Difference Frequency Generation and Spectral Filtering for Quantum Frequency Conversion

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Quantum communication, the use of quantum bits rather than classical bits, can allow for the increased security of messages between two parties. The limitation of quantum communication is that the quantum bits cannot be amplified to be sent longer distances, which is why quantum repeaters using quantum memories are used. The quantum memories, however, do not absorb or emit light at the wavelengths which have the lowest attenuation in optical fibers. Therefore, light from quantum memories has to be converted to the appropriate wavelength, the telecom C-band, to allow for long-distance communication. This work is on the experimental setup for the conversion of quantum memory light to the telecom C-band through difference frequency generation. 580 nm light compatible with a $Eu^{3+} : Y_2SiO_5$ quantum memory was pumped with a 930 nm laser into a periodically-poled lithium niobate crystal waveguide and was converted to 1540 nm with an interaction efficiency of 89.5 $\frac{\%}{Wcm^2}$ and a maximum conversion efficiency of 80.5 %. Spectral filtering was applied to reduce noise induced by spontaneous parametric down-conversion of the 930 nm pump, which was achieved by combining a volume Bragg grating and a Fabry-Pérot cavity. The characterized noise was fit to be 10 $\frac{Hz}{Wcm}$ after filters, or 52 $\frac{Hz}{Wcm}$ at the crystal face. A method for increasing the signal-to-noise ratio between the converted light and the broadband noise is thought to be found through the use of simulations, though experimentally unproven in this work.