Time Resolved Measurements of the Polarization State of Supercontinuum Generated in a Monatomic Gas

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Introduction

In previous work [1] we found that circularly polarized few-cycle pulses were more effective at accelerating low divergence, quasimonoenergetic electron beams than their linearly polarized counterparts. These pulses were generated by sending initially elliptically polarized pulses which evolve to circular after propagation through a hollow core fiber (HCF) differentially pumped with Helium and compressed afterward with a chirped mirror compressor. While temporal and spectral effects due to polarization ellipse rotation due to nonlinear effects from bound electrons are well understood [2] as illustrated by its use as a mode locking technique [3] and compression technique [4,5], the temporal effects due to ionization from the laser pulse during supercontinuum generation have only been studied in simulations [6]. In this work we study these effects on the supercontinuum generation by measuring the temporal electric field of the laser pulse before and after spectral broadening.

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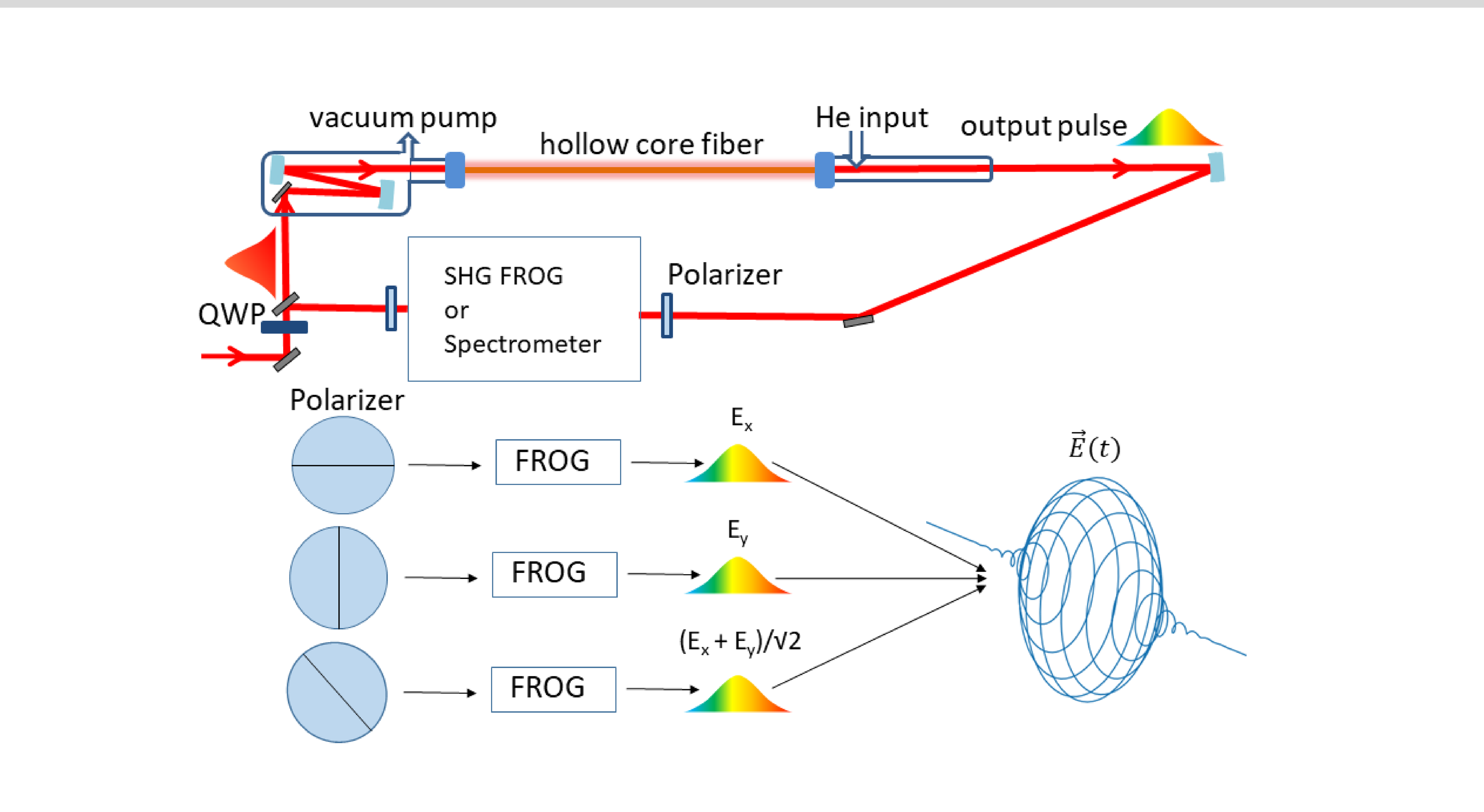
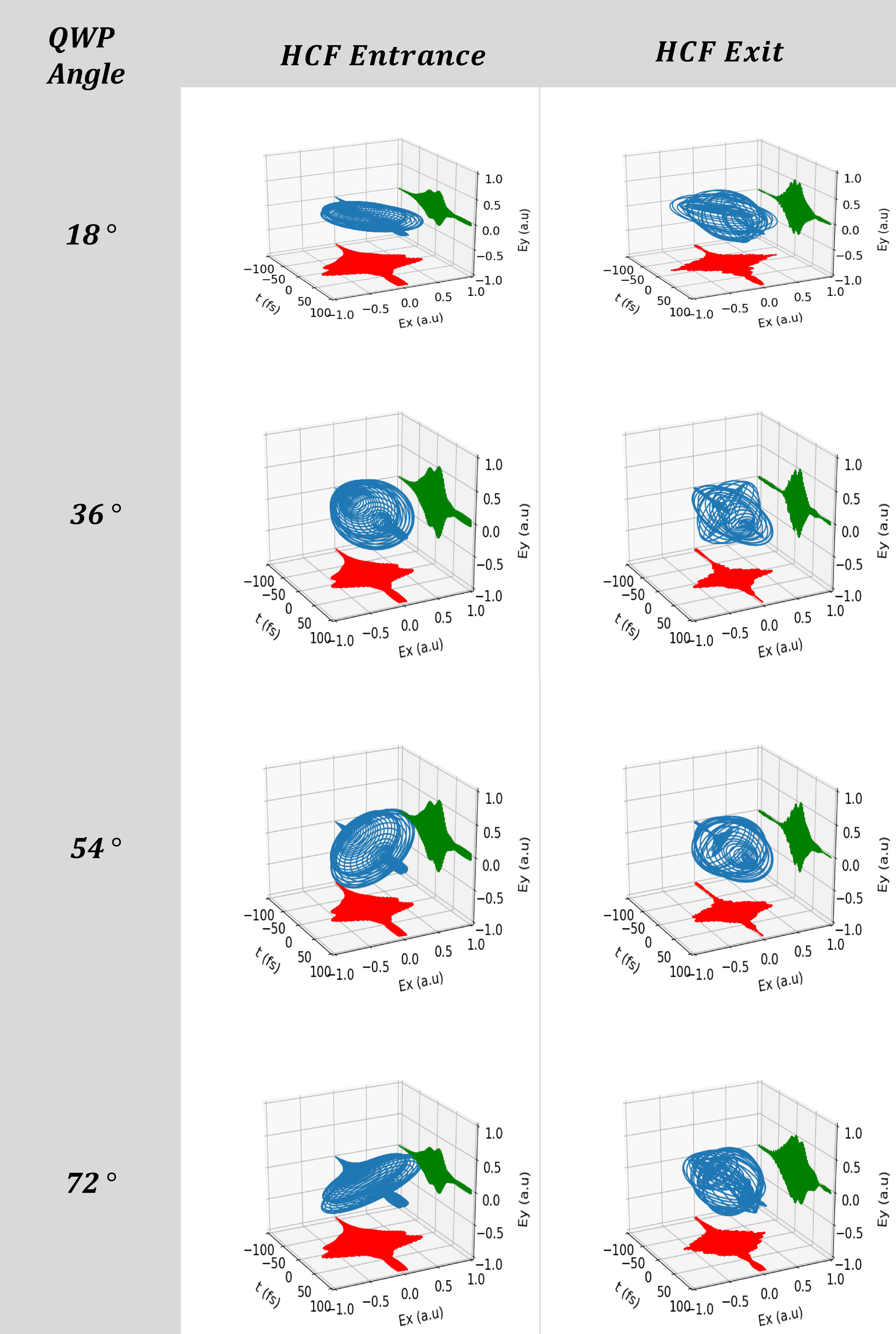
Setup for Measuring Time-Resolved Polarization State



- 40 fs, 6 mJ, 800 nm pulses from pulses from a Ti:Sapphire chirped pulse amplifier are sent through a helium filled HCF with 500 micron core to an SHG FROG after passing through a polarizer at 3 different orientations.
- The FROG traces taken after passing through the polarizer at 2 orthogonal orientations allow for the two transverse components of the electric field to be determined. A FROG trace taken after passing through the polarizer at a third intermediate orientation determines the delay and phase between the components [7,8].

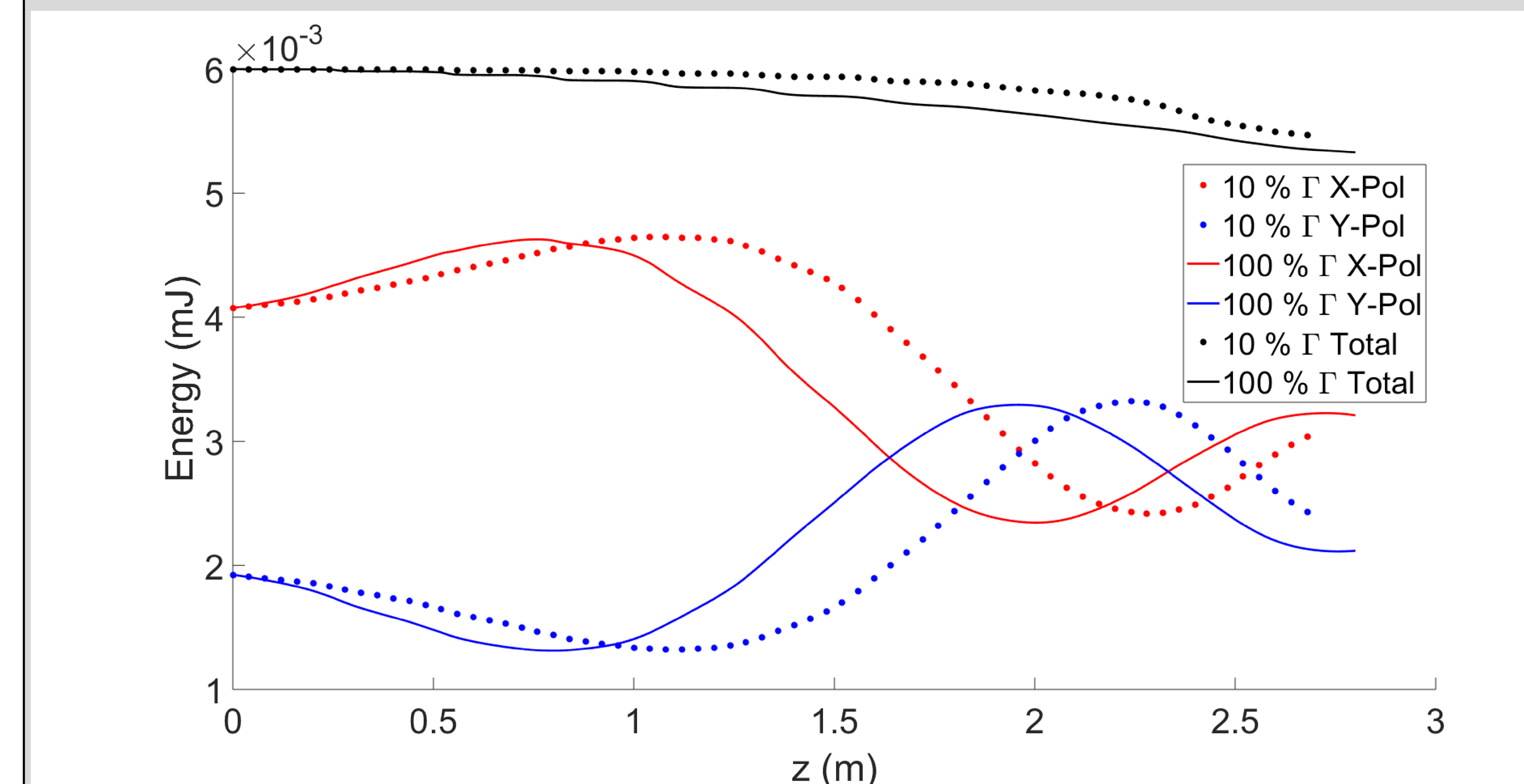
Time Resolved Electric Fields at HCF Entrance and HCF Exit



Preliminary measurements of time resolved polarization state of the pulse before and after propagating through a helium filled HCF at various input polarization states. The quarter waveplate (QWP) angle is taken with respect to the initial polarization of the laser pulse.

- An elliptically polarized input leads to a more circular output [9] that has a nontrivial temporal polarization structure.

Simulations of Polarization Evolution in the Fiber



Unidirectional Pulse Propagation Equations (UPPE) of the evolution of the polarization for an elliptically polarized (QWP at 26.5°) pulse with 6 mJ input energy 40 fs FWHM duration. Γ is the ionization rate.

- Higher ionization rates cause the polarization state of the pulse to evolve more quickly despite a faster decrease in total pulse energy.
- Bound electron effects, such as nonlinear ellipse rotation [5], alone cannot explain the evolution of the polarization state.
- Ionization modifies the polarization dynamics in a nontrivial way.

Conclusions and Future Work

- Time resolved measurements of the vector electric field are useful for investigating polarization dynamics that take place on a femtosecond time-scale at high intensities.
- We have measured the time resolved electric field before and after supercontinuum generation in a helium filled hollow core fiber.
- A nontrivial temporal polarization structure was observed.
- UPPE simulations indicate that Ionization plays a major role in the evolution of the polarization state.
- In the future, we will study how delayed nonlinear effects (not present in monatomic gasses) and the ionization mechanism involved affect the evolution of the polarization state.

Acknowledgements

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