Photodissociation of sympathetically crystallized CaH^+

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Synopsis We demonstrated photodissociation of sympathetically crystallized CaH^+ toward rovibrational spectroscopy by UV-UV or IR-UV double resonance. The photodissociation of CaH^+ was successfully confirmed at λ = 283-287 nm.

Rovibrational precision spectroscopy on sympathetically crystallized molecular ions is expected to be an important tool for discussions of fundamental physical constants stabillity [**?**]. Especially, some precision measurements of vibrational transitions in diatomic hydrides have been proposed toward time variation detection of proton-electron mass ratio β ($= m_p / m_e$) [**?**]. The vibrational transition of $X^1\Sigma(v,N) = (0,0) \rightarrow (1,0)$ in CaH^+ is one of the candidates. Recentry, sympathetic cooling and spectroscopic studies of CaH^+ have been demonstrated by several reserach groups [**?**] [**?**].

We have constructed a cryogenic linear Paul trap for rotational cooling of Coulomb crystallized CaH^+ [**?**] [**?**]. Now we are trying to observe the laser induced fluorescence (LIF) from internally cooled CaH^+. Unfortunately, the transition wavelength to observe the LIF has not been experimentally determined yet. Therefore, as an alternative plan, we started a photodissociation experiment in order to determine the rovibrational constants. Here, we report on the photodissociation experiment of sympathetically crystalized CaH^+ toward rovibrational spectroscopy.

In Fig. (a-1), we show an observed LIF image from a laser cooled Ca^+ crystal. As we demonstrated before, CaH^+ ions can be generated by a laser induced chemical reaction of $Ca^+(^2P_{1/2}) + H_2 \rightarrow CaH^+ + H$. As shown in Fig. (a-2), generated CaH^+ ions are sympathetically crystalized in a Ca^+ crystal. The ion numbers of Ca^+ and CaH^+ are determined by comparing LIF image with simulation images obtained by molecular dynamics simulations [**?**]. In the photodissociation experiment, we irradiated a UV pulsed laser beam (λ = 283-287 nm) to a mixed Coulomb crystal. Theoretical calculation predicted that the photodissociation via the excited state of $1^1\Pi$ in CaH^+ could occur [**?**]. As shown in Fig. (a-2) and (a-3), we successfully observed the photodissociation of sympathetically crystalized CaH^+. Fig. (b) shows a decay curve of the number of CaH^+ as a function of the laser irradiation time. A dissociation rate was determined to be $\gamma = 2.3(0.5)\times10^{-2}$ s^{-1} using a least-square fitting of a single exponential function to the data in Fig.b.

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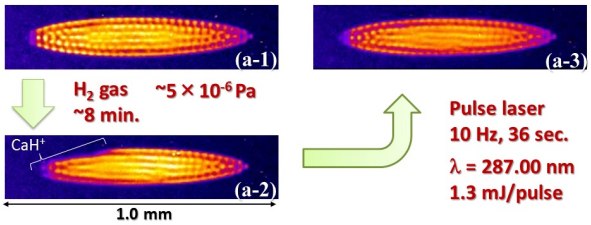

Figure a. CCD images of mixed species Colomb crystals during CaH^+ generation and photodissociaition. The ion numbers of Ca^+ in (a-1) and CaH^+ in (a-2) are 450 and 64, respectively.

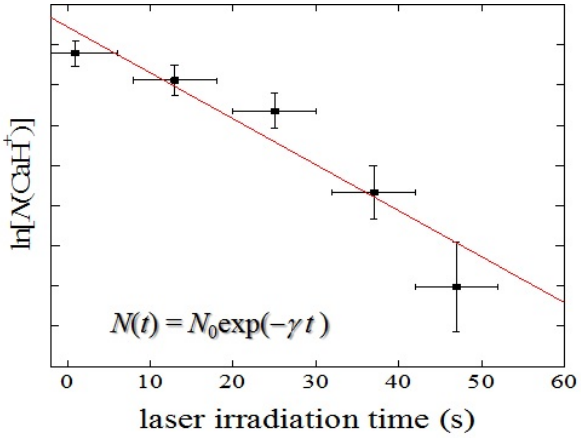

Figure b. A plot of the ion number of CaH^+ as a function of the laser irradiation time.

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