Investigating the Optimal Pump Source for an Optical Quantum Computer Using Type-I Spontaneous Parametric Down-Conversion

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This study’s goal was to determine which pump laser configuration would stimulate type-1 spontaneous parametric down-conversion (SPDC) in beta barium borate (BBO) crystals such that the number of |Phi+> entangled photons and the fidelity of the detected quantum states is maximized. The four pump configurations were a 100 mW continuous wave (CW) laser, a 100 mW pulsed laser (Pulsed at 2x10^-6 s) a 50 mW CW laser, and a 50 mW pulsed laser, using two BBO crystals and an array of four photomultiplier tubes (PMTs) to collect data on the entangled photons produced. Testing was done within a darkroom which produced ~100 dark counts in a 30 second exposure. The 100 mW CW laser produced 185.8 more entangled photons than the 50 mW CW laser, and the 50 mW pulsed laser produced 14.2 more than the 100 mW pulsed laser, both comparisons were significantly different (p < .05). The 100 mW CW laser had the lowest fidelity when compared to the other three pump configurations. The 50 mW pulsed laser (0.471 +/- 0.069 S.D.) significantly outperformed the 50 mW CW laser (0.431 +/- 0.069 S.D.) in terms of fidelity. This implies that the higher entangled photon yield of the 100 mW CW laser is counterbalanced by its low fidelity, and this cost is detrimental to optical quantum computers. There was no significant difference between the 100 mW and 50 mW pulsed lasers in terms of fidelity. Given the low fidelity of the 50 mW CW laser, it can be confidently said that a pulsed laser would be the most effective pump source for an optical quantum computer, with no statistically significant evidence favoring 100 mW or 50 mW lasers. Comparing the pulsed laser in terms of photon output encourages the idea that 50 mW pulsed lasers would be the most optimal in optical quantum computers.

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