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Towards quantum control and spectroscopy of a single hydrogen molecular ion

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The complexity and variety of molecules offer opportunities for metrology and quantum information that go beyond what is possible with atomic systems. The hydrogen molecular ion is the simplest of all molecules and can thus be calculated *ab initio* to very high precision [1]. Combined with spectroscopy this allows to determine fundamental constants and test fundamental theory at record precision [2-4].
Spectroscopy of H_2^+ should improve substantially by performing experiments with single hydrogen molecular ions, reducing systematic uncertainties and improving signal strength. This necessitates quantum control.

I will present our progress towards full quantum control of a single hydrogen molecular ion.
Our most recent results demonstrate the co-trapping of single H_2^+ and $^9Be^+$ ions. We observe trapping durations of H_2^+ of up to eight hours. For the ion pair's axial in-phase mode of motion we estimate a temperature of $\approx 130\ \mu K$ after Doppler cooling of $^9Be^+$, which is a reduction by a factor of ≈ 80 over current state-of-the-art [2-4].

The experimental apparatus features a cryogenic ultra-high vacuum chamber, housing a microfabricated monolithic linear Paul trap. H_2^+ is loaded into the trap by electron bombardment of H_2. We aim to use He buffer gas cooling in combination with quantum logic spectroscopy to initialize the internal state of H_2^+ in a pure quantum state and implement non-destructive readout [5,6].

References

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