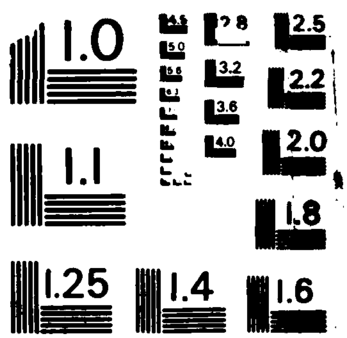
AD-A179 376 SUBPICOSECOND OPTICAL DIGITAL COMPUTATION USING PHASE 1/1
CONJUGATE PARAMETRI..(U) CITY COLL NEW YORK INST FOR
ULTRAFAST SPECTROSCOPY AND LASERS.. R ALFANO ET AL.
UNCLASSIFIED DEC 85 RF-447211 AFOSR-TR-87-0511 F/G 20/6 NL



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

SECURITY C

AD-A179 376

DOCUMENTATION PAGE

1a. REPORT UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION / AVAILABILITY OF REPORT UNRESTRICTED
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) RF-447211	5. MONITORING ORGANIZATION REPORT NUMBER(S) AFOSR-TR- 87-0511
6a. NAME OF PERFORMING ORGANIZATION Department of Physics The City College of N.Y. 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION AFOSR/NE
6c. ADDRESS (City, State, and ZIP Code) 138th Street & Convent Ave. New York, N.Y. 10031	7b. ADDRESS (City, State, and ZIP Code) Building 410 Bolling AFB DC 2033-6448
8a. NAME OF FUNDING / SPONSORING ORGANIZATION AFOSR 8b. OFFICE SYMBOL (If applicable) NE	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER AFOSR-84-0144
8c. ADDRESS (City, State, and ZIP Code) Building 410 Bolling AFB DC 2033-6448	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 61102F PROJECT NO. 2305 TASK NO. B4 WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

Subpicosecond Optical Digital Computation Using Phase Conjugate Parametric Generators,....

12. PERSONAL AUTHOR(S)
Alfano, Robert

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Scientific	FROM 12/1/84 TO 11/30/85	1987, January 15	7

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

~~See attachment~~
See BACK

S D
APR 2 1 1987
A

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UUUU
22a. NAME OF RESPONSIBLE INDIVIDUAL Dr. C Lee Giles	22b. TELEPHONE (Include Area Code) 767-4933 22c. OFFICE SYMBOL NE

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

7 4

NARR. --- PROG. - FROM U)

12/1/84 to 11/30/85

We have demonstrated the use of the Raman induced phase conjugate technique (RIPC) both to obtain strong Raman signals and to measure relaxation times in liquids and solids using picosecond laser pulses. A Sagnac interferometer switch (SIS) with an optical nonlinear material in its loop has been constructed to perform digital optical logic. A model using statistical electrodynamic techniques has been developed to investigate photon echo in intrinsic direct transition semiconductor materials. A new time domain phase conjugate autocorrelator has been developed.

AFOSR-TR- 87-0511

INSTITUTE FOR ULTRAFAST SPECTROSCOPY AND LASERS

ELECTRICAL ENGINEERING AND PHYSICS DEPARTMENTS

Annual Report

AFOSR Grant# 84-0144 ~~FQ8671-8401034~~

RF 447211

Subpicosecond Optical Digital Computation using Phase Conjugate Parametric Generators

Senior Researchers: Professors R. Alfano, G. Eichmann, and R. Dorsinville

Ph.D. Graduate Students: P. Delfyett, Yao Li

December 1985

Table of Contents

GOALS

The purpose of the research program is twofold, to investigate basic fundamental processes and develop subpicosecond phase conjugate four wave parametric generators, optical switches and processors. These devices will be tunable over a wide spectral range.

Significant progress has been achieved over the year in the project in the two areas. Work has been accomplished in new multispectral canonical optical logic elements using the four wave degenerate and Raman mixing mechanism and interference.

Areas of Progress

Progress has been achieved in four areas:

1). We have demonstrated the use of the Raman induced phase conjugate technique (RIPC) both to obtain strong Raman signals and to measure relaxation times in liquids and solids using picosecond laser pulses. We have obtained the picosecond RIPC spectra of carbon disulphide, benzene, nitrobenzene and calcite. By delaying one of the interacting pump beams relative to the other pump and probe beams we were able to determine, with picosecond resolution, the intensities of the phase conjugate beams at the Stokes frequencies as a function of time. This new time resolved spectroscopic method will not only allow to study the relaxation mechanisms of the materials used in new broadband switching devices but also ultimately to develop multispectral ultrafast optical processors.

2). A Sagnac interferometer switch (SIS) with an optical nonlinear material in its loop has been constructed to perform digital optical logic. Both the SIS input and output logic variables were picosecond optical pulses. Using various SIS interconnections, all sixteen two variable binary logic functions can be implemented and both parallel and sequential logic processing are possible. An optical binary full adder has been developed from the SIS and subsequently modified for use as an ultrafast optical sampling device.

3). A model using statistical electrodynamic techniques has been developed to investigate photon echo in intrinsic direct transition semiconductor materials . This model can be directly applied towards creating new techniques in ultrashort time measurements and to develop new optical logic devices. For example, to measure time differences between pulses in the range 10^{-14} - 10^{-13} s, such as in differential measurements due to a variation of the index of refraction of a medium, rotation of medium, etc. it is sufficient, following this model, to measure the intensity of the echo generated by the incoming two pulses. Other potential applications include optical digital computation since all binary logic functions can be implemented using logical switches built around the photon echo effect with the possibility of 10^{12} operations per second.

4). A new time domain phase conjugate autocorrelator has been developed . In this new device three beams derived from the same initial laser pulse interact in a nonlinear medium to produce a backward signal wave in a 90^{o} phase conjugate geometry. The pulse direction is determined from the spatial width of the phase conjugate beam emerging from the interaction region. The range of the pulse durations that can be measured can be easily changed from subpicosecond to hundreds of picoseconds. An important characteristic of this new technique is that, depending on the nonlinear medium, one can obtain information about the intensity or about the coherence correlation function of the laser pulse .

Future Directions

I) FUNDAMENTAL INVESTIGATIONS AND DEVICES

Fast nonlinear optical switches and logic devices can only be build with materials with large nonlinear coefficients and ultrafast relaxation dynamics. The main trust during the second year of the grant will be toward investigating the nonlinear coefficients, measuring vibrational relaxation times, and determining carrier energy , momentum relaxation and phonon dephasing times in neat liquids, polymers, solution of dyes, and semiconductors, using the four wave mixing techniques developed during the first year.

The experiments to be performed are :

1) Polymers, because of their large nonlinear coefficients are among the most promising materials. We plan to measure, using the phase conjugation technique, the magnitude and response time of coefficient X^3 for polyacetylene, polydiacetylene and other polymers at different wavelengths. We will also study the effect of the proximity of a resonance absorption band on the magnitude of the nonlinear coefficient X^3 for a fixed wavelength. In polydiacetylene the absorption band will be moved relative to the excitation wavelength by changing the pH of a water solution of the polymer.

2) Similar experiments will be carried out with semiconductors. We plan to measure X^3 in bulk semiconductors such as GaP, CdS, ZnO etc. The same samples will be studied in powder form ($\approx$10 μm particles) where a substantial increase of X^3 is expected due to surface nonlinear effects. Phase conjugation technique will also be used to study microstructures such as GaAs/GaAlAs and CdTe/CdMnTe.

3) The time resolved Raman induced phase conjugation (RIPC).technique will be used to measure vibrational relaxation times in liquid nitrogen and in different dye solutions. Phonon dephasing times will be studied in GaP, CdS, and $LiNbO_3$

4) The phase conjugation bandwidth and pulse duration will be investigated by using the picosecond super continuum as the probe beam and two monochromatic counter propagating pump beams.

5) The angular dependence of the phase conjugation process will be investigated by changing the angle of incidence of the probe beam upon the phase conjugate mirror.

6) Pulse compression is needed to perform the time resolved experiments since shorter laser pulses are necessary to achieve high resolution. Different techniques will be tried separately or in combination to shorten the YAG pulse duration from 30 ps to few picoseconds. They are: the selection of a pulse in the back of the train, compression to the coherence lifetime of the laser pulse by reflection off a phase conjugate mirror, broadening, chirping and compression using self phase modulation (SPM) in a nonlinear medium and a pair of grating .

7) Experiments will be performed to construct all proposed canonical SIS logic elements. Switching materials, such as multiple quantum well structures and polymers, will be studied as the active element.

8) A grating type SIS will be investigated and the enhancement of visibility versus. The pulse broadening will be studied.

9) A binary optical SIS sampler will be implemented.

Publications

1) J. T. Manassah, R. R. Alfano, M. Conner and P. P. Ho, Photon Echo in Direct Gap Semiconductor, Physics Lett. 106A, 65 (1984).

2) J. Buchert, R. Dorsinville, P. Delfyett, S. Krimchansky and R. R. Alfano, Determination of Temporal Correlation of Ultrafast Laser Pulses Using Phase Conjugation, Opt. Comm. 52, 433 (1985).

3) G. Eichmann and H. J. Caufield, Optical Learning (Inference) Machines, Applied Optics 24, 2051 (1985).

4) G. Eichmann, Y. Li, R. R. Alfano, Digital Optical Logic of Sagnac Interferometer Switch, (submitted).

5) G. Eichmann, Y. Li, R. R. Alfano, Pulse Mode Laser Sagnac Interferometry with Applications in Nonlinear Optics and Optical Switching, (submitted).

6) R. Dorsinville, P. Delfyett, R. R. Alfano, Time Resolved Picosecond Raman Induced Phase Conjugation in Liquids and Solids, (submitted).

Conference Paper

1) G. Eichmann, Phase Conjugate Optical Four Wave Mixing Devices for Optical Logic Computation and Interconnect, OSA Topical Meeting on Optical Computing, Lake Tahoe, March 1985.

END
5-87
DTIC