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EDITORIAL

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Editorial

Special issue celebrating 25 years of re-collision physics

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Twenty five years ago, a novel physical picture came into focus, one that allowed for a unified interpretation of phenomena such as above threshold ionization (ATI) and high harmonic generation (HHG), which had fascinated and perplexed the strong field atomic and molecular physics community over the preceding decade. In a number of papers that followed each other in rapid succession, experimental observations made possible by newly-developed laser sources were explained by breaking down the laser–atom interaction into steps that are distinguished by their very different time, energy and length scales. These include (i) field-driven ionization over a small fraction of the laser cycle, (ii) propagation and acceleration of the ionized electron under the influence of the oscillatory laser electric field, driving the electron first far away from the ion core and then back towards it, leading to (iii) an electron–ion re-collision. The electron's return facilitates the production of high harmonic radiation, further excitation or ionization of the ion in inelastic collisions, or elastic scattering resulting in high energy ATI electrons. Importantly, the recollision process is coherent—the electron interacts with the ion core it left—and lasts for a small fraction of the laser cycle, enabling attosecond physics to emerge out of the non-linear dynamics driven by femtosecond lasers.

In the years that have followed, this intuitive picture has formed the basis for a number of revolutionary developments, most prominent of all the emergence of attosecond science. This is because the recollision picture, while easily grasped, also allows for a number of solid predictions, especially the intensity-dependent phase of the returning electron wave packet, which dictates the spatial, spectral and temporal properties of the observed attosecond radiation. This deep understanding of the properties of attosecond pulses has also allowed ultrafast physics to expand from studying the time-dependent properties of atoms and molecules to studying the time-dependent properties of the electrons inside these atoms and molecules, which govern most of their physical and chemical properties.

The impact of the recollision picture has not been limited to HHG. An ever-deepening understanding of electron–ion recollisions has led to novel insights into electron correlation, manifest, for example, in the process of non-sequential double ionization, and the measurement of the absolute phase of laser pulses via the observation of elastically rescattered electrons. In recent years, it has inspired novel approaches towards elucidating time-resolved structural changes in molecules through the concept of laser-induced electron diffraction (LIED). Today, LIED is used as a method to determine both static molecular structures as well as the time-dependent structures of molecules undergoing the first steps towards a chemical change. Significant further development of the LIED technique may be anticipated in the years to come.

The purpose of this special issue is to celebrate the recollision model that emerged twenty five years ago, and also to highlight many of the important developments in recollision physics that have occurred since then. We hope that it will inspire new insights and innovations in the many areas touched by strong field physics. Whether grouped under the commonly used headers of 'strong field

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physics', 'recollision physics' or 'attosecond science', the message remains the same: highly intuitive physical pictures such as the recollision model of HHG continue to provide a powerful means to interpret experiments involving strong laser fields, and they continue to guide the development of important spectroscopic techniques.

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