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Dissociation Dynamics of Multiply Charged CO_2 by Low Energy Ion Impact Using Coincidence Mapping

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Synopsis Dissociation dynamics of multiply charged CO_2 has been studied by 1.2 MeV Ar^{8+}. The geometry of the excited states of the precursors undergoing three-body break-up has been estimated by Monte-Carlo simulation. It has been found that when more electrons are removed from the peripheral O atoms, bent dissociative structure of the parent molecular ion comes into play which gives non-zero momentum contribution to the central C atom.

Complete Coulomb fragmentation of CO_2 in collision with very high [1, 2] and very low [3] energy ions have already been studied where maximum available fragment charge state reported is 3. We have studied the multiple ionization and fragmentation of CO_2 induced by intermediate energy (1.2 MeV) Ar^{8+} impact using the technique of time-of-flight mass spectrometry employing time and position sensitive detectors in multi-hit coincidence mode. The experiments were carried out at the ECR ion source based Low Energy Ion Beam Facility (LEIBF) at the Inter - University Accelerator Centre (IUAC), New Delhi, India. The details of the experimental setup can be found in [4]. We observe undissociated CO_2^+, CO_2^{2+}, CO^{q+} (with q=1,4,6) and various ionic fragments originating from multiply charged transient molecular ions in the time of flight (TOF) spectrum. The broad width of CO^+ indicates large kinetic energy release associated with it. The coincidence map of the TOF of the first and second ions arising from a single event and the triple coincidence, give the evidence of formation and dissociation of CO_2^{q+} (with q=2-6). A metastable state of CO_2^{2+} has been observed [5]. In the coincidence spectrum, C^+:O^+ island has a *star-like* structure due to different dissociation mechanisms. It is clear from the coincidence islands, lying along m/q lines of C^{q+} (q=1-3), that O ions, having charge states upto 4, possess much larger kinetic energies than corresponding C ions, as expected from linear geometry of CO_2 molecule. The narrow structures of O^{m+}:O^{n+} lie along -1 slope since they are moving with equal and opposite momentum leaving the central C ion at rest. But when the number of electrons removed from one of the peripheral O is greater than that of central C, coincidence islands between C and O ions show that C ions are produced with a not-inconsiderable amount of momentum which appears to be inconsistent with linear geometrical structure of CO_2 where C atom occupies the central position and would be expected to possess almost zero momentum due to the symmetrical rupture of both the bonds [6]. From the shape and slope of the coincidence island and with the help of numerical simulations, we have found that under the impact of low energy highly charged ions on CO_2, the linearity of the molecule is no longer maintained and this may give non-zero momentum contribution to the central C atom.

The more the electron removal takes place from one of the peripheral O atoms, more will be the bending of parent molecular ion, and C ion will be ejected with more kinetic energy release.

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