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Three-body fragmentation dynamics of CO_2^{q+} $(q = 3,\ 4)$ induced by electron collision at 500 eV impact energy

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Synopsis Electron impact induced three-body fragmentation of CO_2^{q+} $(q = 3,\ 4)$ is investigated. For CO_2^{3+}, non-sequential and sequential fragmentation processes are observed. For CO_2^{4+}, however, only non-sequential fragmentation processes are observed. The momentum correlations of each dissociative channel is analyzed by Newton diagram.

The fragmentation dynamics of molecule is one of the fundamental tasks in physics, chemistry as well as biology. The major challenges in this field are to understand the molecular bond breakage selectivity and to clarify which parameters control the bond cleavage. During the past decades, with the help of the rapid developing imaging techniques [1, 2], was it possible to reveal multi-body fragmentation dynamics for small molecules.

In this work, the three-body fragmentation dynamics of CO_2^{q+} $(q = 3,\ 4)$ is studied:

$$CO_2^{3+} \rightarrow C^{+} + O^{+} + O^{+}, \quad (1)$$
$$CO_2^{4+} \rightarrow C^{2+} + O^{+} + O^{+}, \quad (2)$$
$$\rightarrow C^{+} + O^{+} + O^{2+}, \quad (3)$$

where the molecular ions, CO_2^{q+} $(q = 3,\ 4)$, are formed by electron collision at impact energy of 500 eV and the three final ions are detected in coincidence by a momentum imaging system.

The Newton diagrams of channel (1), (2) and (3) are shown in Figure 1 (a), (b) and (c), respectively. The relative momentum vector of O^+ is fixed on the x axis while C^+ and another O ion are plotted in the upper and the lower half of the plane. For channel (1), as shown in Figure 1 (a), the two dense islands correspond to linear and bending dissociation of CO_2^{3+}. In addition, as marked by the dashed circle, each of the islands drags a half circle tail, which is the evidence of the sequential fragmentation of CO_2^{3+} [3, 4]. In this situation, the two C-O bonds break stepwisely.

The structures in Newton diagrams of channel (2) and (3) are similar to the dense islands in that of channel (1) indicating that the two C-O bonds break simultaneously in channel (2) and (3). For channel (2), the two O^+ ions are indistinguishable and they share equivalent momentum. As a result, the island of O^+ in the lower half plane of Newton diagram, as shown in Figure 1 (b), located on a circle with unit radius. For channel (3), the momentum of O^{2+} is larger than that of O^+. In addition, the correlation angle of C^+-O^{2+} is also larger than that of C^+-O^+. This is because that the Coulomb repulsion between C^+ and O^{2+} is much larger than that between C^+ and O^+.

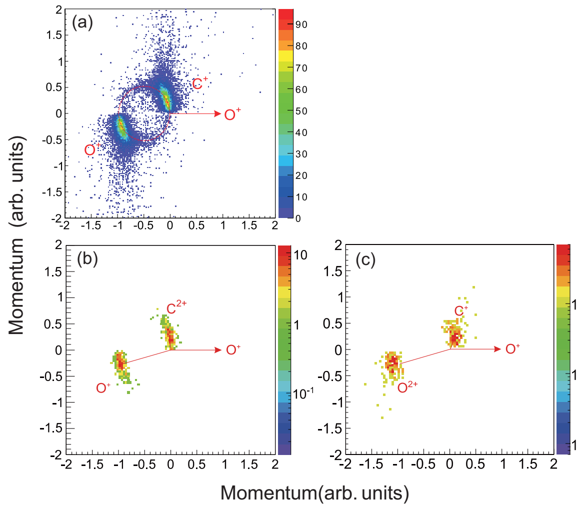

Figure 1. Newton diagrams for three-body fragmentation (a) for CO_2^{3+}, (b) and (c) for CO_2^{4+}.

References

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