Control of Structure and Reactions of Molecules and Clusters in Intense Laser Fields

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強光子場中において、原子、分子、クラスターは特異な振る舞いを示す。我々は新しい実験手法を開発することにより、強光子場中での分子およびクラスターの反応ダイナミクスを明らかにするとともに、その制御を試みている。

From the pioneering studies in resent years, it has been revealed that atoms, molecules and clusters behave in very characteristic ways in an intense laser field whose magnitude is as large as the Coulomb field within atoms and molecules [1]. In such an intense laser field, atoms, molecules, and clusters are heavily mixed with the light field, and are multiply ionized in most cases, and eventually, a phenomenon called Coulomb explosion occurs in which multiple-charged parent molecules are decomposed into smaller charged fragment ions having large kinetic energies.

Recently, our group introduced a new method called coincidence momentum imaging (CMI) [2], and this method was found to be very powerful in determining the fragmentation pathways of multiply charged parent ions. For example, the existence of the two different three-body fragmentation pathways of CS_2^{3+}, that is, the concerted pathway and the stepwise pathway, was shown clearly by the CMI method [3]. Furthermore, the temporal evolution of the nuclear wavepacket of CS_2^{2+} formed in an ultrashort pulsed intense laser field was traced in real time by the pump-and-probe technique combined with coincidence momentum imaging. On the basis of the momentum correlations among the fragment ions obtained as a function of the pump-probe time delay, it was revealed that the nuclear wavepacket in CS_2^{2+} evolves not only along the anti-symmetric stretching coordinate to yield S^+ and CS^+ but also along the symmetric stretching coordinate leading to the simultaneous breaking of the two C-S bonds.

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We showed also that the temporal width of short pulsed laser light is a key factor for the selective bond breaking in ethanol by adopting the pulse shaping technique [4], and that the characteristic decomposition reaction proceeds within the complexes of aniline cation with ammonia molecules by tandem-type mass spectrometry [5].

References

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