*Title of the Paper in (Times New Roman Bold, Italics , size 16)*

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**Abstract: (150 words) The study of light matter interaction involves two basic questions. One is to understand the structure and properties of matter using light. The other is to explore the possibility of controlling material properties using light. Ultrafast spectroscopy using femtosecond laser pulses enable the observation of very fast molecular dynamical processes[1]. Driving a quantum system into a pre-defined target state has recently become experimentally feasible and recently, successful control experiments have been demonstrated. This provides new ways to understand molecular dynamics and opens the way for a multitude of practical applications. Some of the basic concepts and practical aspects of coherent control and a few of its applications in spectroscopy are discussed in this contribution (150 words, Size 11)**

# *Keywords- Bold And Italics, Size 11, Max 6 words*

# INTRODUCTION(size 12, block letters)

**The length of the paper must be restricted to maximum of 6 pages. Stick to line spacing of 1.15 and font size of 12. Figures must be given the caption at the bottom of the figures as “Fig1.** Caption in size 11, unbold**”. Tables must be given labels at the top as “Table1.** Description in unboldwith font size 11**”.**

The roots of the idea of coherent control or quantum control can be traced back to the days of development of lasers in 1960. Since then it was a chemist’s dream to use the unique properties of lasers – high intensities, monochromaticity, and wavelengthtunability and more importantly, the phase coherence – to control the outcome of a photochemical reaction [2]. Most of the approaches to control a photochemical reaction were based on using lasers of precise frequency to dump energy into a particular bond of a molecule to break it. But, in polyatomic molecules, due to the large density of vibrational or rotational states, the supplied energy is quickly redistributed into other modes. This process of redistribution of energy into other modes is generally termed as intramolecular vibrational relaxation (IVR) and is often much faster compared to the time scale of breaking of a bond. Thus, IVR results in a statistical and uncontrolled distribution of excitation energy resulting in unwanted photoproducts.

The development of femtosecond lasers was a significant breakthrough in the field of coherent control. The femtosecond time scale (10-15 s) is very important in coherent control as it is much shorter compared to a vibrational period of motion (10-14 s – 10-13 s). Thus sequences of femtosecond laser pulses with specifically tuned time delays between them can create and manipulate vibrational wavepackets before the spoiling IVR sets in. Additionally, femtosecond pulses can be shaped in amplitude and time and such shaped pulses can be used to influence the outcome of light matter interaction. The following sections presents most commonly used control mechanisms, pulse shaping techniques and some of the experimental results from the coherent control facility developed in BARC.

1. EXPERIMENTAL DETAILS
2. *Subheading1*

One of the simplest examples of coherent control is control of photodissociation using time delay between a pair of femtosecond pulses as the control parameter [3]. This scheme is commonly known as the pump-dump scheme and the method is pictorially depicted in figure 1. Initially, the molecule ABC which is in the ground vibrational state is excited by a femtosecond pump pulse. This creates an excited state vibrational wavepacket (ABC\*) which evolves in time. A second femtosecond pulse is applied after a certain time delay to dump the excited state wave packet back into one of the dissociation channels AB+C or A+BC. Thus by carefully controlling the time delay between the pulses, the photodissociation channel can be chosen. But this method is useful only for small molecules with simple potential energy surfaces.

1. *Subheading2*

Another way to manipulate the outcome of light matter interaction is to shape the femtosecond pulse [4]. In this method one makes use of the quantum mechanical nature of matter and coherence properties of the laser to manipulate the outcome of the interaction between them. The time evolution of a molecular system is interacting with a light field is determined by the time dependent Hamiltonian H(t)=HM+HMR, where HM is the molecular Hamiltonian (radiation free) and HMR is the molecule-radiation interaction Hamiltonian, which, in the dipole approximation, can be written as HMR=-µ.E(t). In order to manipulate the time evolution of this system one needs to modify the total Hamiltonian H(t). An easy way to modify the Hamiltonian is to modify the interaction Hamiltonian by modifying the electric field E(t) of the light pulse. This is the basis of coherent control by pulse shaping and can be applied even to polyatomic molecules with complex potential energy surfaces. From a theoretical point of view, the electric field that is required to prepare a desired quantum state of the molecule can be calculated if the molecular Hamiltonian is known. Usually, for complex molecules either the Hamiltonian is not completely known or, even if the Hamiltonian is known, the calculation might be too cumbersome. To overcome this difficulty, a method was developed to extract the optimal electric field (or, pulse shape) iteratively within a feedback controlled, closed loop experiment using a search algorithm [5].The techniques of femtosecond pulse shaping and finding the optimal pulse shape using learning algorithms is discussed in the following sections.

1. *Subheading3 Femtosecond Pulse Shaping*

Femtosecond pulse shaping involves the manipulation of phase, amplitude and/or polarisation of the different spectral components constituting the pulse in a programmable manner according to user specification [6]. In the time domain, the shape of an ultrashort pulse is defined by its electric fieldE(t). In the frequency (spectral) domain, the pulse is described by a complex function E(ω)=A(ω)eiφ(ω), where A(ω) is the spectral amplitude and φ(ω) is the spectral phase. Ultrashortpulses can be shaped either in the time domain or in the frequency domain. Frequency domain shaping is the easiest and most commonly used shaping technique. In this method, the femtosecond pulse is first dispersed into its constituent spectral components. The properties, such as amplitude, phase, and/or polarization, of individual spectral components are then manipulated using a programmable liquid crystal spatial light modulator (SLM) and the modified spectral components are combined back into a time domain pulse. The most commonly used experimental setup for frequency domain pulse shaping is the 4f-pulse shaper which is shown schematically in figure 2.

The 4f-pulse shaper consists of two gratings, two focusing mirrors and a programmable liquid crystal spatial light modulator (SLM). The SLM consists of two separately controllable liquid crystal (LC) displays each consisting of 640 pixels. Each of the pixels of the two LC displays can be individually controlled by externally applied voltages. The SLM uses electrically controlled birefringence of the LC materialfor phase and amplitude modulation. The input pulse to the pulse shaper is split into its spectral components by the first grating (grating 1). The dispersed spectrum is then collimated using a cylindrical mirror. The SLM is placed at the focal plane (Fourier plane) of the cylindrical mirror. A second cylindrical mirror, placed at a distance f from the SLM, collects the output spectrum from the SLM and focuses it onto a second grating (grating 2). The second grating recombines the individual spectral components giving a shaped output pulse.

# result and discussions

1. *Subheading 1*

We have developed a coherent control setup for applying the technique in spectroscopy. Here, pulse shaping technique is used to selectively excite a specific vibrational mode of a model molecule, β-carotene, in a femtosecond coherent anti-Stokes Raman scattering (CARS) experiment. In CARS using femtosecond pulses, several vibrational modes are simultaneously excited due to the broad spectral width of femtosecond pulses. Pulse shaping technique can be used to focus the excitation into a desired vibrational mode. The results are shown in figures5 and 6. The CARS spectrum using an unshaped pulse is shown in figure 5 and the results of various shaped pulses to focus the excitation to specific vibrational modes is shown in figure 6.

1. *Subheading 2*

 The results show that coherent control by femtosecond pulse shaping is a promising tool in spectroscopy & microscopy. In microscopy, this technique can be applied to obtain chemically selective images. Apart from its application in spectroscopy, the technique finds application in many areas of physical and chemical sciences such as nonlinear optics, material processing, quantum computing and control of chemical reactions etc.

# CONCLUSION

 The results show that coherent control by femtosecond pulse shaping is a promising tool in spectroscopy & microscopy. In microscopy, this technique can be applied to obtain chemically selective images. Apart from its application in spectroscopy, the technique finds application in many areas of physical and chemical sciences such as nonlinear optics, material processing, quantum computing and control of chemical reactions etc.

# aCKNOWLEDGEMENT

REFERENCES

1. R. Saharaki et al, “Synthesize of Zinc Ferrite Nanoparticles at Room Temperature,” Journal of Nanostructures, pp. 413-416, 2013.
2. **FONT SIZE 10**