Multiple ionization of Coronene ($C_{24}H_{12}$) induced by fast O ions: Large enhancement in double and triple ionization

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Synopsis The multiple ionization and fragmentation of coronene ($C_{24}H_{12}$) under impact of fast (2-6 MeV/u) O-ions are investigated as a function of projectile energy and charge state q (between 5+ to 8+). The Wiley-McLaren type time-of-flight mass spectrometer has been used. The absolute cross sections are deduced by using a novel normalization procedure. The partial cross sections for formation of different charge states (1+ to 3+) of the coronene parent ion are also studied. Dramatically large enhancements in the double and triple ionization, compared to other gas atoms and fullerene, are observed.

Polycyclic aromatic hydrocarbons (PAHs) have been in the focus of atomic and molecular physics research over the last decade or so. From an astrophysical viewpoint, the interaction of these molecules with ultraviolet (UV) radiation, as well as with ions over various energy ranges present in the stellar wind can shed light on the astrochemistry of these molecules. While several studies exist for PAH interaction with UV photons [1], as well as with low-energy ions [2], the interaction of high energy ions with PAHs are quite sparse in the literature. The impact of fast heavy ions (∼few MeV/u) can lead to multiple ionization and fragmentation of molecules as the dominant channel. We have also observed the influence of giant plasmon resonance on the electron emission spectrum in such collisions. It would be interesting to study the single and multiple ionization of the PAHs, such as, coronene ($C_{24}H_{12}$) under the impact of fast highly charged ions.

We have measured the mass spectra of coronene in collisions with 1.5-5.5 MeV/u O^{q+} ions with q_O =5 to 8. We have normalized the spectra using a novel normalization procedure, based on the KLL Auger electron peak as obtained from the electron spectrometer based experiment. A typical spectrum is shown in Fig. 1. In recent experiments with UV photons (see *e.g.* [1]), the intensity-ratio of doubly ionized to singly ionized charge states (R_{21}=I(2+)/I(1+)) of PAHs and other large molecules displays an 'anomalous' rise above the corresponding scaled values for the He atom. Since ionization is one of the dominant channels in fast highly charged ion impact, we would expect such effect to be enhanced. We have deduced the the intensity ratio, R_{21}, R_{31} i.e. the intensity ratio of triple-to-single ionization. The ratio R_{21} is found to be as large as ~ 1.6 and R_{31} was also as large as ~ 0.6. This imply that double ionization is doubly probable than the single ionization and the triple ionization is as strong as single ionization. The ratio 2+/1+ for the N_2, measured in the same experiment, is much less (i.e. only about 0.1-0.2), indicating a different mechanism of coronene-ionization compared to ion-atom collisions. We surmise that this may be due to the effect of the plasmon resonance of the correlated electrons in coronene [3] combined with the planar geometry. The ratio R_{21} in case of C_{60} fullerene [4, 5] under fast heavy ion collisions was found to be about 28% in our earlier investigation which is still large compared to simple gaseous atoms/molecules, but much lower compared to that for the coronene.

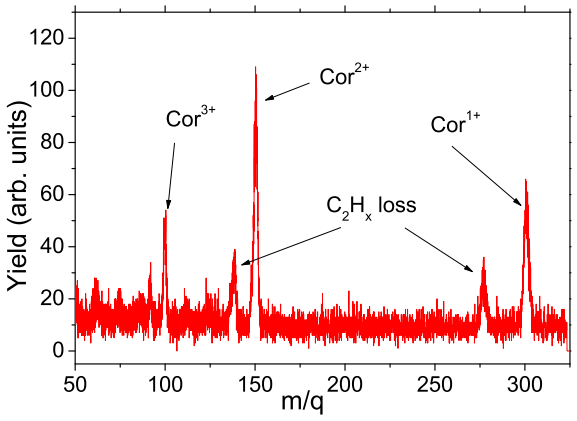

Figure 1. Typical time-of-flight spectrum for coronene under 3.75 MeV/u O^{8+} impact

References

[1] T. Hartman *et al.* 2013 *Phys. Rev. A* **87** 063403

[2] H. A. B. Johansson *et al.* 2011 *Phys. Rev. A* **84** 043201

[3] S. Biswas and L. C. Tribedi 2015 *Phys. Rev. A* **92** 060701(R)

[4] L.C. Tribedi, A. H. Kelkar S. Kasthurirangan 2010 *Nucl Instr and Meth B* **268** 060701(R) 3183

[5] A. H. Kelkar, L. GulyÃąs, and Lokesh C. Tribedi , 2015 *Phys. Rev. A* **92** 052708

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