Dication formation and escape probability of ions from planetary atmospheres

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In space, ionic species are formed in various ways, depending on the specific conditions of the extraterrestrial environment considered. They are extremely important in the upper atmosphere of planets where they govern the chemistry of ionospheres. Molecular ions have also been detected in comet tails. The interaction of neutral molecules with cosmic rays, UV photons, X rays and other phenomena such as shock waves are all important processes for their production. In general, the UV photons (in the Vacuum and Extreme UV with a wavelength ranging between 200 and 10 nm, i.e. 6.20 and 124 eV, respectively) have enough energy to ionize molecules producing single and doubly charged ions. In the latter case we have the so called molecular dications.
The experimental and theoretical characterization of the fundamental properties of multiply charged molecular ions, such as energetics, structure, stability, lifetime and fragmentation patterns, is of great interest to understand and to model the behavior of gaseous plasmas as well as ionosphere and astrophysical environments. The measurements of the Kinetic Energy Release (KER) for various ionic species originating_from two-body dissociations reactions, induced by Coulomb explosion of molecular dications produced by double photoionization of CO_2, C_2H_2 and N_2O neutral molecular precursors of interest in planetary atmospheres, are reported. The KER distributions as a function of the ultraviolet (UV) photon energy in the range of 30-65 eV (Vacuum and Extreme UV photons) are extracted from the electron-ion-ion coincidence spectra obtained by using tunable synchrotron radiation coupled with ion imaging techniques. at the ELETTRA Synchrotron Light Laboratory Trieste, Italy**,** using the ARPES end station of the Gasphase Beamline. This experimental method, coupled with a computational analysis of the data based on a Monte Carlo trajectory simulation allows assessing the probability of escape for some simple ionic species in the upper atmosphere of Mars and Titan. In fact, the KER measured for H^+, C^+, CH^+, CH_2^+, N^+, O^+, CO^+, N_2^+ and NO^+ fragment ions are ranging between 1.0 and 5.5 eV (only for H^+ the maximum value reaches 6.0 eV), and these translational energies are large enough to allow these ionic species in participating in the atmospheric escape from Mars and Titan into space (for CO^+, N_2^+ and NO^+, the measured KER of 0.5-2.5 eV, 0.5-2.8 eV and 1.0-2.5 eV, respectively, allows the possible escape only from the Titan atmosphere) [1]. Moreover, these studies are helpful in understanding important details about the chemistry of the planet ionospheres, like that of Mars where we were able to suggest a possible explanation for the observed behavior of the O^+ and CO_2^{2+} ion density profiles.

[1] S. Falcinelli et al., 2014, Planetary and Space Science, 99, 149
[2] S. Falcinelli et al., 2014, Lecture Notes in Computer Science, 8579, 55

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