PROGRESS IN THE KINETICS OF NON-EQUILIBRIUM PLASMAS

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The kinetics of dissociation of diatomic molecules under non-equilibrium plasmas is a complicated result of different microscopic processes. The kinetics is initiated by the electrons which pump vibrational energy in the ground electronic state of the molecule. The introduced vibrational quanta are then redistributed by V-V (vibration-vibration) energy exchanges up to the top of vibrational ladder. This pumping mechanism is hindered by V-T (vibration-translation) energy exchanges, which tend to destroy the vibrational content of the molecules. This pumping mechanism, called pure vibrational mechanism (PVM), can be important to dissociate those molecules such as N_2 and CO which present high e-V (electron-vibration) and V-V rates and small V-T ones. The importance of PVM is, however, weakened by the onset of the atoms, which are in general very effective in removing vibrational energy.

An other important dissociation mechanism comes out from direct excitation of diatomic molecules by electrons (DEM). The combination of PVM and DEM brings to a joint vibroelectronic mechanism (JVE). In this case, however, DEM occurs not only from the ground vibrational level of the molecule but also from high lying vibrational levels populated by e-V and V-V energy exchanges.

All these mechanisms need of the knowledge of e-V end e-D (electron-dissociation) rates, which can be obtained from the relevant cross sections and from the electron energy distribution function (edf). Edf's, in turn, depend on the vibrational non equilibrium present in the discharge, specially through the superelastic vibrational collisions. This means that a good characterization of PVM, DEM and JVE can be done only coupling the Boltzman equation for edf with the system of kinetic equations describing the vibrational population densities as well as the atom concentration. The relative selfconsistent problem will be in particular discussed for H_2 and O_2.

The presence of parent atoms has in general three effects i) a strong deactivation of vibrational energy ii) a modification of the electron energy distribution function of the molecular system iii) a creation of a vibrational plateau extending from the continuum to levels near to the ground vibrational state. Point iii) can favour dissociation via the vibrational ladder.

The close analogy between the processes induced by electrons and the corresponding ones induced by IR laser pumping will be emphasized. The superposition of an IR pulsed CO laser to a CO discharge will be also considered, particular attention being focused to the effects on the dissociation rate.

The non equilibrium vibrational situation previously described can influence the synthesis of NO from vibrationally excited N_2.

Some experimental evidence of non equilibrium vibrational effects on the dissociation and chemical reactions of polyatomic molecules has been recently reported by our laboratory. An attemptto explain these effects can be done by using a model developped for understanding IR laser induced reactions under the collision regime.