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Towards ultrafast spectroscopy with trapped molecular ions and photodissociation of CaOH+

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Trapped atomic ions are one of the most promising platforms for quantum simulation and computation. Our project focuses on their application in quantum logic spectroscopy to investigate the rovibrational structure of various molecular ions co-trapped with atomic ions, as demonstrated experimentally on diatomic molecular ions such as CaH^+ and N_2^+. Utilizing femtosecond laser pulses, we aim to explore ultrafast intramolecular dynamics in polyatomic molecular ions. The collective motion of the ion crystal will be prepared in a non-classical state to measure the net momentum transfer from the pump and delayed probe pulses to the molecular ion. The evolution of vibrational excitations inside a single polyatomic molecule can then be studied. Our goal will be to advance our understanding of quantum phenomena in molecular systems, especially in complex molecules of chemical or biological importance.

While constructing the experimental setup, we also measure the photodissociation threshold of $CaOH^+$ molecules. The molecules are generated via chemical reactions between trapped Ca^+ ions and water molecules which are introduced into the experimental chamber using a gate valve. Following the reaction, photodissociation threshold are measured by applying laser pulses of tunable wavelength to dissociate the “dark” molecule back to a “bright” Ca^+ ion.

Primary authors: SCHINDLER, Philipp; WU, Zhenlin (University of Innsbruck)

Co-authors: Mr ISAZA-MONSALVE, Mariano (University of Innsbruck); Dr FUREY, Brandon (University of Innsbruck); Dr WALSER, Stefan (University of Innsbruck); Mr MU, Guanqun (University of Innsbruck); Mr NARDI, René (University of Innsbruck)

Presenter: SCHINDLER, Philipp

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