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Quantum Memory in Solids

MATTHEW SELLARS, University of Otago

Quantum memories are likely to be critical components in any future long range quantum communication network. A method is described for storing light that operates by controlling the local group velocity of light in a crystal, using an applied electric field gradient to Stark shift an optical transition. Unlike other proposals for quantum memories no optical control pulses are required greatly simplifying the operation of the memory and improving its signal to noise. It is shown that the technique has the potential to operate with near 100% efficiency with little excess noise, making it suitable as a quantum memory. Preliminary experimental results will be presented demonstrating efficiencies up to 45%. These experiments utilized the $^3H_4 \Leftrightarrow {}^1D_2$ optical transition (605.7 nm) in a 4 mm long crystal of Pr^{3+}:Y_2SiO_5 cooled to liquid helium temperatures. The experiments are well described by Maxwell-Bloch simulations and such simulations suggest efficiencies much closer to unity should be possible with only modest improvements to the experiment. This work was carried out in collaboration with G. Hetet, J. J. Longdell, A. L. Alexander, P. K. Lam and M. P. Hedges.