Phase Coherent Photorefractivity in ZnSe Single Quantum Wells

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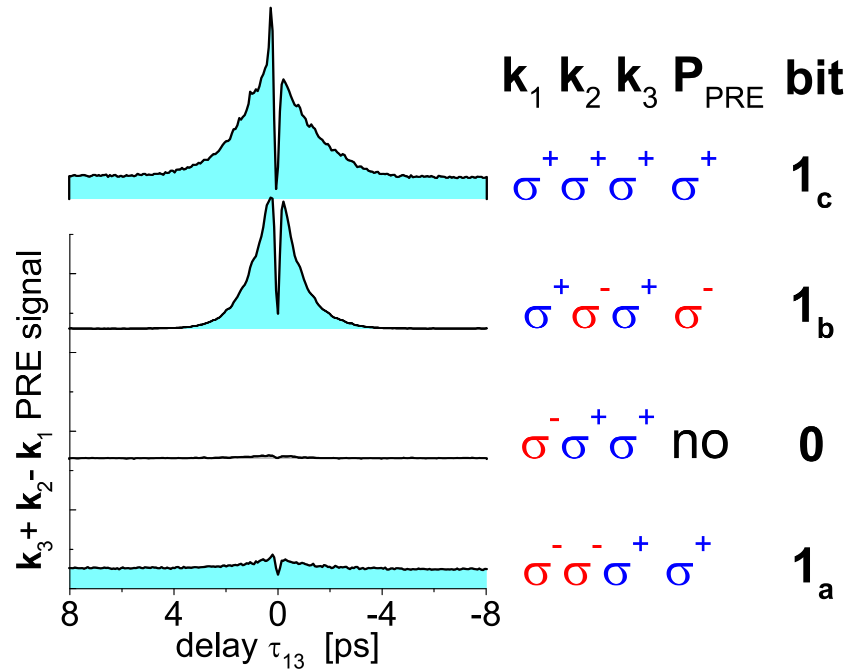
Present exciton-resonant photorefractive devices do not use the coherence of excitons to conserve the phase and polarization information of incident light fields. We observe a novel phase coherent photorefractivity (PCP) in ZnSe single QWs using ultra-short (90 fs) light pulses that need not overlap in time. The PCP is attributed to the formation of an electron grating formed by the interference of coherent excitons. Of particular interest is the possibility to erase the PCP at temporal pulse overlap and to store one logic 0 bit and three different logic 1 bits using various circular pulse polarizations during the exciton coherence time.



Traces of the diffracted photorefractive signal P_{PRE} at the exciton transition recorded at 55 K. Delay ♦$_{13}$ denotes the time difference between pulse $\mathbf{k}_1$ and $\mathbf{k}_3$ in a three-pulse four-wave mixing configuration. Delay ♦$_{12}$ was kept fixed at 200 fs. The different field polarizations of pulse $\mathbf{k}_1$, $\mathbf{k}_2$, $\mathbf{k}_3$ and of P_{PRE} are labeled. Also shown are logic bits that are defined by the $\mathbf{k}_1$ and $\mathbf{k}_2$ polarizations.

Motion of electrons in electrical circuits is usually detected by measuring the current, which is a flow of millions of electrons. The situation is much different in the case of nanoscale objects, called quantum dots whose behavior is dominated by only a few loosely bound electrons. Working in the field of quantum information science, we have shown that it is possible to control the rate at which the electrons escape the quantum dots. For example, we have developed devices such as a Single Electron Transistor (SET) that can be switched on or off with the addition of a single electron. With our collaborators from Bell Laboratories, we have used a special type of SET and detected the motion of individual electrons in and out of a semiconductor quantum dot. The experiment was done at temperatures only a few hundredth of a degree above absolute zero. We measured the output signal from the SET in a coded way and transformed it so we can see the changes in the SET signal in real time. Our group observed sudden changes in the SET output and showed that these changes correspond to individual electrons moving in and out of the tiny semiconductor dot in roughly ten millionth of a second. This is the first time that individual electron flow had been determined via an SET, and is of considerable interest from the standpoint of new quantum device development. This work was published in the May 22, 2003 issue of Nature.

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Education:

Two graduate students (Suvranta Tripathy and Pradeep Bajracharya) contributed to this work. Both are members of the PIs group and performing related experiments in a state of the art laser facility. Such training will benefit their ability to find employment opportunities after they have finished their PhD work.

Societal Impact:

The ability to conserve the phase and polarization information of incident light fields within solids is very important for future optical applications. The additional degree of coherence in these novel PCP structures may open new design possibilities for optical data storage and computation.