Chemistry in Attoseconds: Ultrafast Hydrogen Migration in Hydrocarbon Molecules in Intense Laser Fields

Kaoru Yamanouchi

Department of Chemistry, School of Science, The University of Tokyo, Japan

In an ultrashort intense laser field, molecules exhibit a variety of characteristic dynamics. Among our recent experimental findings, ultrafast migration processes of hydrogen atoms within a polyatomic molecule are noteworthy [1]. The discovery of the ejection of triatomic hydrogen molecular ions, H_3^+, from methanol (CH3OH) was the beginning of the series of our studies on ultrafast hydrogen migration [1-4]. By introducing the coincidence momentum imaging method, we found for methanol [3] and allene (CH_2CCH_2) [4] that the ultrafast hydrogen migration process occurs during the ultrashort laser pulse duration of 10~60 fs, indicating that hydrogen atoms move extremely rapidly. This can be regarded as an appearance of quantum mechanical nature of light-weighted hydrogen atoms. For probing this ultrafast spread of the distribution of hydrogen atoms within a molecule, it will be necessary to introduce attosecond pulses whose pulse duration is below 1 fs. The ultrafast hydrogen migration is now guiding us to the new experimental frontiers of attosecond chemistry as well as to the new theoretical frontiers beyond the BO approximation.

[1] Y. Furukawa, K. Hoshina, K. Yamanouchi, H. Nakano, *Chem. Phys. Lett.* **414**, 117-121 (2005).
[2] T. Okino, Y. Furukawa, P. Liu, T. Ichikawa, R. Itakura, K. Hoshina, K. Yamanouchi, H. Nakano, *Chem. Phys. Lett.* **419**, 223-227 (2006).
[3] T. Okino, Y. Furukawa, P. Liu, T. Ichikawa, R. Itakura, K. Hoshina, K. Yamanouchi, H. Nakano, *Chem. Phys. Lett.* **423**, 220-224 (2006).
[4] H. Xu, T. Okino, and K. Yamanouchi, *Chem. Phys. Lett.*, **469**, 255-260 (2009).