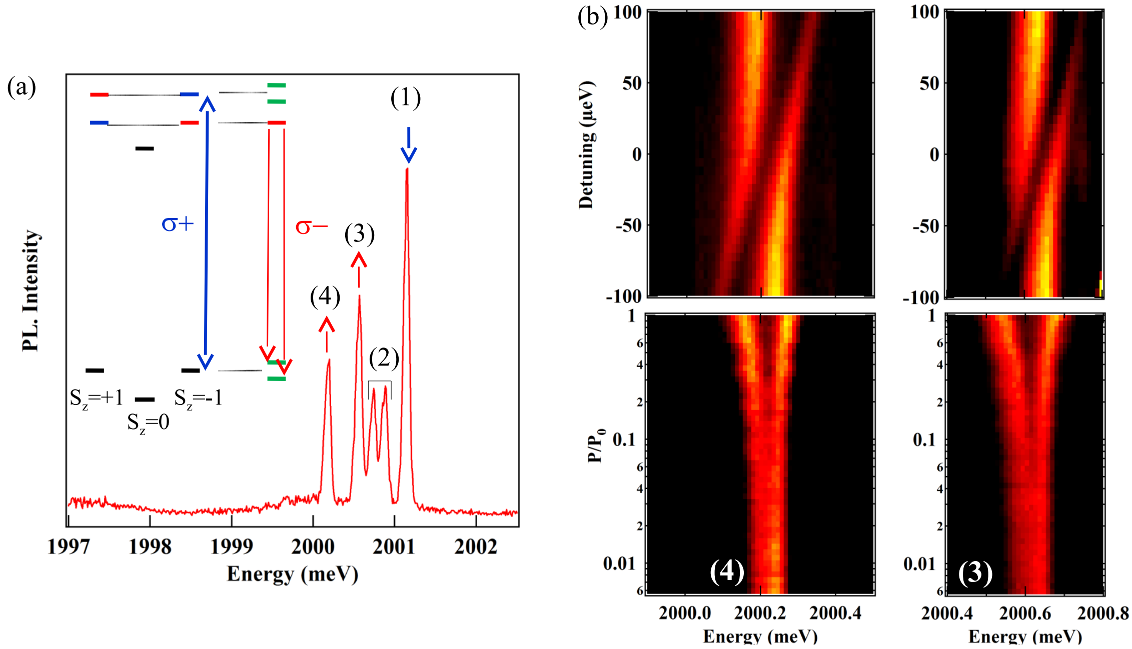

Figure I.13: (a) PL of X-Cr and configuration of excitation in the resonant optical control experiments. The inset illustrate the laser induced splittings in the ground and excited states for a $\sigma+$ excitation on $S_z = -1$. (b) PL intensity maps of lines (5) and (4) for an excitation on (1) as a function of the detuning (top) and of the excitation intensity (bottom). The PL is produced by a second non-resonant laser.

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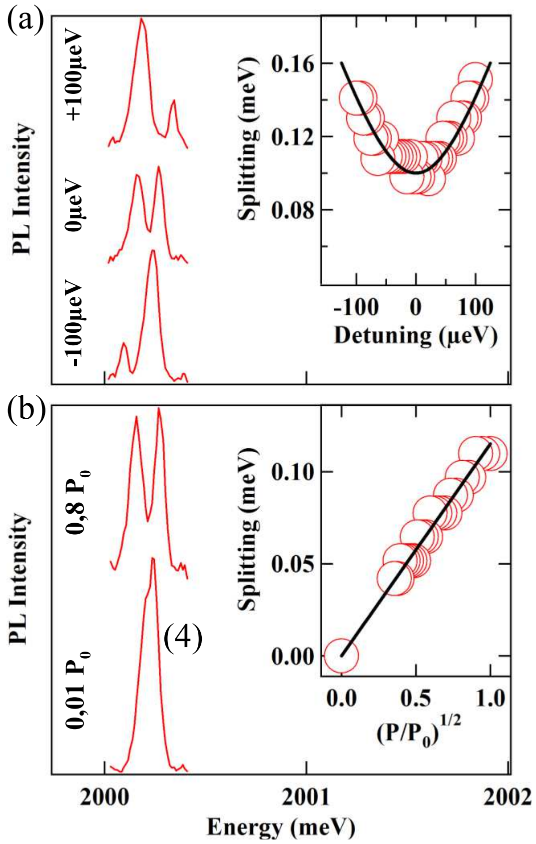

Figure I.14: Line (4) PL spectra taken for (a) no and max detuning in each direction, and (b) low and high power. The insets show the splitting of the PL doublet as a function (a) of the laser detuning and (b) of the excitation intensity. The fit is obtained with $\hbar\Omega_r = 100\ \mu$eV.

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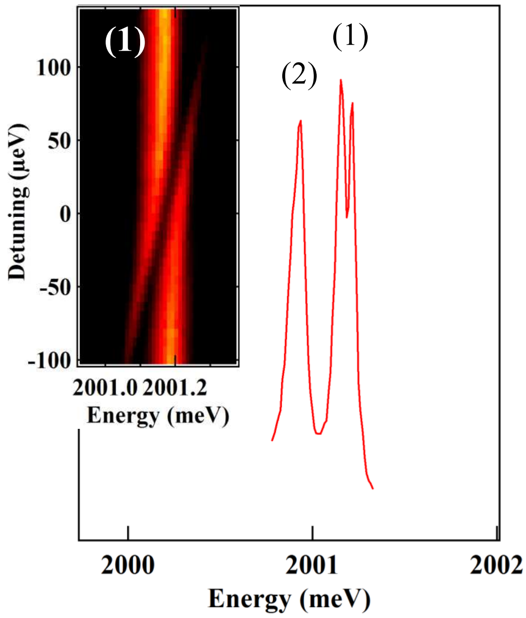

Figure I.15: PL of line (1) and (2) (high energy line) for a laser on resonance with the dark exciton state (4). Inset: PL intensity map of line (1) as a function of the laser detuning around (4).

amet ut arcu. Nullam id vehicula enim, at tincidunt velit. Duis vestibulum lorem a molestie fringilla. Nullam tincidunt semper placerat. Donec nibh sem, ornare eget cursus ac, luctus sit amet eros. Phasellus eget interdum nisi. Donec mollis risus id lectus fringilla, et commodo risus iaculis. Donec at lacus sed nibh posuere posuere sit amet eget sapien. In dignissim, enim sit amet convallis fermentum, lacus nulla gravida tortor, non facilisis ex nisl sit amet augue. Maecenas eu enim condimentum, consectetur ligula vel, tincidunt nisl. Nam laoreet dictum volutpat. Donec at erat venenatis, ultrices lorem ac, vestibulum neque.

Bibliography

[1] P. Michler, A. Imamoglu, M. D. Mason, P. J. Carson, G. F. Strouse, and S. K. Buratto, "Quantum correlation among photons from a single quantum dot at room temperature", Nature **406**, 968 (2000).

[2] C. Santori, D. Fattal, J. Vuckovic, G. S. Solomon, and Y. Yamamoto, "Indistinguishable photons from a single-photon device", Nature **419**, 594 (2002).

[3] G. Sallen, A. Tribu, T. Aichele, R. Andre, L. Besombes, C. Bougerol, M. Richard, S. Tatarenko, K. Kheng, and J.-P. Poizat, "Subnanosecond spectral diffusion measurement using photon correlation", Nat Photon **4**, 696 (2010).