DUBLIN CITY UNIVERSITY

Abstract

Faculty of Science and Health

School of Physical Sciences

Doctor of Philosophy

Fast and Ultrafast Multiphoton-Multicolour Ionization and Spectroscopy of Small Quantum Systems

by Lazaros Varvarezos

The interaction of atoms (Kr) and small molecules (CO_2, CH_4), with laser light emitted by different types of sources was investigated.

Photoelectron spectroscopy was applied to study the two photon double ionization of krypton, induced by free electron laser (FEL) photons at 25.2 eV. Velocity map imaging (VMI) spectroscopy was also used to record the angular distributions of the photoelectrons for both the first and second ionization steps. The resolution of the spectrometer was high enough to allow for resolving the spin-orbit components in the photoelectron spectra. Measurements for different FEL intensities were performed to illustrate the intensity dependence for each spin-orbit component. The main result was the observation of an intensity dependent pattern, characteristic for each spin-orbit component.

Photoabsorption measurements around the carbon and oxygen K-edges were acquired for neutral 'not ionized' CO_2 and CH_4 molecules. Similar measurements were performed for the CO_2 and CH_4 photoionized plasmas. The photons used to create and subsequently probe the plasmas were emitted by a laser produced plasma (LPP) source based on the double stream gas puff target geometry. The main result, was the observation of atomic ions in the absorption spectra of the photoionized plasmas, contrary to the case of the 'not ionized' neutral molecules.

A comparative study was performed for methane irradiated by ultrafast laser pulses at 800 nm and 400 nm. Ionization and subsequent dissociation mechanisms were investigated via ion spectroscopy at different laser intensities for both the fundamental (800 nm) laser field and the second harmonic (400 nm) field. The main result was the observation of different fragmentation pathways for each laser wavelength. The fragmentation pathways were also found to be dependent on the laser intensity.