Probing Coulomb fragmentation dynamics in MeV energy ion-molecule collisions

A. H. Kelkar, [1]*
*presenting author
[1]akelkar@iitk.ac.in, Dept. of Physics, Indian Institute of Technology Kanpur, Kanpur – 208016, India

The study of ionization and fragmentation dynamics of small and large molecules is an active area of atomic physics research. Fragmentation of molecular ions leads to the creation of atomic ions and free radicals. The creation and evolution of such ionic and neutral fragments is a key aspect in understanding the processes related to plasma physics, atmospheric and space physics, radiation damage etc. Towards this goal, we have developed a recoil ion momentum spectrometer (RIMS) setup for investigating heavy ion induced atomic and molecular ionization and fragmentation. The RIMS setup was designed and developed at IIT Kanpur. It is equipped with a 2D position sensitive detector and multi-hit TDC electronics for investigation of many-body breakup processes. The setup is installed at the 20-degree beam line of the 1.7MV tandetron accelerator facility, IIT Kanpur.

In this talk I shall discuss results from our recent experiments on molecular fragmentation of di- and tri- atomic molecules upon heavy ion impact. We have studied the fragmentation dynamics of the CO_2^{q+} (q=2,3) molecular ions formed under the impact of 1 MeV. Both two-body and three-body fragmentation channels arising from the doubly and triply ionized molecular ions of CO_2 are identified and analyzed. The slopes for different channels are extracted and compared with the previous experiments and theoretical predictions. Kinetic energy release (KER) distributions have been obtained for all these channels. With the help of Dalitz plots and Newton diagrams concerted and sequential processes have been assigned to different channels. In addition, angular correlations are used to determine the molecular geometry of the precursor molecular ion. It is found that the symmetric breakup involves asymmetric stretching of the molecular bonds in CO_2^{3+} prior to dissociation via concerted decay implying the fact that with 1 MeV proton induces an asynchronous decay in CO_2.

I will also discuss the fragmentation dynamics of triply charged, diatomic, molecular ions of NO and CO. Here, we have measured the Kinetic Energy Release distributions (KERDs) for various fragmentation channels. The potential energy curves (PECs) for ground and several excited states of NO^{3+} and CO^{3+} molecular ions were also calculated using the multi-reference configuration interaction (MRCI) method. The obtained KERDs will be discussed in the background of the calculated PECs as well as the simple Coulomb excitation model. We have observed that the Coulomb breakup of the precursor molecular ion shows a clear preference for the $N^{2+} + O^+$ (and $C^{2+} + O^+$) fragmentation channel.

References:
1. Duley, A., Tyagi, R., Bari, S. B. & Kelkar, A. H. Design and characterization of a recoil ion momentum spectrometer for investigating molecular fragmentation dynamics upon MeV energy ion impact ionization. *Rev. Sci. Instrum. 93, 113308 (2022)*.
2. Duley, A., Dutta, N. N., Bagdia, C., Tribedi, L. C., Safvan, C. P. & Kelkar, A. H. Fragmentation dynamics of diatomic molecules under proton impact: Kinetic energy release spectra of CO^{q+} and NO^{q+} (q = 2, 3) molecular ions. *Eur. Phys. J. D 76, 162 (2022)*.