New Lifetime Limit for the Ground State Vinylidene Anion H_2CC^-

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The molecular isomers acetylene ($HCCH$) and vinylidene (H_2CC) form one of the simplest systems for studying isomeric reactions involving hydrogen.

In anionic form, the state with lowest total energy has the vinylidene structure, H_2CC^-, with an electron affinity of about 0.5 eV. It lies 1.5 eV above the lowest neutral level of the acetylene structure, opening up the possibility that isomerization linked with electron emission could limit the lifetime of H_2CC^-.

Indeed, an experiment at a room-temperature storage ring reported a finite intrinsic lifetime of about 110 s [1], by extrapolating from collision-limited (about 10 s) to collision-free beam lifetimes of H_2CC^-, using a stable reference ion.

To access longer ion beam lifetimes, and thereby enable a better estimate of the ground state H_2CC^- lifetime, we employed the Heidelberg electrostatic Cryogenic Storage Ring (CSR) [2]. The CSR provides a cryogenic environment with strongly suppressed blackbody radiation and extremely low residual gas density, allowing to store and observe fast ion beams over time scales on the order of an hour.

We used photodetachment to monitor the decays of simultaneously stored H_2CC^- and CN^- ion beams. Here, CN^- served as a stable reference ion with nearly identical mass-to-charge ratio. Comparing the two decays at storage times of up to 3000 s allowed us to discriminate against most of the storage-ring induced loss processes. Furthermore, by using the novel isochronous mass spectrometry method [3], we were able to prove that no ion beam contaminations could significantly affect the observed lifetimes.

We present preliminary results which suggest that the intrinsic lifetime of the ground-state of H_2CC^- is several thousand seconds, i.e., at least an order of magnitude longer than assumed previously.

References

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