

Time-domain measurement of spontaneous Raman scattering in optical fibre in the single-photon regime

A. Restelli¹, J. C. Bienfang¹

¹Joint Quantum Institute, National Institute of Standards and Technology, 100 Bureau Drive, Gaithersburg, Maryland 20899, USA

Spontaneous Raman scattering (SpRS) in single-mode optical fibre is well known to plague quantum communications; when necessary classical communications tasks such as synchronization or polarization compensation are implemented using bright classical signals that coexist with the quantum signals in the same fibre, SpRS necessitates strong spectral or temporal separation of the classical and quantum light or SpRS photons can severely degrade the quantum channel. While the Raman gain and its Stokes and anti-Stokes spectra are well known [1, 2], the temporal distribution of SpRS observed through a fibre link is not reported, even though it directly impacts the design of time-division multiplexing schemes to suppress Raman noise in the single-photon regime. We report temporally resolved measurements of SpRS in the single-photon regime across the dense-wave-division-multiplexed (DWDM) channels in the telecom C-band. This work is motivated by the need to define the operational requirements of classical-quantum coexistence in a quantum network.

To observe Raman scattering we pump a 25 km single-mode fibre with a 400 ps pulse at 1550.92 nm (100 GHz DWDM channel 33) at a rate of 1 MHz, with $\approx 8 \times 10^5$ photons per pulse. At the output of the fibre we suppress the pump by -100 dB with a series of 0.8 nm bandwidth notch filters, and then pass the SpRS through a 1 nm tuneable bandpass filter to a gated InGaAs/InP SPAD operating at 1 MHz with a 1 ns temporal gate. To make temporal measurements we step the detection gate across 125 ns relative to the pump pulse. Figure 1 shows the full temporally resolved forward-SpRS spectrum as observed by the InGaAs/InP SPAD with the bandpass filter removed (dots), along with temporally resolved measurements of forward-SpRS in four different DWDM channels (lines) that span the C-band. Due to fibre dispersion, anti-Stokes (Stokes) SpRS photons arrive before (after) the pump and span more than 20 ns across the DWDM channels, and ≈ 120 ns across the detectivity spectrum of the InGaAs/InP SPAD.

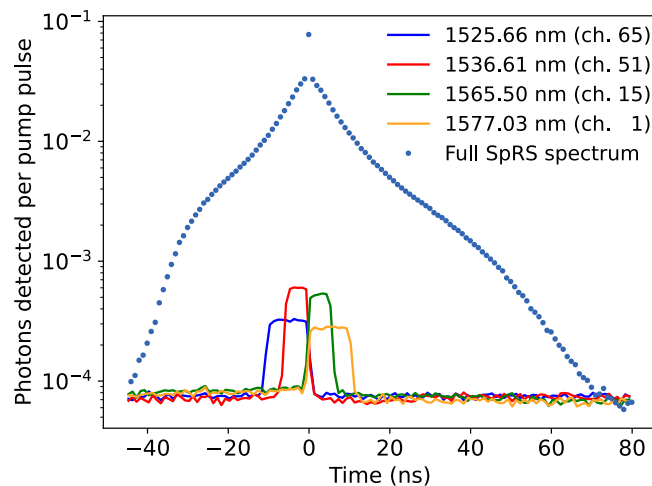


Fig. 1: Temporal distribution (photons detected in a 1 ns gate) of forward-scattered SpRS photons at four DWDM channels (lines) in a 1 nm band, and across the full detection range (dots) of the gated InGaAs/InP SPAD, relative to the bright 400 ps pump pulse at 1550.92 nm (DWDM ch. 33).

References

- [1] J. Bromage, *J. Lightwave Tech.* **22**, 1, 79 (2004).
- [2] I. Choi, R.J. Young, P.D. Townsend, *Opt. Express* **18**, 9, 9600 (2010).