1 GHz Picosecond Laser Source at 925 nm for the Excitation of Single-Photon Quantum Dot Emitters

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Single photon sources (SPS) based on semiconductors quantum dots (QD) [1] (e.g. InAs/GaAs QDs) are optically excited by laser pulses centered in the range from 910 nm to 950 nm and delivering picosecond pulses through spectral slicing from femtosecond sources [2]. An optimized laser source would deliver transform-limited multi-picosecond pulses at GHz (QD emitters limit) repetition rate with large power spectral density (PSD) and broad wavelength tunability around 925 nm. This source could drive several SPS in parallel and at high rate, thereby increasing the number of indistinguishable photons used for quantum computation. The development of custom-designed picosecond excitation sources is therefore in an active stage. There are very few demonstrations of SPS reaching the GHz limit [3, 4], and to our knowledge, none that uses laser excitation. Furthermore, the demonstrations of GHz femtosecond laser around 920 nm are not suited to excitation of QD-based SPS [5]. In this communication, we extend and improve our previous excitation laser [6] to a repetition rate of 1 GHz. The proposed hybrid laser system generates Fourier transform pulses around 925 nm with a duration of about 7 ps. The system, schematically shown in Fig. 1a, is based on frequency-doubling of 1850 nm pulses from a soliton self-frequency shifted (SSFS, Fig. 1b, 1c) source pumped by an amplified laser at 1560 nm operating at 1 GHz (Menhir 1550). Long 7 ps (0.3-nm bandwidth) second harmonic (SH) pulses are obtained in a $\chi^{(2)}$ PPLN crystal (Fig. 1d). We achieve high conversion efficiency (~50%) from the fundamental frequency pulse to the SH pulse, which contains 1 nJ of energy. The SH wavelength is finely tuned within ± 10 nm by adjusting the temperature of the PPLN crystal. The laser parameters could be fine-tuned to excite a QD-based SPS in a quasi-resonant scheme [2]. Additional results regarding the laser source, QD excitation, and the characterization of emitted single photons will be presented.

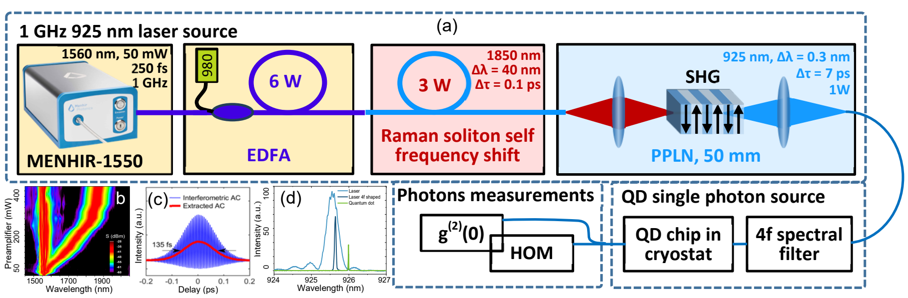

Fig. 1: *(a) Schematic of experimental setup. EDFA: Erbium-doped fiber amplifier; PPLN: Periodically-poled lithium-niobate crystal; SHG: Second-harmonic generation; QD: InAs-GaAs quantum-dot based single-photon source; HOM: Hong-Ou-Mandel interferometer; $g^{(2)}(0)$: second-order correlation. (b) Soliton self-frequency shift. (c) Autocorrelation trace of soliton at 1850 nm. (d) Spectrum of SH pulse before and after 4f filter along with QD emission.*

References

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