

Observation of Coherence Effect of Two-Color Exciting Nonlinear Frequency Conversion in Argon

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Abstract

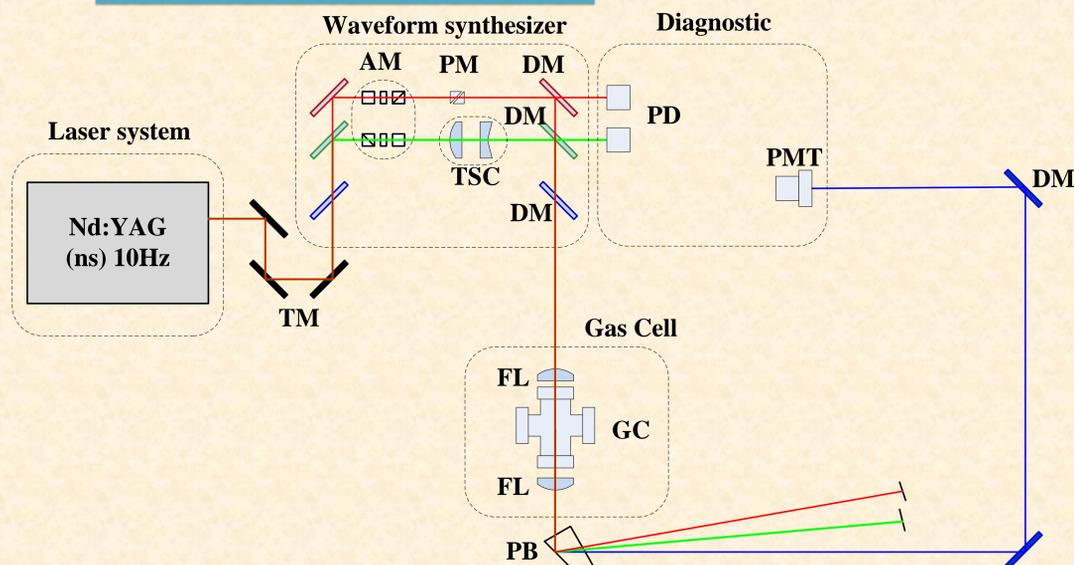
We observed the coherent control of third harmonic signal (355nm) by the interference of direct third harmonic generation ($3\omega = \omega + \omega + \omega$) and four-wave mixing processes ($3\omega = 2\omega + 2\omega - \omega$). The third harmonic signal will oscillate periodically with the relative phases of the two-color driving electric fields. We used the fundamental and second harmonic beam (1064nm and 532nm) to generate these two processes in argon gas and measured the contrast of interference at different laser power ratio and gas pressure.

Motivation

The field about quantum coherent control is originally formulated in order to achieve the goal of modify and manipulating molecular system in the late 1980s and 1990s. Quantum coherent control drive a quantum system from initial state to final state and enhance the desirable final state by constructive quantum-mechanical interferences while avoiding undesirable final state through destructive interferences. Although the initial concepts were formulated with molecular processes, the ideas of quantum coherence control were later extended to other systems. Today the most common reach about quantum coherent control is pulse shaping technique that not only control the envelope shape of laser pulses but also extend to manipulate the waveform of the electric field of laser pulse.

In our experiment, the coherent effect of two kinds of same frequency outputting optical harmonic generation process has been research.

Experiment Setup



TM: triple band mirror, DM: dichroic mirror, AM: amplitude modulator, PM: phase modulator, PD: photo detector, PMT: photomultiplier tube, GC: gas cell, FL: focusing lens, PB: pellen-broca prism, TSC: telescope

Laser system:

GCR-Pro 290 :an injection-seeded Q-switched Nd:YAG laser produce 1064 nm pulses with pulse duration of 10 ns and the maximum pulse energy is 1.9 J/pulse.
The second harmonic (532 nm) beam was generated by KD*P. the maximum pulse energy is around 1 J/pulse.

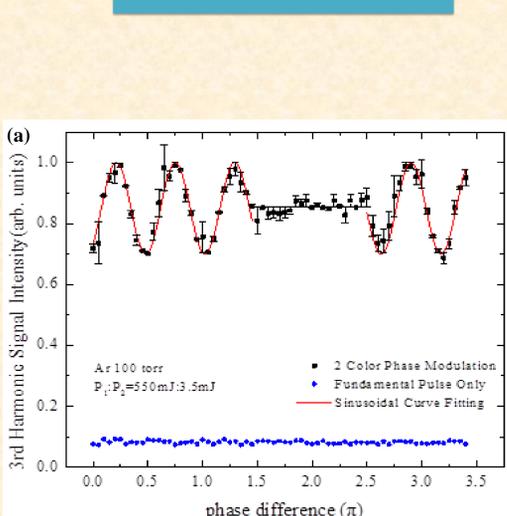
Waveform synthesizer :

- This part is an important part used to control the coherence effect of two processes.
- the dichroic mirror (DM) is used to separate the three color beam and take the color that we want to use. The amplitude modulator part (AM) can modulate the power of fundamental and second harmonic pulse.
- The PM is made by a pair of right-triangle prisms (PP). By sliding the relative position of the two prisms, we can change the relative phase of two pulse.
- The telescope system (TSC) is used to adjust the place of focus point of second harmonic beam at longitudinal direction and make it overlap with the focus point of fundamental beam.

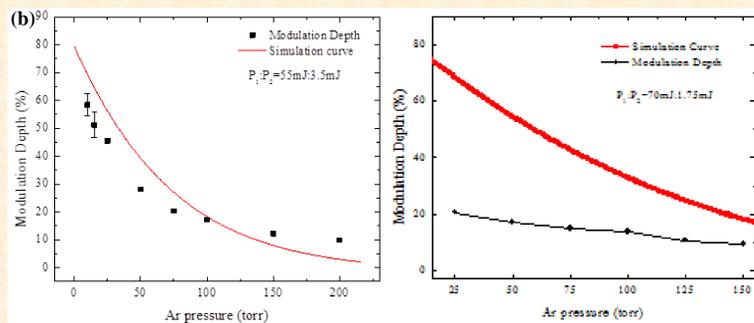
Gas cell :

- After we modulate the phase and amplitude of fundamental beam and second harmonic beam, we focus the two pulses into an argon gas cell by focus lens (FL).
- This part generate the 355nm beam by the direct third harmonic generation process and four wave mixing process.
- The pellen-broca prism (PB) is used to separate the 1064nm, 532nm and 355nm beam.

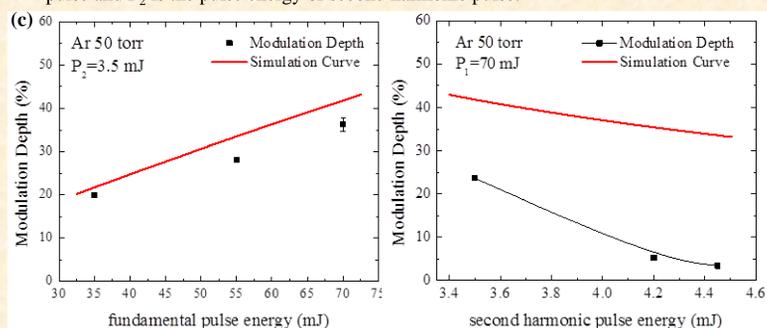
Results



(a) 3th harmonic signal v.s. phase different, The ratio of pulse energies for the fundamental and second harmonic are 55mJ: 3.5 mJ, The modulation depth=17.7%



(b) The pressure dependence of modulation depth. The P_1 is the pulse energy of fundamental pulse and P_2 is the pulse energy of second harmonic pulse.



(c) The power dependence of modulation depth. The pressure of Argon that we used is 50torr.

Conclusions

- Using perturbative nonlinear optics, we predict that the TH signal will show sinusoidal modulation as the relative phases of the two-color driving laser fields are varied. This is due to the interference from a direct THG channel and a four-wave mixing (FWM) channel.
- We find that when the pressure decrease, the modulation depth increase.
- When the power of fundamental pulse increase and the power of second harmonic pulse decrease, the modulation depth increase.