De-exciting Rydberg Atoms Using a Half-Cycle THz Pulse Train

Pankaj K. Mandal, Kourosh Afrousheh, and Andrew Speck
Rowland Institute at Harvard, Harvard University, Cambridge, MA 02142, USA

Abstract— **Work is in progress to combine an ultra-cold atom trap and half-cycle THz set-ups. Half-cycle THz pulses generated via exciting a GaAs antenna by a femtosecond laser beam of a Ti:Sapphire oscillator have been characterized in detail. The effect of fiber coupling on THz generation has been studied.**

The objective of our research is to study the interaction of highly excited, or Rydberg atoms, with unipolar terahertz (THz) electromagnetic pulses (half-cycle pulses). These systems provide a fascinating regime in which to explore atomic states which exhibit both classical and quantum properties. In particular, these pulses provide an impulsive kick to the excited electron and thus interact in a much different manner than traditional bipolar continuous wave laser radiation.

Previous theoretical studies have suggested that the application of a certain number of these pulses should drive the Rydberg atoms to lower quantum states.[1] More recent theoretical work shows that a properly chirped half cycle pulse train can de-excite the Rydberg atoms more efficiently.[2] In principle this broadband technique should allow the efficient de-excitation of antihydrogen atoms from the currently produced mix of excited states to the ground state which is a necessary prerequisite for a CPT comparison with hydrogen.

The THz set-up for producing half cycle pulses (Figure 1) and an ultra-cold atom trap for producing Rydberg atoms (Figure 2) have been fabricated independently. The half cycle THz pulses are produced by exciting a GaAs photoconductive antenna by ultrafast laser pulses, produced by a Ti:Sapphire oscillator. The half-cycle THz pulse generation has been characterized extensively.

A hollow-core photonic band gap crystal fiber is used to deliver the laser pulses to the photo-conductive antenna, which will sit right outside the atom-trap chamber. This fiber makes it possible to focus an ultrafast laser beam onto the antenna without causing excessive loss and dispersion. This arrangement enables us to avoid using a large number of optics and the chance of misalignment in order to route the ultrafast laser beam to another room. The dependence of the nature of the half-cycle pulses on the fiber coupling has been studied.

The work to combine the THz set-up with Rydberg atoms is in progress. Upon successful completion, the experiment of de-excitation of Rydberg atoms by interaction with a train of half cycle pulses will be conducted. The latest results will be presented in the poster. In particular, characterization of half-cycle pulse generation and fiber coupling will be discussed.

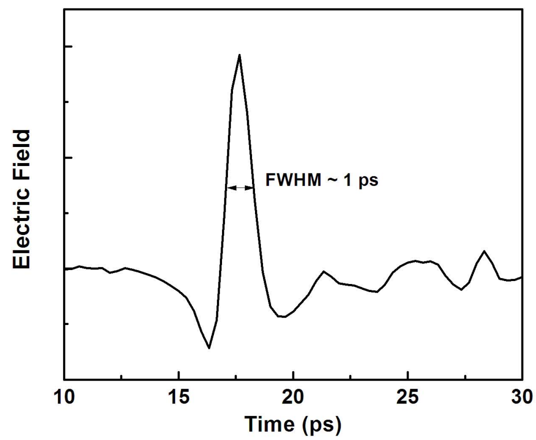

Figure 1: Half-cycle THz pulse produced by exciting a GaAs photoconductive antenna by an ultrafast laser pulse obtained from a Ti:Sapphire oscillator.

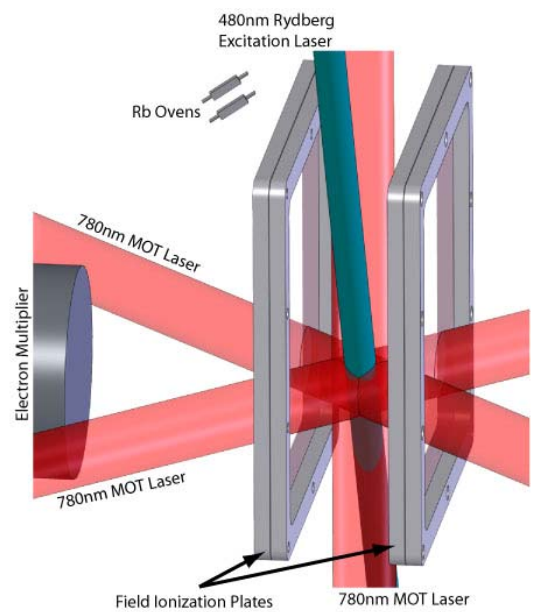

Figure 2: Schematic of the ultra-cold atom trap.

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