Lifetime measurement of the first vibrationally excited state of MgH^+ in a cryogenic Paul trap (CryPTEx)

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A method is presented to measure the decay rate of the first excited vibrational state of polar molecular ions being part of a Coulomb crystal in a cryogenic linear Paul trap (CryPTEx [1]). Specifically, we have monitored the decay of the $|v=1,J=1\rangle_X$ towards the $|v=0,J=0\rangle_X$ level in MgH^+ by saturated laser excitation of the $|v=0,J=2\rangle_X$ -$|v=1,J=1\rangle_X$ transition followed by state selective resonance enhanced two-photon dissociation out of the $|v=0,J=2\rangle_X$ level. Due to the ~5K cryogenic environment of CryPTEx, other transitions (e.g., rotational excitations) in the molecular ion can be essentially be neglected during the few second-long measurements. The technique presented here can be extended to other simple molecular ions, e.g., of astrophysical relevance such as CH^+, OH^+, and NH^+, and it enables the determination, with an accuracy at the few percent level, of decay rates and thus absorption strengths.

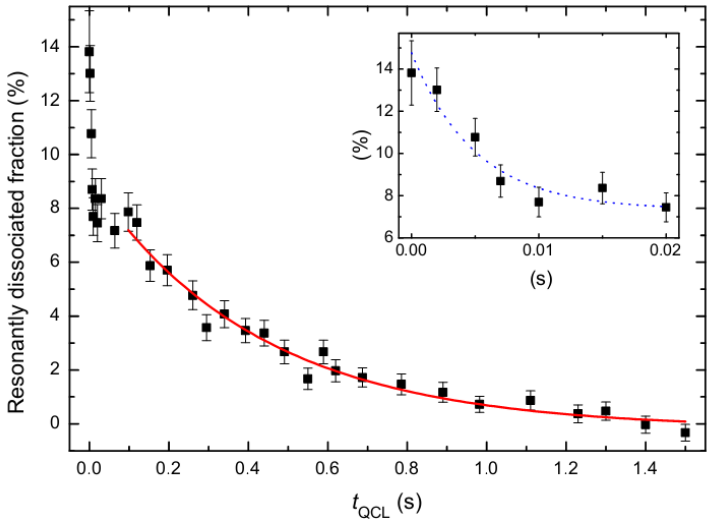

Fig.1 *The relative population of the $|v=0,J=2\rangle_X$ level of trapped MgH^+ molecules after application of a Quantum Cascade Laser (QCL) for a time t_{QCL}. The population is probed through resonance enhanced two-photon dissociation. The red solid curve represents an exponential fit to the data points (black squares) and yields a $|v=1,J=1\rangle_X$-$|v=0,J=0\rangle_X$ decay rate of 6.32(0.69)s^{-1}, in good agreement with the most recent theory value (this work) of 6.14(3)s^{-1}. The inset presents a close-up of the data for the first 20ms depicting the fast QCL equilibration, including an exponential fit to this data selection (blue dotted line).*

References:
[1] M. Schwarz *et al.*, Rev. Sci. Instr. **83**, 083115 (2012)