Comparative effects of 10.2 eV photon and 200 keV proton irradiation on condensed CO.
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Introduction: The existence of solid CO_2 in interstellar ice grains - expected from the abundance of condensed CO - was confirmed by the Infrared Space Observatory (ISO) [1]. The small abundance of gas phase CO_2 suggests that CO_2 ice is produced in situ from condensed CO by oxidation with atomic oxygen originating from impact dissociation of CO, radiation processing of other oxygen containing molecules, or incident on the grain from the gas phase [2]. The comparison of ISO observations with laboratory infrared spectra reveals that CO can exist both in apolar ices and water ice mixtures. Here we address the relative efficiency of CO_2 synthesis from pure CO ice by 200 keV proton and Lyman-α (10.2 eV) photons. This topic has been researched recently by Gerakines et al. [3], who reported that CO_2 synthesis by Lyman-α is more efficient than by 800 keV protons. This is a striking result for two reasons. First, the ionization channel is energetically unavailable in the case of Lyman-α photolysis of CO ions and a previous observation gave an extremely small cross section for CO_2 photosynthesis of less than 10^{-20} cm². Second, previous studies of photodesorption and ion-induced sputtering of water ice [4,5], revealed much higher erosion yields by the fast protons. In particular, a dominant double collision channel is available for ions and not for photons, which is manifested in a quadratic dependence of the sputtering yield on electronic stopping power (S_e) [6]. The case of CO is expected to be analogous since in this case also the sputtering yield is proportional to S_e^2 [7]. Our new study was designed to eliminate a potential source of experimental error, the condensation on the sample of CO_2 molecules desorbed from the vacuum system walls. To discriminate against those molecules, we used ^{13}CO ice that yields $^{13}CO_2$ with a different infrared spectrum (band at 2281 cm^{-1}; 4.38 µm) than that of the adventitious $^{12}CO_2$ (band at 2350cm^{-1}; 4.26 µm).

In figure 1, we show optical depth from infrared spectra of ^{13}CO ice before and after processing by 200 keV protons. In figure 2, we compare the column density of $^{13}CO_2$ formed by UV photolysis and 200 keV proton irradiation. From the initial slope of the dose dependence it is evident - as can be shown quantitatively - the CO_2 synthesis by Lyman-α radiation is not more efficient than synthesis with 200 keV protons.

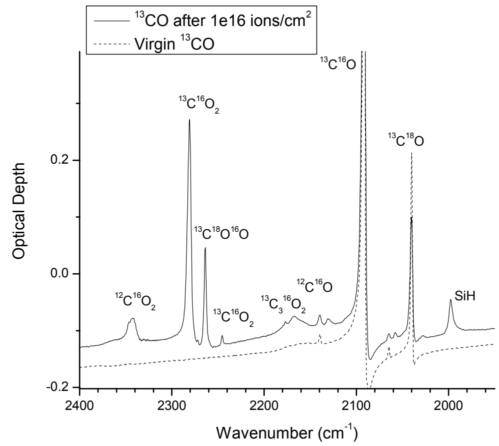

Figure 1. Infrared spectra before and after 200 keV H^+ ion processing of a 5.4 x 10^{17} molecules/cm² ^{13}CO film at 16 K.

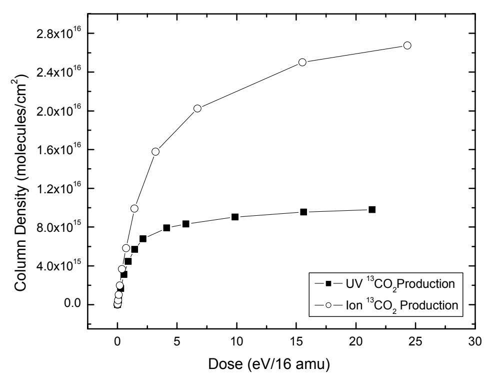

Figure 2. Comparison of the column density of $^{13}CO_2$ formed from 5.4 x 10^{17} molecules/cm² ^{13}CO ice at 16 K during UV photolysis and 200 keV proton irradiation.

References: [1] Gerakines et al. (1999) *APJ*, 522, 357-377. [2] Roser et al. (2001) *APJ*, 555, L61-L64. [3] Gerakines, P.A., Moore, M.H., 2001, *Icarus*, 154, 372 [4] Brown, W.L. et al. (1984) *Nuc. Ins. and Met. in Phys. Res. B1,* 307-314. [5] Westley et al. (1995) *Nature,* 373, 405-407 [6] Baragiola et al. (2003). *Nucl. Instr. Methods. Phys. Res. B* 209, 294-303. [7] Brown, W.L. et al. (1984) *Nuclear Instruments and Methods in Phys. Res.B1,* 307-314.