OASIS 2007 March 26-27 מרכז הירידים, ת"א

The 11th Meeting on Optical Engineering and Science in Israel

הכינוס האחד עשר לאופטיקה, אלקטרואופטיקה והנדסה אופטית

Session 5

Lectures:

Coherent Controlled Photoemission from Surfaces- Polarization Controlled

Zeev Fradkin[a], Dan Oron[b], Ron Naaman[a]

a) Dep. of Chemical Physics

b) Department of Complex Systems

Weizmann Institute, Rehovot 76100, Israel.

Interference between one and two-photon excitation has been used for control of electrical currents in semiconductors[1] and the direction of photoemission from a surface.[2] In the case of metal substrates, because of the fast dephasing,[3] very short pulses have to be applied for demonstrating coherent control of two-photon photoemission processes.[4]

The role of the light polarization on the efficiency of photoelectron emission from surfaces is well known and theoretically understood. Generally, the efficiency is greater for electron ejected by light polarized perpendicular to the surface (p-polarization) as compared to light that is polarized parallel to the surface (s-polarization). Polarization dependent two photon photoemission (2PPE) studies provided details on the electron dynamics and on the nature of the intermediate state.[3]

We have found that it is possible to affect photoemission processes, from metal and semiconductor surfaces, by shaping the polarization of a single laser pulse and by varying the phase between the two polarizations. As more corrugated is the surface, so more sensitive is the photoemission to the phase between the polarization components. In addition, the affect of polarization shaping on the photoelectrons angular distribution is investigated.

---

[1] G. Kurizki, M. Shapiro, and P. Brumer, Phys. Rev. B **39**, 3435 (1989); E. Dupont *et al.,* Phys. Rev. Lett. **74**,3596 (1995); R. Atanasov *et al.,* Phys. Rev. Lett. **76**, 1703 (1996).

[2] N. B. Baranova, A. N. Chudinov, and B. Ya. Zel'dovich, Opt. Commun. **79**, 116 (1990); V. B. Deyirmenjian and J. E. Sipe, Phys. Rev. Lett. **82**, 4942 (1999).

[3] M. Wolf, A. Hotzel, E. Knoesel, and D. Velic, Phys. Rev. B, 59 5926 (1999).

[4] H. Petek, A. P. Heberle, W. Nessler, H. Nagano, S. Kubota, S. Matsunami, N. Moriya, and S. Ogawa1, Phys. Rev. Lett. **79**, 4649 (1997); H. Petek, Su. Ogawa**,** Ann. Rev. Phys. Chem.**, 53,** 507 (2002).

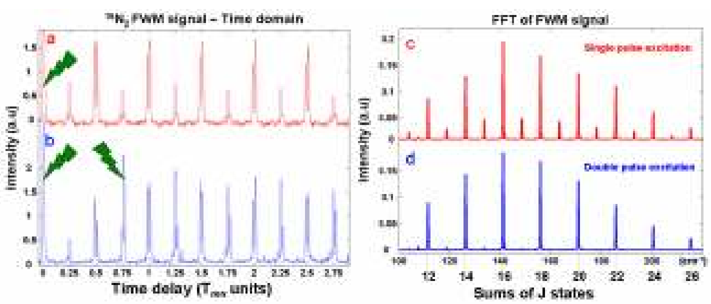
SELECTIVE OPTICAL ADDRESSING OF CLOSE MOLECULAR SPECIES

Sharly Fleischer, I.Sh. Averbukh and Yehiam Prior

Department of Chemical Physics, Weizmann Institute of Science, Rehovot 76100, Israel

We experimentally demonstrate a new approach to selective excitation of close molecular species in mixtures[1]. Following excitation by an ultrashort, strong laser pulse, the molecules are repetitively aligned (depending on their rotational constants). In our double-pulse scheme, the first pulse excites both components in a binary mixture, and the second pulse de-excites one, while enhancing excitation degree of the other. This enables the application of another strong, linearly polarized pulse for preferential dissociation/ionization of the selected molecular component; thereby enrichment of the sample becomes feasible. Since this process is nonresonant and does not require any special conditions like temperature etc. this approach is general and can be applied to most linear molecules. In our work we implemented this approach to molecular isotopes and spin isomers.

The case of molecular isotopes is based on slight difference in the masses of the molecular components, and supported by the periodic process of repetitive alignment, one can distinguish between the isotopic components and selectively affect them. The case of spin isomers is more complicated since there are no differences in the mechanical or electrical properties of the spin isomers to be selectively controlled. Here we utilize the symmetry and statistics of the specific molecular wavefunction and demonstrate selective excitation of Ortho/Para nitrogen using non resonant laser pulse at room temperature. Typical data is shown in the figure where we compare the molecular response to single (red, top) and double (blue, bottom) pulse in time (left) and frequency (right) domains. The absence of odd frequencies in the double pulse case, serve as a signature of selective excitation of a single isomeric component.



Time domain FWM signal from $^{15}N_2$ following a) a single pulse. b) 2 pulses delayed by ~¾Trev. c) and d) Fourier transforms of a) and b) respectively.

[1] Sharly Fleischer, Ilya Sh. Averbukh and Yehiam Prior, Phys. Rev. A. **74**, 041403 (2006).

SCHEMES OF QUANTUM AND CLASSICAL CONTROL FOR PHOTOASSICIATION OF ULTRACOLD ATOMS

S. Kallush and R. Kosloff

The Fritz Haber Research Center, The Hebrew University of Jerusalem,

Jerusalem 91904, Israel

kallush@fh.huji.ac.il

We explore the possibilities for accelerating ultracold atoms toward each other to increase the efficiency of the production of cold molecules by photoassociation. Light-induced exchange of momentum between two electronic surfaces is achieved by controlling the phase or the amplitude of the light field. The possibility for pure quantum light-induced acceleration is also discussed but found to take place only for intensities at the order of 10^{15} W/cm^2.

Femtosecond Control of Multiphoton Excitations and Information Processing

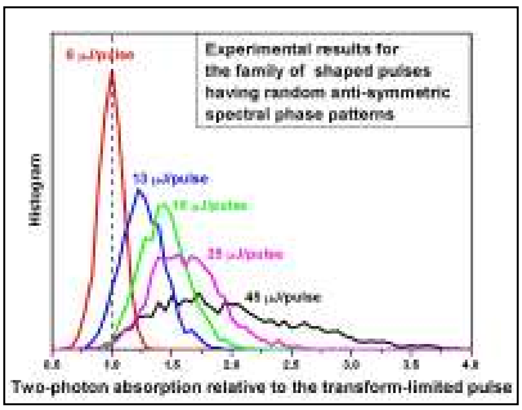
<u>Zohar Amitay</u>, Lev Chuntonov, Andrey Gandman, Leonid Rybak

Schulich Faculty of Chemistry, Technion, Haifa, Israel (amitayz@tx.technion.ac.il)

The present experimental research is along two inter-connected directions of coherent control using shaped femtosecond pulses. One direction is extending the control capabilities with pre-designed pulses (as opposed to "black-box" feedback optimization) beyond the weak-field regime. The other direction is photo-induced coherent information processing.

We have studied coherent phase control over two- and three-photon absorptions in a system of coupled multiphoton excitations in Na at weak and intermediate pulse intensities. In the weak-field regime the absorptions are induced, respectively, by non-resonant two-photon and resonance-mediated (2̣1) three-photon transitions, and are fully described by 2nd- and 3rd-order (i.e., lowest order) time-dependent perturbation theory. In the intermediate-field regime the valid description also includes the next perturbative order (4th and 5th). Then, the two-photon absorption also involves four-photon transitions (such as 2̣1̃1). The results demonstrate high degree of control over the different multiphoton absorptions and over the correlation and ratio between them. In combination with extended numerical calculations, we have identified the intensity range of 4th-order perturbative regime. This has allowed us to keep analyzing the photo-excitations in the frequency domain also at intermediate intensities, differently from the commonly used time-domain analysis. This is very powerful for pre-designing optimal pulse shapes, since the frequency domain is the domain of experimental pulse shaping. Indeed, it led us to identify special families of pulse shapes, which at intermediate fields, as opposed to weak fields, enhance the two-photon absorption relative to the transform-limited (i.e., unshaped) pulse (see figure). The special phase patterns are anti-symmetric (or close to it) around half the non-resonant two-photon transition frequency.

Based on all these studies, we have implemented the information-processing task of identifying the anti-symmetry character of a given arbitrary numerical function: anti-symmetric, constant, or neither.



The well-characterized multiphoton absorptions in Na are used to efficiently characterize an unknown driving shaped pulse, into which the function is optically encoded in the spectral phases. Going from the weak-field to the intermediate-field regime allows introducing a tolerance to small deviations from perfect anti-symmetry.

Optical and plasma filaments generated during propagation of a high power short pulse laser in air

S. Eisenmann, Y.Katzir, A.Pukhov, A. Zigler, Hebrew Univer, Jerusalem, Israel
Y. Sivan, G. Fibich Tel-Aviv University, Israel
Y. Ehrlich, E.Louzon, Z. Henis, Soreq Research Center, Israel
zigler@vms.huji.ac.il

Recently, the self-focusing dynamics of high-power, ultrashort laser pulses has attracted significant attention, particularly for the case in which high-power pulses propagate in air. The resulting long-distance filamentation behavior has been exploited for remote sensing in the atmosphere. The dynamic balance between Kerr self-focusing and defocusing due to plasma generation may be affected by the laser beam noise, inducing multiple filamentation (MF). We will describe our investigations on control of beam breakup into multiple filaments and methods for generation of a single filament. The experiments were carried using both "low" and "high" quality beams. The uncontrolled beam collapse to a large number of filaments results in randomly distributed filaments. This feature makes the measurements of any single filament characteristics very difficult. Recently we proposed a new scheme for multiple filamentation stabilization by introducing astigmatism to the beam using a tilted lens. Thus, we can reduce the number of filaments and arrange the spatial pattern, making the task of measuring a single filament plausible. The ability to obtain select and stabilize a single filament during propagation of an ultra short pulse, high intensity laser in air allowed us to study the longitudinal structure of plasma channel left in the light filament wake. Here we are presenting detailed measurements of plasma channel density variation along laser propagation. Over the length of the filament electron density variations of three orders of magnitude were observed.

Spatial modes in a PCF generated continuum

Y. Vidne and M. Rosenbluh

Resnick Institute for Advanced Technology, Bar-Ilan University, Ramat-Gan, Israel, 52900

vidney@mail.biu.ac.il

Abstract: We measure the propagation properties of a highly nonlinear photonic crystal fiber (PCF). The spatial, temporal and frequency dependent properties of the propagating modes are measured under conditions of high power, seven picosecond excitation, white light continuum generation. The experimentally determined multi-mode nature of the white light continuum is found to be in good agreement with numerical simulations.

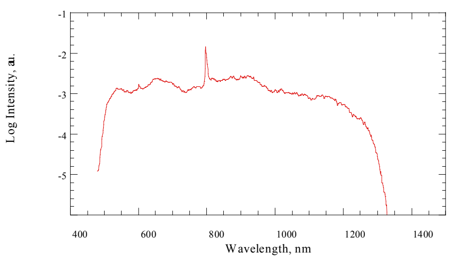


Fig. 1. Broadband SC generation.

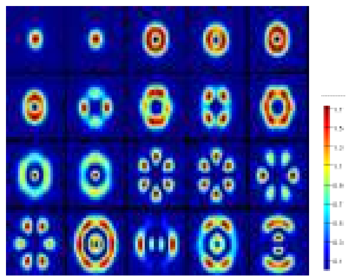


Fig. 2. Intensity distribution of the first 20 spatial modes.

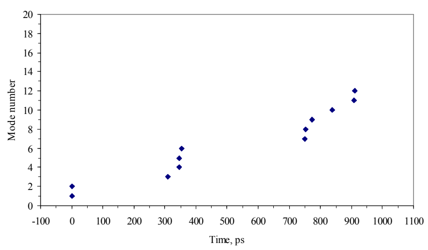


Fig. 3. Group delay of the first 12 modes as calculated by the simulation.

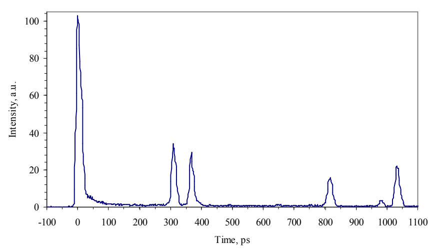
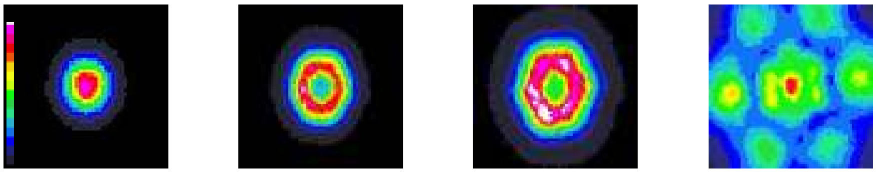


Fig. 4. The lowest order modes of the PCF in the time domain at a wavelength near 790nm.



(a) (b) (c) (d)

Fig. 5. Far field images of the spatial modes after spectral and intensity filtering. The images were obtained on a gated camera with 300 ps between images (a) and (b), 450 ps between (b) and (c) and 150 ps time difference between (c) and (d).

References and links

[1] Y. Vidne and M. Rosenbluh, "Spatial modes in a PCF fiber generated continuum," Opt. Express 13, 9721-9728 (2005)

Bragg-soliton formation and pulse compression in a one-dimensional periodic structure

Amir Rosenthal and Moshe Horowitz

Department of Electrical Engineering,

Technion – Israel Institute of Technology, Haifa 32000 Israel.

Email: eeamir@tx.technion.ac.il;

We present a new method for compressing optical pulses. The method is based on efficiently exciting a Bragg soliton in a one-dimensional periodic structure such as a fiber Bragg grating (FBG). The Bragg soliton formation is based on a new interaction between Bragg solitons and on a high intensity enhancement, caused owing to the reduced propagation velocity inside periodic structures, known as the slow-light effect. We have theoretically demonstrated pulse compression with a compression ratio of 2800 – over two orders of magnitude higher than previously reported. Our results may be applied to generate high-power picosecond pulses by compressing the output of inexpensive nanosecond sources such as Q-switched lasers.

We have designed a nonuniform chirped grating for obtaining high pulse compression. Figures 1(a) and 1(b) show the input and the output pulses. At the first section of the grating, high pulse intensity is obtained owing to the slow-light effect in FBGs, as demonstrated in Fig. 2. Modulation instability causes the formation of multiple pulses as shown in Fig. 1(c). A new soliton interaction causes the transmission of a single pulse while the trailing pulse is back-reflected, as shown in Fig. 1(d).

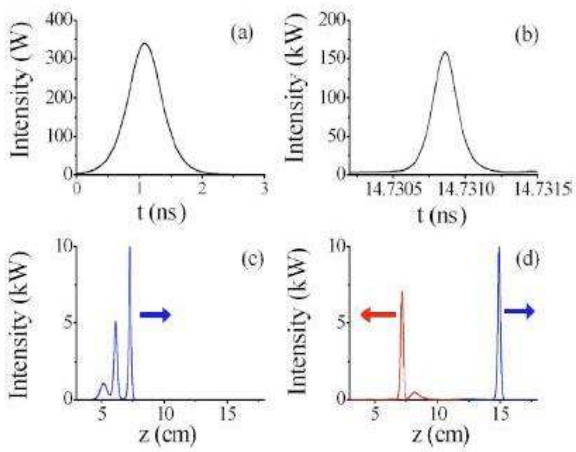


Fig. 1. (a) Incident pulse, (b) transmitted pulse, (c) the formation of a pulse train owing to modulation instability, and (d) transmission of a single pulse owing to the soliton interaction.

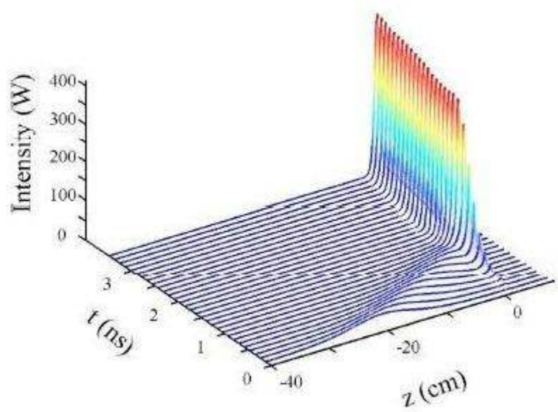


Fig. 2. Demonstration of the slow-light effect for pulse compression. As it enters the grating at z=0, the incident pulse is decelerated and subsequently compressed.