Observation of Ultrafast Intra-Molecular Charge Migration in a Biomolecule

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Ultrafast charge migration within single molecules is the fundamental initiator of many important biological processes and chemical reactions, including photosynthesis, catalysis, and DNA damage by ionizing radiation [1,2]. Recent developments of attosecond science not only facilitate the observation of such dynamics, but also unveil the possibility of controlling electron dynamics within molecules and nanostructures.

We present here the first experimental observation of ultrafast charge migration in a biological molecule - the amino acid phenylalanine. To facilitate gas-phase studies, we have developed a laser-induced acoustic desorption (LIAD) technique to produce clean, neutral plumes of isolated molecules [3]. This target was irradiated by an XUV pulse (consisting of two attosecond pulses separated by 1.5 fs) to ionise an electron from the molecule, creating a positive hole. By using a 6 fs, visible/near-infrared probe pulse at a controllable delay time, the positive charge was observed to migrate to one end of the cation within 30 fs [4]. This was achieved by observing the yield of a doubly charged ion which was sensitive to the relative location of the hole (figure 1).

A process on this timescale is consistent with a model of ultrafast, coherent, charge oscillations to and from one end of the cation being terminated due to nuclear rearrangement. This scheme provides an extremely powerful technique for further studies of this phenomenon, in which we can hope to understand more fully the principles of ultrafast intra-molecular charge migration.

![Figure 1: The yield of doubly charged immomium ions with respect to the time delay between the XUV pump and VIS/NIR probe. Charge migration to one end of the cation suppresses ionisation by the probe.](image)

References