

§18. Plasma Spectroscopy in Dissociated Fragments Produced from Vibrationally Excited Molecules

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In research on the controlled thermonuclear fusion, electron capture processes of slow H^+ ions in collisions with impurity molecular gases such as hydrocarbons and other fusion relevant molecules below a few-keV energies play a key role in low temperature edge plasmas of the current fusion devices with carbon-coated or graphite-lined walls as plasma facing materials. These impurity hydrocarbons, which have been detected near the divertor region in many different kinds of experiments, are known to be in highly vibrationally excited states. Although many experimental studies on charge transfer and ionization in collisions of plasma ions with these impurities have been performed, these investigations were concerned with vibrationally ground-state molecules, but experimental as well as theoretical studies from vibrationally excited targets are nearly non-existence. However it has been well known that under the usual operational condition of fusion reactors, non-negligible amount of gases is known to be in vibrationally excited state. Although collision cross-section data from these vibrationally excited species are urgently needed, very few study has been carried out so far. Furthermore, after collisions, these molecular ions and excited species produced are unstable and undergo dissociation producing various kinds of fragmented species such as radicals and smaller ionic species. By detecting photons emitted from these fragmented species, many kinds of

physical parameters characterized plasma qualities could be extracted.

For this reason, we have been undertaking a joint experimental and theoretical investigation for charge transfer of H^+ , He^+ , C^+ and O^+ ions colliding with vibrationally excited hydrocarbons and others such as H_2 , D_2 , CH , NH , H_2O , NH_3 , and C_mH_n ($m < 4$) molecules in the energy range of 0.2 to 4.0 keV in collaboration with Prof. Buenker at U. Wuppertal. As one of the most important findings from this research, here we summarize that for some molecules, vibrationally excited species in the initial channel decrease the exothermicity, and hence, are expected to increase the electron capture cross section by an order of magnitude even when the target is in the first vibrational excited state. On the other hand, for others, vibrational excited states are found to increase the exothermicity, which may lead to the smaller cross section. Hence, dynamics of electron capture from the vibrationally excited molecule varies from system to system, and needs to be considered carefully and systematically [1, 2].

As for production of fragmented species, we have observed the strong dependence on the vibrational state, i.e., *the temperature effect*, in which the vibrational state of the target molecules significantly affects the production mechanism and hence kinds of species produced. Accordingly, our results clearly suggest the strong species-dependence of emitted photons.

References

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