College of Natural Sciences
& Mathematics
UNIVERSITY OF DENVER

Physics & Astronomy Colloquium

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Dr. Kathryn Hamilton

Professor, Department of Physics
University of Colorado Denver

Electrons Under Inspection: Probing Electron Dynamics Via High-Harmonic Generation

Since their discovery in the late 1800's, electrons have been a constant source of curiosity for scientists. Their properties and behaviour have been studied and harnessed to produce some of the greatest inventions of the past century, including electron microscopes and particle accelerators. However, one fundamental question about their behaviour still remains: how do electrons move inside atoms and molecules?

Electron motion within atoms has proved difficult to study due to the incredibly short timescale it occurs on (the attosecond timescale, or 10-18 seconds). One method of capturing electron motion is to use very short laser pulses to take a series of snapshots of the system. This requires laser pulses shorter than the duration of the dynamics we want to observe (similar to using a short flash on a camera to obtain an image of a fast-moving object). The means to do this have only become possible in the past decade with the advent of new ultrashort (<100 as) lasers, which have become feasible due to a process called high-harmonic generation (HHG).

Harmonic generation occurs when an atom is exposed to a short laser pulse. Electrons are removed from the atom by the laser field, accelerated, and then recombine with the parent atom emitting high-energy harmonic light. This light can then be manipulated to produce the attosecond pulses required to image electronic motion. Analysis of the spectra produced by harmonic generation can also give an insight on the attosecond-scale dynamics of electrons. An accurate theoretical description of high harmonic generation would therefore be extremely beneficial for the advancement of attoscience.

In this colloquium I will present recent results obtained using the R-Matrix with Time dependence (RMT) method, firstly to treat high-harmonic generation in two-color laser fields, and then on applications of the attosecond pulses generated during the HHG process to measure ionization delays. Finally, I will comment on planned future extensions of the RMT code, including an interface with the B-Spline atomic R-Matrix (BSR) code, and the operation of both codes via the Atomic, Molecular, and Optical Sciences (AMOS) Gateway.

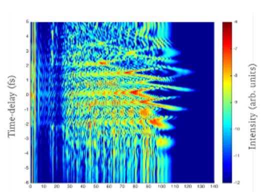

Figure 1: High-harmonic spectrum of neon atoms irradiated by a two-color (800nm + 400nm) laser field. The red "v" shapes are spectral caustics, formed by the coalescence of two or more electron trajectories in the same energy space.