

ULTRAFAST PULSE SHAPING:  
AMPLIFICATION, CHARACTERIZATION,  
AND APPLICATIONS

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## *ABSTRACT*

The phenomena of self-induced transparency and adiabatic rapid passage can be predicted from the Maxwell-Bloch equations. These equations govern the propagation of light through a two-level system, such as a gas of rubidium, which includes not only the effect of the atoms on the light pulse, but the effect of the light pulse on the atoms. Previous experimental work has demonstrated these effects. Theoretical work has predicted that a particular optical pulse shape, the secant hyperbolic pulse with tangent hyperbolic frequency sweep, will be particularly robust method of demonstrating adiabatic rapid passage. In this work, we experimentally study, for the first time, the effect of this pulse shape on an atomic system.

Making a high energy shaped pulse required developing a unique laser system. Technology already existed that allowed us to generate amplified pulse shapes. Also, unamplified pulse shaping has been demonstrated. We demonstrate the amplified pulse shaping system. As we will show, this system is a versatile tool that allows us to shape pulses in the amplitude and phase domains. We also utilised an advanced detection tool, the STRUT, that allowed us to fully characterize the shaped femtosecond pulses. Using the techniques outlined in this work, we hope that other researchers will find it straightforward to construct their own amplified pulse shaping system.

Having shown the capability to do amplified pulse shaping, we applied this work to an atomic system, rubidium. The results were quite intriguing, although not what we initially had expected. The data shows that the pulses are being reshaped in the spectral domain,

and the nature of that reshaping depends on the input pulse shape. They also show evidence of inversion, and that inversion depends on the pulse shape. Self-focusing is also observed. Using a computer simulation, it was shown that the results were in fact consistent with the Maxwell-Bloch equations.

These surprising results from the rubidium experiment suggest a wide variety of future experiments. Hopefully, this amplified pulse shaping laser system will produce many more interesting results.

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