

Investigation of fragmentation dynamics of nitrogen dimers by collisions with highly charged ions

X. L. Zhu*¹, S. Yan*, W. T. Feng*, D. L. Guo*, Y. Gao*, S. F. Zhang*, Z. K. Huang*,†, H. B. Wang*,†, D. B. Qian*, D. M. Zhao*, D. P. Dong*,†, and X. Ma^{† 2}

* Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou 730000, China

† University of Chinese Academy of Sciences, Beijing 100049, China

Synopsis The fragmentation dynamics of nitrogen molecule dimers have been studied by using highly charged Ne^{8+} ions at impact energy of 1.0 MeV. For its three-body fragmentation, three fragmentation mechanisms have been identified by analyzing Dalitz plot and Newton diagram of the momenta of three fragment ions. The sequential dissociation of covalent first breakdown is quite surprising in contrast to the fragmentation of triatomic molecule.

The multiple-ionization of clusters induced by highly charged ions may result in multiple bond breakage. If the target is nitrogen molecule dimer, which offers a combination of covalent bond and van der Waals bond [1], the opportunity to learn about the competition among different bonding schemes in the fragmentation process may be provided.

In an intuitive consideration, the covalent bond energy is three orders larger than the van der Waals bond energy, so the breakage of the latter one will be likely to happen in the cluster ion fragmentation. Does this assumption always true? In the present work, we investigated the three-body fragmentations of nitrogen dimer induced by 1 MeV Ne^{8+} ions by employing Reaction Microscopes in Lanzhou [2]. By detecting all fragment ions in coincidence, we obtained the momenta of each ion in the 3-body fragmentation of $(\text{N}_2)_2^{3+}$ ions. Through the corresponding Dalitz plot and Newton diagram of fragment ions momenta, contributions from three fragmentation mechanisms were clearly observed: (a) one step concerted fragmentation, in which the covalent bond N-N breaks up simultaneously with the breakup of the van der Waals bond $\text{N}_2\text{-N}_2$. (b) van der Waals-first-covalent-second sequential dissociation: the van der Waals bond breaks down in the first step, and a stable $(\text{N}_2)^+$ molecular ion is emitted, leaving a rotating metastable $(\text{N}_2)^{2+}$ ion behind. The $(\text{N}_2)^{2+}$ ion fragments in a second step after a time delay; (c) covalent-first-van der Waals-second sequential dissociation: the covalent bond breaks up firstly, and induces the production of $\text{N}^+(\text{N}_3)^{2+}$ ion pair, and leaves the $(\text{N}_3)^{2+}$ ion in a metastable state. In the second step, the transient ion $(\text{N}_3)^{2+}$ fragments into N^+

and $(\text{N}_2)^+$ ions through Coulomb explosion. The measured Newton diagram of three-body fragmentation is shown in Figure 1. The type (c) of sequential dissociation is surprising; it suggests the covalent bond may be more easily to fragment in some cases. It may be due to a potential energy minimum existing in the potential energy surface, which gives the priorities to the formation of metastable $(\text{N}_3)^{2+}$ than that of $(\text{N}_2)^{2+}$ [3].

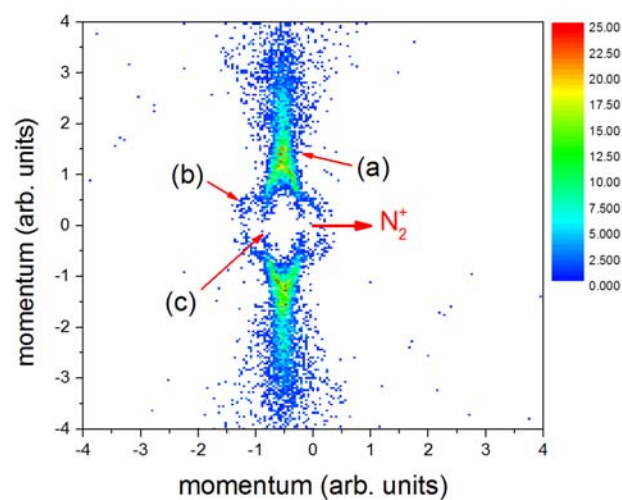


Figure 1. The Newton diagram for three-body fragmentation, $(\text{N}_2)_2^{3+} \rightarrow \text{N}^+ + \text{N}^+ + \text{N}_2^+$.

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References

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¹E-mail: zhuxiaolong@impcas.ac.cn

²E-mail: x.ma@impcas.ac.cn