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Towards frequency comb Raman spectroscopy for quantum logic

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One of the most attractive quantum computing platforms is that of atomic ions. We aim to investigate an alternative approach that substitutes atomic ions with molecular ions, which allows for the utilization of rotational degrees of freedom for quantum information encoding. However, due to the complex internal structure of molecules, advanced methods are required to manipulate and readout their quantum states. In order to prepare, control, and characterize molecules at the quantum level, we are developing a setup for two-beam frequency comb Raman spectroscopy.

The two-beam frequency comb Raman setup allows precise control over driving rotational transitions in molecular ions. We will drive two-beam frequency comb Raman carrier transitions between the electronic D-levels in Ca^+. The same system will be used for driving rotational state transitions in CaH^+ and $CaOH^+$. The possibility of directly driving sideband transitions with the frequency comb will also be explored. Driving rotational transitions in molecules, especially sideband transitions, requires higher intensities, necessitating the use of an amplifier. Dispersion in the optical path also decreases Raman efficiency. My project focuses on the amplification and dispersion compensation of the comb light used in this Raman setup.

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