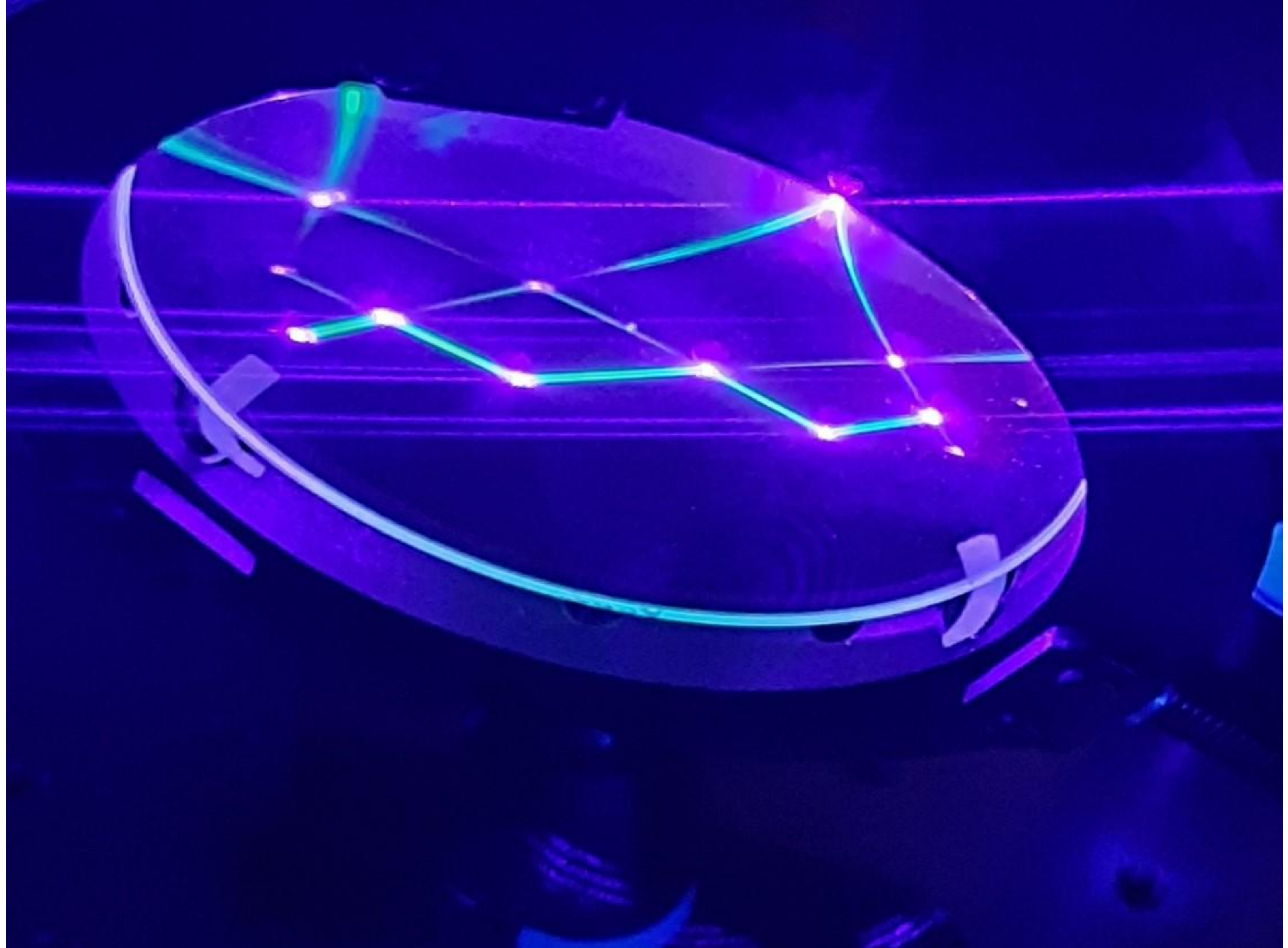
SCOP2022

7th Student Conference on Optics and Photonics

Abstract Book



28 - 30 September 2022

Physical Research Laboratory, Ahmedabad

About

Optica (formerly OSA) student chapter of Physical Research Laboratory, Ahmedabad has been organizing an annual conference, titled Student Conference on Optics and Photonics (SCOP) since 2015.

The conference addresses various topics in the vast spectrum of optics with major focus on nonlinear optics, quantum optics, and ultrafast science. The primary purpose of the conference is to provide a platform for Ph.D. and postdoctoral students to share and discuss their work with peers and experts in their respective fields. In addition, the conference provides a unique opportunity for professional development and networking, which is beneficial in pursuing a scientific career.

Organizing committee

Chair: Tanya Sharma

Co-Chair: Saumya Jyoti Sarkar

Student Committee

Madhusudhan P.

Rituparna Das

Subith Kumar PM

Satyajeet Patil

Sarika Mishra

Anju Sharma

Sandeep Singh

Pranav Bhardwaj

Vardaan Mongia

Chahat Kaushik

Technical Committee

Anirban Ghosh

Vimlesh Kumar

Nimma Vinitha

Jaya Krishna Meka

Pooja Chandravanshi

Shreya Mishra

Jayanth R.

Advisory Council

Prof. R.P. Singh

Dr. Gautam K. Samanta

Dr. Rajesh Kushawaha

Dr. Shashi Prabhakar

Organized by the Optical Society: PRL - Student Chapter

SCOP 2022

Schedule

Day 1: Wednesday, September 28, 2022

Venue: K. R. Ramanathan Auditorium, PRL

8:45 AM - 9:00 AM	**Welcome Address**	
Session I: Nonlinear optics & their application		
Chair: Sandeep Singh / Saumya Sarkar		
9:00 AM - 9:25 AM	**Invited Talk (IT-1)**	
25 + 5 min	Dr. Chaitanya Kumar Suddapalli	*Mid-infrared optical parametric oscillators: challenges and advantages*
9:30 AM - 9:55 AM	**Invited Talk (IT-2)**	
25 + 5 min	Prof. Sergio Carbajo (Online)	*Frontiers in Ultrafast and Quantum Light-Matter Interactions*
10:00 AM - 10:25 AM	**Invited Talk (IT-3)**	
25 + 5 min	Dr. Rakesh K. Singh	*Correlation imaging with higher order interferometers*
10:30 AM - 10:40 AM	**Student Talk (ST-1)**	
10 + 2 min	Akansha Tyagi	*Dispersion-less all reflective attosecond resolved delay line for ultrafast metrology*
10:45 AM - 11: 15 AM	***Tea Break***	
11:15 AM - 11:40 AM	**Invited Talk (IT-4)**	
25 + 5 min	Dr. Amit D. Lad	*Ultra-Intense Laser Produced Shock Waves*
11:45 AM - 11:55 AM	**Student Talk (ST-2)**	
10 + 2 min	Ravishankar Sugumar	*Angular distribution of electrons from a collimated aerosol jet aerodynamic lens*
12:00 PM - 12:25 PM	**Invited Talk (IT-5)**	
25 + 5min	Dr. Arijit Kumar De	*Optical trapping with femtosecond pulses: Excitements, challenges and opportunities*
12:30 PM - 02:30 PM	***Lunch + Poster Presentation***	

Session II: Quantum Optics and Quantum Communication I		
Chair: Satyajeet Patil		
02:30 PM-02:55 PM	**Invited Talk (IT-6)**	
25 + 5 min	Prof. Mehul Malik (Online)	*Programming high-dimensional quantum optical circuits inside a multi-mode fibre*
03:00 PM-03:25 PM	**Invited Talk (IT-7)**	
25 + 5 min	Dr. Bhaskar Kanseri	*Photonic quantum secure communication: Activities and prospects*
03:30 PM - 03:55 PM	***Tea Break***	
4:00 PM - 5:00 PM **Venue:** Nano Sims	Amrit Vyankhyan **Prof. Siddharth Ramachandran**	
05:00 PM-06:00 PM	**Panel Discussion**	
06:00 PM - 06:20 PM	***Tea Break***	
07:45 PM – 09:00 PM	***Conference Dinner***	

—------- End of Day 1 —----------

Day 2 : Thursday, September 29, 2022

Session III: Quantum Optics and Quantum Communication II		
Chair: Sarika Mishra / Vardaan Mongia		
9:00 AM - 9:25 AM	**Invited Talk (IT-8)**	
25 + 5 min	Prof. Ebrahim Karimi	
09:30 AM - 09:55 AM	**Invited Talk (IT-9)**	
25 + 5 min	Dr. Jasleen Lugani	*Integrated photonics for quantum information processing*
10:00 AM - 10:10 AM	**Student Talk (ST-3)**	
10 + 2 min	Vishal Sharma	*Analysis of Information Reconciliation for Quantum Key Distribution*
10:15 AM - 10:25 AM	**Student Talk (ST-4)**	
10 + 2 min	Sreeshna Subhash	*Quantum back action nullifying meter to improve the sensitivity of squeezed light optomechanical interferometer*
10:30 AM – 11:00 PM	***Tea Break***	
11:00 AM - 11:25 AM	**Invited Talk (IT-10)**	
25 + 5 min	Dr. Anindya Banerji	*Distributing entanglement over a fiber network and publicly verifiable quantum randomness*
11:30 AM - 11:55 PM	**Invited Talk (IT-11)**	
25 + 5min	Dr. Anirban Pathak	*Secure quantum communication and computation: Which tasks can be realized and/or commercialized in near future?*
12:00 PM - 12:25 AM	**Invited Talk (IT-12)**	
25 + 5 min	Dr. Haw Jing Yan (Online)	*National Quantum-Safe Network - A Singapore initiative*
12:30 PM-12:55 PM	**Invited Talk (IT-13)**	
25 + 5 min	Dr. Shouvik Ghorai	*1-sided device independent continuous-variable QKD with discrete modulation*
01:00 PM - 02:30 PM	***Lunch + Poster Presentation***	

Session IV: Ultrafast Optics

Chair: Rituparna / Pranav Bhardwaj		
02:30 PM-02:45 PM	**Student Talk (ST-5)**	
10+2 min	Sonali Khanna	*Boosting electron emission from liquid droplet microplasma*
02:50 PM-03:15 PM	**Invited Talk (IT-14)**	
25 + 5 min	Dr. Gopal Dixit	*All-Optical Ultrafast Valley-Switch in Two-Dimensional Materials*
03:20 PM - 03:30 PM	***Tea Break***	
03:30 PM - 03:55 PM	**Invited Talk (IT-15)**	
25 + 5 min	Dr. Thierry Ruchon	*Extreme nonlinear optics with beams carrying angular momenta*
04:00 PM-04:25 PM	**Invited Talk (IT-16)**	
25 + 5 min	Prof. Marcos Dantus	*Linear and Nonlinear Optical Interference in Ultrafast Science*
04:30 PM-04:55 PM	**Invited Talk (IT-17)**	
25 + 5 min	Dr. Kamal P. Singh	*Ultrathin attosecond delay line for IR-IR control of harmonics*
05:00 PM - 05:10 PM	**Student Talk (ST-6)**	
10+2 min	Rambabu Rajpoot	*High-order harmonic generation by sub-cycle laser pulses and associated scaling laws*
05:15 PM - 05:25 PM	**Student Talk (ST-7)**	
10+2 min	Sanket Sen	*Dissociation dynamics of C 1s Auger decayed doubly charged camphor molecule using soft x-ray radiation*
05:30 PM - 06:00 PM	Prof. Federico Capasso	*Structured Light and Dark by metaoptics*
06:00 PM - 06:20 PM	***Snacks***	
06:30 PM - 07:30 PM	**Public Lecture II : Prof. Anil Bhardwaj**	
07:45 PM - 09:00 PM	***Director's Dinner***	

——-------- *End of Day 2* ——----------

Day 3 : Friday, September 30, 2022

Session V: Nano-photonics		
Chair: Chahat Kaushik / Indrajit		
09:00 AM-09:25 AM	**Invited talk (IT-18)**	
25 + 5 min	Prof. Arup Lal Chakraborty	
09:30 PM - 09:40 PM	**Student talk (ST-8)**	
10+2 min	Krishna Joshi	*Observation of exceptional points in Anderson-localizing systems*
09:45 PM-09:55 PM	**Student talk (ST-9)**	
25 + 5 min	Anagha Sreedharan	*Rotation of polarization and spin modes in a uniaxial crystal plate*
10:00 AM – 10:30 PM	***Tea Break***	
Session VI: Optics in Interdisciplinary Sciences		
Chair: Naval / Namita		
10:30 AM - 10:55 AM	**Invited Talk (IT- 19)**	
25 + 5 min	Dr. Joe Philip Ninan	*Precision calibration of astronomy spectrographs using Laser Frequency Combs*
11:00 AM-11:10 AM	**Student Talk (ST-10)**	
10 + 2 min	Aravind K.	
11:15 AM-11:40 AM	**Invited Talk (IT-20)**	
25 + 5 min	Dr. Ravindar Kumar Banyal	*High-contrast Imaging & Spectroscopy of Extrasolar Planets*
11:45 AM-12:10 PM	**Invited Talk (IT-21)**	
25 + 5 min	Dr. Saurabh Raj	*A single molecule insight into DNA-protein interactions*
12:15 PM - 12:40 PM	**Invited Talk (IT-22)**	
25 + 5 min	Dr. Sankar De	*Vector magnetometry with electromagnetically induced transparency*
12:45 PM - 12:55 PM	**Student Talk (ST-11)**	
10 + 2 min	Sandeep Kumar	*Ultrafast photothermal THz-hysteresis in a spintronic emitter*
01:00 PM - 02:30 PM	***Lunch***	

—------- ***End of Conference*** —------

List of Abstracts

FRIDAY, 28TH SEPTEMBER, 2022 (DAY 1)

Invited Talk (IT1): **Dr. Chaitanya Kumar Suddapalli**

Title: Mid-Infrared Optical Parametric Oscillators: Challenges and Advantages

Invited Talk (IT2): **Prof. Sergio Carbajo (Online)**

Title: Frontiers in Ultrafast and Quantum Light-Matter Interactions

Photon and particle sources are powerful tools with extremely high societal impact because they underpin myriad groundbreaking scientific, technological, and medical advancements. Topological and structured photonics can probe, excite, and manipulate matter with unparalleled spatio-temporal accuracy to study new functional materials. They can also carry quantum-level information with many degrees of freedom without suffering decoherence, and thus render new technologies in quantum materials, information sciences, and (bio)chemical physics, among others. In the X-ray regime, ultrafast photon and electron sources, such as X-ray free-electron lasers (XFEL), have demonstrated the capacity to make molecular movies that reveal conformational dynamics in biomolecules and ultrafast chemistry at atomic-level spatial and femtosecond temporal resolutions. Motivated by their overarching relevance, we will review some of the most recent scientific and technological advances in photon and particle sources and some of their most important breakthroughs in life, chemistry, and energy sciences.

Invited Talk (IT3): Dr. Rakesh K. Singh

Title: Seeing the invisible from the speckle grains

When a light propagates through a random scattering medium, the constituent photons undergo scattering events, and emerge diffusely scattered in all directions. Consequently, the output light is scrambled in space and time to deliver any useful information in the usual context. The information available at the observation plane is a low contrast, random, and seemingly information-less pattern. Therefore, the issue of seeing or quantitatively extracting the information from speckle appears to be challenging, yet a highly practical problem. Different techniques have been proposed to overcome challenges of the speckle. Some of these techniques are adaptive optics, phase coupling, transmission matrix, and filtering desired photons. Majority of these techniques require measurement and compensation and selection of the randomly scattered light.

On the other hand, correlation of the speckle field carries information of the scattered source in the far field. The correlation, one of the fundamental features of the light, provides a direct estimate of the speckle grain in two and three dimensions. Therefore, signatures of the randomly scattered light and speckle grains can be utilized to design and develop new trends in optical imaging. In this talk, we discuss the importance and advantages of correlation optics in imaging, and some of our recent contributions in this area. In contrast to the previously mentioned techniques, correlation optics led approach is capable of exploiting the randomness rather than cancelling it, and preserving the desired two-and three-dimensional space. Moreover, the possibility of combining correlation optics with computational methods is expected to bring more advantages in the un-conventional imaging.

Invited Speaker (IT4): Dr. Amit D. Lad

Title: Ultra-Intense Laser Produced Shock Waves

Ultra-intense, femtosecond laser pulses are capable of producing hot, dense plasma and thereby generate intense shock waves. In the present study, a system is considered in which the laser contrast is high; yet, there is sufficient energy in the pre-pulse to form a limited pre-plasma. This turns out to have an interesting consequence as the cold target is now sitting sufficiently close to the probe critical surface. The cold target explodes under the influence of the intense pump pulse, driving a strong shock outward into the pre-plasma, where it is witnessed by changes in the probe reflectivity and Doppler shift [1-4].

A detailed understanding of the critical surface motion of high intensity laser produced plasma is a very crucial parameter for understanding the interaction [1]. Experimentally resolving the ultrafast dynamics of high intensity laser driven plasma at both the relevant length scales and timescales simultaneously is challenging due to mainly the lack of diagnostic approach. Here, we present a novel technique based on pump-probe Doppler spectrometry to map spatially and temporally the ultrafast dynamics of hot-dense plasma generated by femtosecond, relativistic laser pulses [2]. Our technique offers hundreds of femtoseconds time resolution simultaneously with a few micrometer spatial resolution across the transverse length of the plasma. The experiment was carried out using the TIFR 150 TW laser system with peak intensity of [Fig. 1 (a)]. The part of the main beam is extracted using the thin beam-splitter and converted to a second harmonic (400 nm). The up-converted harmonic probe allows us to interrogate the dynamics in plasma which is over-dense with respect to the pump laser. A normally incident time-delayed probe pulse reflected from its critical layer experiences a change in its wavelength due to the motion of the critical layer. Measuring the time dependent Doppler shifts at different locations across the probe beam we obtain two-dimensional velocity maps of the probe-critical plasma layer at ultrafast timescales [Fig. 1 (b)]. The time and spatial resolution offered by the proposed technique could be improved using a short duration probe pulse and increasing number of detection channels respectively. Harmonics of the pump can be used to penetrate more deeper and capture the ultrafast motion of the solid density plasma [3,4]. Early time measurements, using this technique, provide very important information about shock wave generation and propagation in dense medium [2].

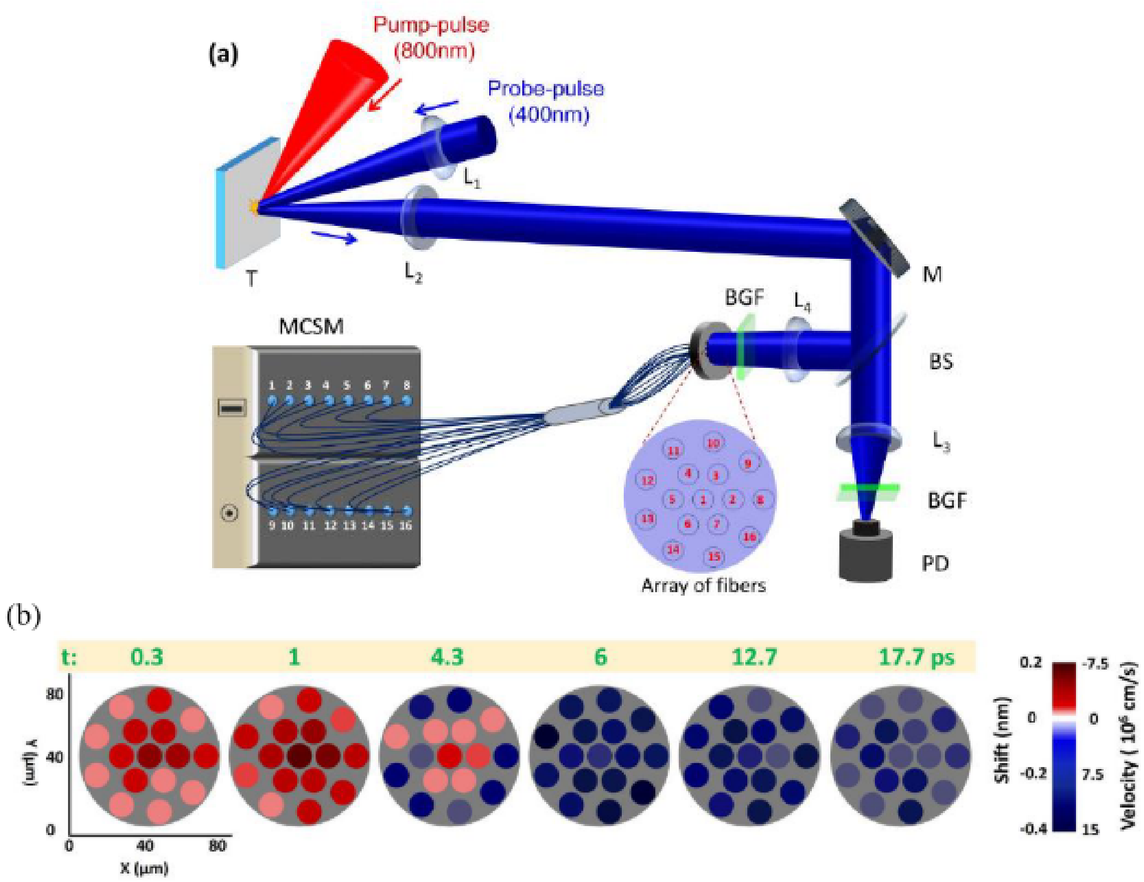


Figure 1. (a) Schematic of experimental setup for 2D Doppler spectrometry. (b) Spatially resolved Doppler shifts and corresponding velocity maps.

References:

1. P. K. Kaw, Rev. Mod. Plasma Phys. 1, 2 (2017).
2. K. Jana, A. D. Lad, D. West, W. Trickey, C. Underwood, Y. M. Ved, A. P. L. Robinson, J. Pasley, and G. R. Kumar, Phys. Rev. Research 3, 033034 (2021).
3. S. Mondal, A. D. Lad, S. N. Ahmed, V. Narayanan, J. Pasley, P. P. Rajeev, A. P. L.
4. Robinson, and G. R. Kumar, Phys. Rev. Lett. 105, 105002 (2010).
5. A. Adak, A. P. L. Robinson, P. K. Singh, G. Chatterjee, A. D. Lad, J. Pasley, and G. R. Kumar, Phys. Rev. Lett. 114, 115001 (2015).

Invited Talk (IT5): Dr. Arijit Kumar De

Title: Optical Trapping with femtosecod pulses: Excitements, Challenges and opportunities

Recent theoretical and experimental studies pursued in our group demonstrated that the nature of force/potential in optical trapping under continuous-wave excitation and ultrashort pulsed excitation (at the same time-averaged power) are distinctly different. In this talk I will first elaborate the concept of 'escape potential', arising from nonlinear optical force under femtosecond pulsed excitation, which was first theoretically envisaged by us and subsequently validated through meticulous experiments which also revealed the critical role played by thermal nonlinearity manifested by observation of an 'adjustment dynamics'. I will further discuss how we can harness optical nonlinearity to reverse the direction of force or to split a single trapping potential well into many wells which is promised to have far reaching applications in facile and controlled optical manipulation.

Invited Talk (IT6): Prof. Mehul Malik (Online)

Title: Programming high-dimensional quantum optical circuits inside a multi-mode fibre

Quantum states of light entangled in high dimensions offer the potential for noise-robust quantum communication networks that harness the full information carrying capacity of a photon. A central challenge in the realisation of such networks is the ability to precisely control and reliably transport high-dimensional entangled states of light. I will begin this talk by introducing the paradigmatic source of high-dimensional photonic entanglement—a nonlinear crystal generating a pair of photons entangled in the position-momentum degrees-of-freedom [1]. I will go on to discuss how knowledge of the continuous bi-photon wave function allows us to tailor discrete high-dimensional entangled states of light with record quality in a variety of spatial mode bases. As an example, I will present the generation and measurement of high-dimensional "pixel" entanglement with fidelities exceeding 94% and entanglement dimensionalities up to 55 [2].

In the second part of this talk, I will briefly review some recent work from my group on the transport [3] and noise-robustness [4] of high-dimensional entanglement. I will then go on to discuss how the platform of a simple complex scattering medium can be used for the precise manipulation of high-dimensional entangled states of light. I will present our "top-down" approach that allows us to embed a general photonic quantum circuit within a complex scattering medium such as a commercial multi-mode fibre [5]. Using this approach, I will show how we can program high-dimensional quantum optical circuits inside a multi-mode fibre through inverse-design techniques. I will demonstrate how this programmability allows us to turn the multi-mode fibre into a generalised multi-outcome device, enabling us to both transport and manipulate entanglement within the transmission channel itself. By harnessing the large, ambient mode space of a complex scattering medium as an additional resource, our work serves as an alternate yet powerful approach to standard photonic circuit design.

References:

1. V. Srivastav, N.H Valencia, S. Leedumrongwatthanakun, W. McCutcheon, M. Malik, "Characterising and Tailoring Spatial Correlations in Multi-Mode Parametric Downconversion" arXiv:2110.04506 (2021)
2. N.H. Valencia, W. McCutcheon, V. Srivastav, M. Pivoluska, M. Huber, N. Friis, M. Malik. "High-Dimensional Pixel Entanglement: Efficient Generation and Certification." Quantum 4, 376 (2020).
3. N.H. Valencia, S. Goel, W. McCutcheon, H. Defienne, M. Malik. "Unscrambling Entanglement through a Complex Medium." Nature Physics 16, 1112-1116 (2020).
4. V. Srivastav, N.H Valencia, W. McCutcheon, S. Leedumrongwatthanakun, S. Designolle, Roope Uola, Nicolas Brunner, M. Malik, "Noise-Robust and Loss-Tolerant Quantum Steering with Qudits," arXiv:2202.09294 (2022).
5. S. Goel, S. Leedumrongwatthanakun, N. H. Valencia, W. McCutcheon, C. Conti, P. Pinkse, and M. Malik, "Inverse-design of high-dimensional quantum optical circuits in a complex medium." arXiv:2204.00578 (2022).

Invited Talk (IT7): Dr. Bhaskar Kanseri

Title: Photonic quantum secure communication: Activities and prospects

Quantum key distribution (QKD) has become a new generation security solution, which does not rely on the computation assumptions of problems presumed to be difficult. This talk would begin with several key aspects of fiber and free-space quantum secure communication and would further highlight efforts being made by our group at IIT Delhi for both research and development in these areas. Some implementations of QKD in lab scale and in the field would also be discussed. The prospects of photonic quantum technologies would also be highlighted emphasizing field deployable devices for QKD.

Student Talk (ST1): Akansha Tyagi

Title: Dispersion-less all reflective attosecond resolved delay line for ultrafast metrology

Optical delay lines are key tools in ultrafast science and technology with several applications from femtosecond metrology to attosecond pump-probe spectroscopy of matter. For femtosecond metrology, with conventional whole beam and transmission grating-based delay lines the measuring ultrashort pulse has to pass through glass beam splitters at the cost of adding dispersion in the fundamental pulse. Here, we have developed an all-reflective dispersion free knife edge prism mirror-based delay line, which is ideal for measurement of hundreds of femtoseconds up to tens of femtosecond pulses in near-IR to visible spectral range. It is based on symmetrical splitting of measuring pulse, providing two separate arms for both split beams which make it more versatile for a wide range of applications in ultrafast measurements.

We have demonstrated our delay line with NIR –femtosecond pulse characterization with Field autocorrelation, non-linear autocorrelation (FRAC) and Second Harmonic-frequency resolved optical gating (SH-FROG) technique showing attosecond stability and precision. The delay line serves as an easy recording of time zero and also allows beam manipulation of individual split beams by controlling power, spectrum, polarisation and spin/orbital angular momentum. The delay line is dispersion free, compact, easy to align and provides attosecond precision and stability without any active stabilization. We envision to use this in-line delay setup for IR-IR or XUV-IR attosecond pump-probe experiments and optical gating using few cycle pulses.

Reference:

Akansha Tyagi, Mehar S. Sidhu, Ankur Mandal, Sanjay Kapoor, Sunil Dahiya, Thomas Pfeifer, and Kamal P. Singh "Attosecond stable dispersion free delay line for easy ultrafast metrology" Scientific Reports 12(2022) 8525

Student Talk (ST2) : Ravishankar Sugumar

Title: Yet to be filled Electron spectrum and angular distribution from aerosol jet collimated by an aerodynamic lens

Electrons at relativistic temperatures are typically generated with laser intensity of 10^{18} W/cm^2. However, electrons of temperature at 200 keV and 1 MeV and photons of energies up to 6 MeV have been observed at non-relativistic intensities (~10^{16} W/cm^2) for single micro-droplet target of size 15μm [1] and from boric acid solid particles of size ranging from 100 nm to 1μm [2]. To bridge the gap in understanding of the physics in 1μm – 10μm particle size interaction with the laser, an aerosol generator was considered as the particle source and an aerodynamic lens to collimate the aerosol jet to increase the particle intensity. Simulation of the aerodynamic lens was carried out on SimScale and the lens was fabricated according to the design. The size and velocity distribution of the jet were calculated by analysing the images of the droplets imaged with nanosecond laser pulses. In this work, we present the data from the aerosol size distribution, the electron spectrum and angular distribution obtained from the aerosol interaction with a femtosecond laser at an intensity of ~10^{16} W/cm^2.

References:

1. A. Mondal, arXiv preprint, arXiv:2107.03866 (2021).
2. R.K. Yembadi, PhD thesis (2021)

THURSDAY, 29TH SEPTEMBER, 2022 (DAY 2)

Invited Talk (IT8): Prof. Ebrahim Karimi

Title: Yet to be given

Invited Talk (IT9): Dr. Jasleen Lugani

Title: Integrated photonics for quantum information processing

Integrated photonics is expected to play a crucial role in developing quantum technologies. Leveraging on the existing infrastructure and technical know-how, integrated platforms offer scalable, stable and miniaturized hardware for implementing quantum information protocols. In this talk, I will present an overview of how basic optical elements such as waveguides, directional couplers and phase shifters on these platforms can be used to develop major building blocks of a quantum optics experiment. These functional elements can be appropriately engineered to generate desired quantum states of light and also manipulate them using tunable linear optical circuits for a multitude of quantum information applications.

Invited Talk (IT10): Dr. Anindya Banerjee

Title: Distributing entanglement over a fiber network and publicly verifiable quantum randomness

In the first part of this talk, I will introduce some of the advancements that we have made towards the development of a compact and efficient quantum communication network for campus-wide implementations. We show that, contrary to popular belief, non-compatible wavelengths can be used for high quality distribution of entangled photons through existing telecommunication fiber.

In the second part, I will talk about quantum random number generators that allow public randomness testing without compromising the privacy of the generated random bits. This offloads the computationally resource intensive task of randomness certification to a third party while at the same time maintaining the secrecy of the generated bits.

Invited Talk (IT11): Dr. Anirban Pathak

Title: Secure quantum communication and computation: Which tasks can be realized and/or commercialized in the near future?

Discussion about secure quantum communication and computation is usually restricted to the discussion of the schemes for quantum key distribution, but there are several other cryptographic tasks for which quantum protocols are known. In this talk, we will discuss possibilities of realization of such protocols with specific attention towards the schemes for quantum secure direct communication, quantum dialogue, quantum voting, quantum lottery, etc. We will also discuss associated technical challenges and which of the possible practical realizations are expected to be commercialized in near future. The discussion will move around the protocols designed by us (theoretically) and corresponding experiments of the other groups. We will also talk about some challenges we face in the lab that students can try to solve.

Invited Talk (IT12): Dr. Haw Jing Yan (Online)

Title: National Quantum-Safe Network - A Singapore initiative

Quantum technologies are indisputably on the rise, developing at unprecedented speeds as they emerge from academic research into a dynamic R&D ecosystem, supported by governments and tech giants. Among the most warranted technology is the resilience against anticipated quantum computers, which poses a threat to existing classical communication networks. Such a mature and large-scale quantum network requires several aspects of its functionality for completeness, for example, open network accessibility for partners, in-depth security evaluation, and reference guidelines to build readiness in the development of national reference specifications.

Motivated by the above, in this talk, I introduce the National Quantum-Safe Network (NQSN) initiative in Singapore. NQSN aims to establish a nationwide collaborative platform and a field-deployed testbed across Singapore, to achieve a systematic construction of quantum-safe communication technologies. We aim to do so by putting the network through a rigorous scrutiny of standards and certification, and on the other hand using it to demonstrate the integration of various quantum-safe applications. Our main goal is to deploy commercial quantum-safe technologies for trials with government agencies and private companies; to conduct in-depth evaluation of security systems; and to develop guidelines to support companies in adopting such technologies.

Invited Talk (IT13): Dr. Shouvik Ghorai

Title: 1-sided device independent continuous-variable QKD with discrete modulation

Invited Talk (IT14): Dr. Gopal Dixit

Title: All-Optical Ultrafast Valley-Switch in Two-Dimensional Materials

Analogues to spin, electrons in two-dimensional (2D) materials endow an additional quantum attribute: valley pseudospin, which is associated with the valleys in the energy landscape of these materials. There are two degenerate valleys situated at the corners of the Brillouin zone in 2D materials. Similar to 0 and 1, two valleys can be seen as two units of operations. Not only that, operations in between the two units, i.e., the superposition of 1 and 0, can also be realised using two valleys. Superposition principle is an essential ingredient for quantum technology. Therefore, these valleys have potential to encode, process, and store quantum information, opening the field of valleytronics at room temperature – A holy grail for quantum computing. Moreover, coherent switching of electronic excitation from one valley to another on a timescale faster than the valley decoherence is quintessential for valleytronics-based emerging quantum technologies at ambient conditions.

In this talk, I will discuss how valley-selective excitation in 2D materials can be achieved by an all-optical means. Non- resonant ultrashort laser pulses are employed to obtain a desire control over valley polarisation. By tailoring the waveforms of the laser pulses to the symmetry of the material's sub-lattice, I will demonstrate that it is possible to induce and read valley polarization in 2D materials including graphene -- a medium where light-driven valleytronics was thought to be impossible. In the later part of this talk, I will show a coherent protocol to initiate valley selective excitation, de-excitation and switch the excitation to another valley within tens of femtoseconds -- timescale faster than any valley decoherence time. Our coherent control protocol consists of three time-separated linear pulses, polarised along the same direction. Laser pulse can cause electrons to wiggle several hundred trillion times a second. This means valleytronics at petahertz rates is possible, which exceeds modern computational speeds by a million times.

Invited Talk (IT15): Dr. Thierry Ruchon

Title: Extreme nonlinear optics with beams carrying angular momenta

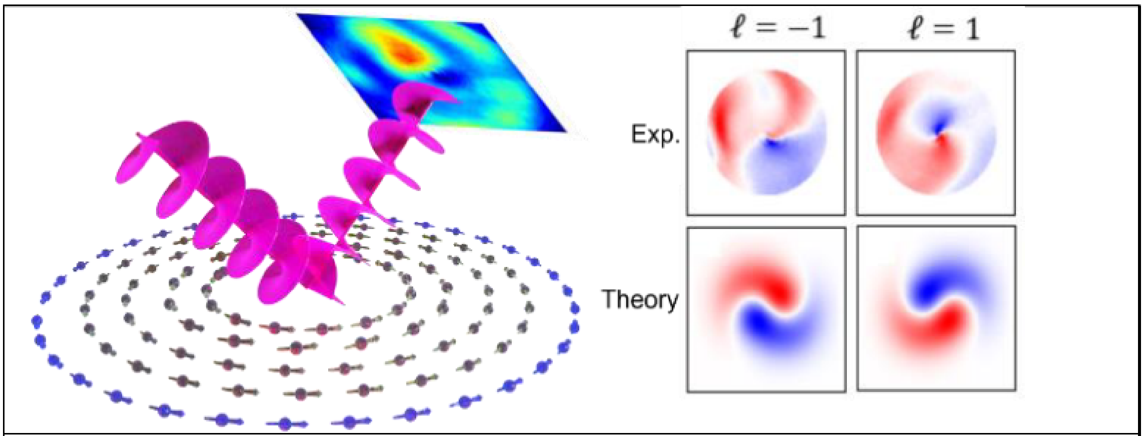


Fig. 1: (Left) Experimental sketch for the observation of magnetic helicoidal dichroism. (Right panel) Differences between the images acquired for two opposite curling senses of the magnetic vortex, showing a typical 2D chiral structure, which depends on the incoming orbital angular momentum (top). Theoretical result (bottom).

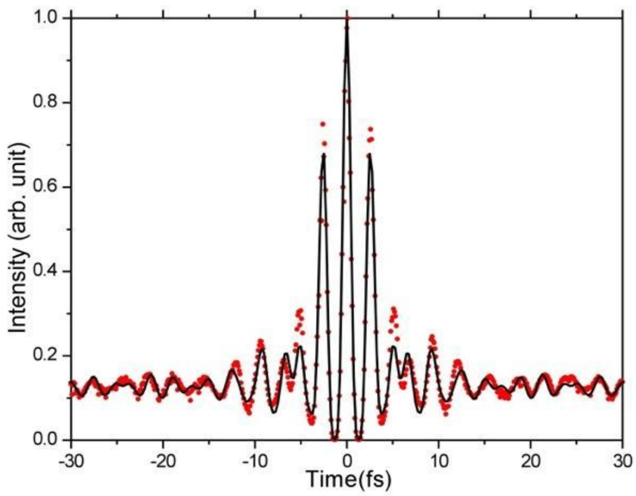
Light beams may carry both a spin and an orbital angular momentum (OAM). While the former is associated with their polarization state, the latter stems from the geometrical properties of their wavefront. In their prototypical form, beams with OAM have "donuts-like" intensity profiles and helicoidal wavefronts, carrying integral multiples of $\hbar$ as angular momenta. Since their "rediscovery" in the late 90's, beams with OAM of visible wavelengths have found innumerable applications in quantum optics, microscopy or information transfer. A major recent development was the generation of such beams with much smaller wavelengths – in the extreme ultraviolet (XUV) - using synchrotron sources, free electron lasers as well as high harmonic sources (HHG). In this latter case, it creates ultrashort XUV sources of beams with OAM, suited for time-resolved applications at femtosecond and attosecond time scales. In this communication, we will review recent progress, which allows us to control the angular momenta of femtosecond and attosecond XUV beams with great flexibility [1, 2, 3, 4]. It offers a new playground to test conservation laws in an extreme nonlinear process [5], as well as an original tool to explore new kinds of dichroisms [6, 7, 8].

References:

1. Géneaux, R. et al., 2016. Nature Communications, 7, 12583. http://dx.doi.org/10.1038/ncomms12583
2. Géneaux, R. et al., 2017. Phys Rev A, 95, 051801. http://dx.doi.org/10.1103/PhysRevA.95.051801
3. Gauthier, D. et al., 2017. Nature Communications, 8, 14971. http://dx.doi.org/10.1038/ncomms14971
4. Camper, A. et al., 2017. Optics Letters, 42(19), 3769. http://dx.doi.org/10.1364/ol.42.003769
5. Luttmann, M. et al., 2022. Conservation of a half-integer angular momentum in nonlinear optics with a polarization möbius strip. http://dx.doi.org/10.48550/ARXIV.2209.00454
6. Fanciulli, M. et al., 2021. Physical Review A, 103(1). http://dx.doi.org/10.1103/physreva.103.013501
7. Fanciulli, M. et al., 2022. Physical Review Letters, 128(7), 077401. http://dx.doi.org/10.1103/physrevlett.128.077401
8. Luttmann, M. et al., 2022. In V. Yakovlev and S. Haacke, eds., Advances in Ultrafast Condensed Phase Physics III. SPIE. http://dx.doi.org/10.1117/12.2620539

Invited Talk (IT16): Prof. Marcus Dantus (Online)

Title: Linear and Nonlinear Optical Interference in Ultrafast Science



Wave interference is central to optics, as this phenomenon helps us understand the formation of laser pulses and leads us to impressive applications, such as certifying the surface curvature of the James Webb Space Telescope while it was being built on Earth. When laser pulses are used in nonlinear optics, we find that the material response, for example second harmonic generation, is very sensitive to the spectral phase of the pulse. This observation has led to very powerful methods for characterizing, compressing, and shaping femtosecond laser pulses: an approach that we called

Multiphoton Intrapulse Interference Phase Scan (MIIPS) [1,2]. In contrast to all previous methods used to characterize laser pulses, MIIPS does not require beam splitters, optical delay lines, or overlapping pulses. It relies on interference among frequencies within the pulse, also known as intrapulse interference. The method is best carried out with a programmable pulse shaper to scan a reference phase across the spectrum of the laser. Once the spectral phase distortions of the pulse are measured, the programmable pulse shaper can introduce a complementary phase to cancel out the phase distortions and thus arrive at transform limited pulses. We have used MIIPS to compress pulses down to sub-two-cycle 4.3 fs pulses and solve significant challenges such as improving biomedical imaging [3], to identify cancer [4], proteomic sequencing by cleaving strong chemical bonds while leaving weak bonds intact [5], and standoff trace detection methods to enable fast imaging of trace quantities of explosives [6]. In this lecture, I will review aspects of linear interferometry and its applications. Then, I will explain links between linear interference and ultrafast laser pulses. Finally, I will devote the rest of the lecture to nonlinear optical interference and explain how it can be used to characterize the light itself, as well as for applications in ultrafast spectroscopy.

References:

1. B. Xu, J. M. Gunn, J. M. Dela Cruz, V. V. Lozovoy, M. Dantus, “Quantitative investigation of the MIIPS method for phase measurement and compensation of femtosecond laser pulses,” J. Optical Society B **23**, 750-759 (2006)
2. Y. Coello, V. V. Lozovoy, T. C. Gunaratne, B. Xu, I. Borukhovich, C. -h. Tseng, T. Weinacht, and M. Dantus, "Interference without an interferometer: a different approach to measuring, compressing, and shaping ultrashort laser pulses," J. Opt. Soc. Am. B **25**, A140-A150 (2008).
3. P. Xi, Y. Andegeko, L. R. Weisel, V. V. Lozovoy, M. Dantus, “Greater Signal and Less Photobleaching in Two-Photon Microscopy with Ultrabroad Bandwidth Femtosecond Pulses,” Opt. Commun. **281**, 1841-1849 (2008).
4. H. Tu, Y. Liu, D. Turchinovich, M. Marjanovic, J.K. Lyngsø, J. Lægsgaard, E.J. Chaney, Y. Zhao, S. You, W.L. Wilson, B. Xu, M. Dantus and S.A. Boppart, “Stain-free histopathology by programmable supercontinuum pulses,” Nat. Photonics **10**, 534-540 (2016).
5. C. Kalcic, G. Reid, V. V. Lozovoy and M. Dantus, “Mechanism Elucidation for Nonstochastic Femtosecond Laser-Induced Ionization/Dissociation: From Amino Acids to Peptides”, Journal of Physical Chemistry A **116**, 2764-2774 (2012).
6. M. T. Bremer and M. Dantus, “Standoff explosives trace detection and imaging by selective stimulated Raman scattering”, Appl. Phys. Lett. **103**, 061119 (2013).

Invited Talk (IT17): Dr. Kamal P. Singh

Title: Ultrathin attosecond delay liefor IR-IR control of harmonics

In this talk, we introduce an ultra-thin attosecond optical delay line based on controlled wavefront division of a femtosecond infrared pulse after transmission through a pair of micrometer-thin glass plates with negligible dispersion effects. The time delay between the two pulses is controlled by rotating one of the glass plates from absolute zero to several optical cycles, with 2.5 as to tens of attosecond resolution with 2 as stability, as determined by interferometric self-calibration. The performance of the delay line is validated by observing attosecond-resolved oscillations in the yield of high harmonics induced by time delayed infrared pulses, in agreement with a numerical simulation for a simple model atom.

Invited Talk: Prof. Federico Capasso

Title: Structured light and dark by Meta-optics

Student Talk (ST3): Vishal Sharma

Title: Analysis of Information Reconciliation for Quantum Key Distribution

Quantum key distribution (QKD) is a promising technology of distributing secure cryptographic keys in an insecure communication channel. Due to unconditional security, based on the principles of quantum mechanics, this has now become one of the fast approaching communication standards in many industries. QKD Information reconciliation is one of the essential steps of classical post-processing of quantum key distribution to correct the errors in the noisy quantum channel. The proposed technique is based on the low-density parity check codes, investigating the interactivity between the communicating parties, reconciliation efficiency, amount of information revealed, attainable communication distance, secure key generation, and error rate estimation considering complexity and performance of the entire system for real-field practical applications.

Student Talk (ST4): Shreeshna Subhash

Title: Quantum back action nullifying meter to improve the sensitivity of squeezed light optomechanical interferometer

Competition between shot noise and radiation pressure noise limits the accuracy of optomechanical interferometry to standard quantum limit (SQL) when operated at optimum laser intensity. Application of frequency dependent squeezed vacuum improves the sensitivity beyond SQL by a factor of e−r, where r is the squeezing parameter. In this work [1], we apply quantum back-action nullifying meter (QBNM) technique [2] to enhance the sensitivity beyond SQL by a factor of √(e−2rζ/4Δ), where $0 < \zeta/\Delta < 1$, with ζ as the optomechanical

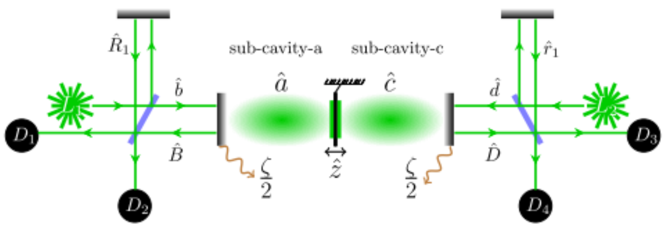
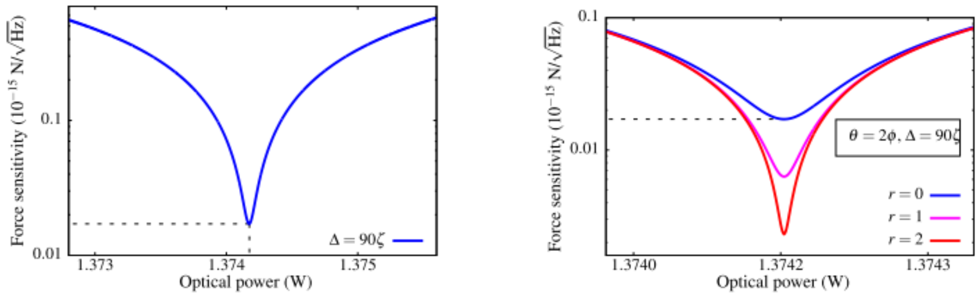


Fig. 1: Interferometer with a perfectly reflective membrane in the middle. The mechanical mirror divides the total cavity into two sub-cavities with equal length, $\hat{a}$ and $\hat{c}$ are the annihilation operators for the sub-cavities as shown in the Fig. 1. $\hat{b}$ and $\hat{d}$ are annihilation operators for external driving fields, and $\hat{B}$ and $\hat{D}$ are the annihilation operators for output fields. $\hat{R}_1$ and $\hat{r}_1$ are the annihilation operators of the reference fields.



(a) (b)

Fig. 2: Variation of force sensitivity as a function of input laser power. (a) shows the variation of force sensitivity at $\Delta = 90\zeta$, (b) variation of force sensitivity with different squeezing parameter r. The squeezing angle θ is fixed at 2ϕ, ϕ is the phase of the input fields. For simulation, we use the following optomechanical parameters: mass of the mechanical oscillator $= 10^{-7}$Kg, eigenfrequency of the mechanical oscillator $= 10^5$Hz, frequency of the external driving fields $= 6\pi/5 \times 10^{15}$Hz, $\Delta = 90\zeta$, $\zeta = 10^6$Hz, decay rate of the mechanical oscillator $=$ 1Hz, optomechanical coupling strength $= 10^{18}$Hz/m.

cavity decay rate and Δ as the detuning between cavity eigenfrequency and driving field. The QBNM allows the cavity field to monitor the mechanical oscillator's motion without radiation pressure noise. As a result, sensitivity is improved beyond SQL by a factor of $\sqrt{(\zeta/4\Delta)}$. When QBNM is combined with frequency dependent squeezing, the sensitivity is improved by a factor of $\sqrt{(\exp.(-2r\zeta/4\Delta))}$ beyond SQL. The results described in this work are valid for frequencies much smaller than the resonance frequency of the optomechanical mirror.

References:

1. S. Subhash, S. Das, T. N. Dey, Y. Li and S. Davuluri, Enhancing the force sensitivity of squeezed light optomechanical interferometer, 2022. 10.48550/ARXIV.2201.10893.
2. S. Davuluri and Y. Li, Light as quantum back-action nullifying meter, 2022. 10.48550/ARXIV.2202.06030.

Student Talk (ST5): Sonali Khanna

Title: Boosting electron emission from liquid droplet microplasma

Laser plasma interaction is a one stop source of high energy electrons, ions, electromagnetic radiation ranging from THz to X-rays. Such a bright particle beam and small source size has potential applications in a wide range of contexts, from medical physics to defence and many other industries. To make the source viable for many applications production of high energy electrons with high repetition rate of laser that can be handled by non-experts is necessary. The recent developments from our group have shown that structural modification of microdroplets with the help of pre-pulse provide efficient environment for two plasmon decay (TPD) instability growth and boosts electron acceleration to MeV energies even at intensity of 10^{16} W/cm^2 obtained with kHz repetition rate lasers. According to intensity scaling law for hot electron temperature, temperature of MeV is expected at an intensity of 10^{18} W/cm^2 which can only be obtained with high laser facilities having repetition rate of few Hz only. Intensity threshold has been reduced by two orders of magnitudes with the help of TPD instability. In this work, we studied the effect of bandwidth on the emission of electrons studied by manipulating the chirp of the laser pulse for its potential use with MHz lasers which have a shorter bandwidth. Also, commercial high repetition laser sources are available with longer pulse width and longer wavelength. Effect of longer pulse width and longer wavelength on TPD growth is studied to check feasibility of source.

References:

1. Felicie Albert and Alec Thomas. Applications of laser wakefield accelerator based light sources. Plasma Physics and Controlled Fusion, 58, 09 2016.
2. Angana Mondal, et al., Laser structures micro-targets generate MeV electron temperature at 4 * 10^{16} W/cm^2. arXiv:2107.033866.

Student Talk (ST6): Rambabu Rajpoot

Title: High-order harmonic generation by sub-cycle laser pulses and associated scaling laws

The field of strong-field interactions and the subsequent study of high-order harmonic generation (HHG) has witnessed tremendous advancement during the past two decades. The parameters of the driving laser pulse play a crucial role in determining the structure of the HHG spectra. By tweaking the driving field parameters, we have already reported the methods to tune the harmonic cutoff energies and the polarization properties of emitted radiation [1, 2]. Additionally, we studied the shaping of a chirped laser pulse by a plasma ramp, and the application of this shaped ultra-short pulse in HHG [3].

Here, our intent is to explore the process of HHG by the sub-cycle driving laser fields. We studied the HHG by the interaction of sub-cycle laser pulses (SCPs) with the He atom. The SCPs are modeled using the complex source vector beam model [4], which accurately models the sub-cycle field profiles.

It is observed that the harmonic cutoff could be extended with the variation of the sub-cycle pulse duration, mainly because of the inherent blue-shift associated with shorter pulses. The scaling laws for the harmonic yield and cutoff energy with pulse duration and fundamental driver wavelengths are also deduced. In addition, a detailed wavelet analysis of harmonic generation by sub-cycle pulses is carried out. Lastly, the appropriate filtering and superposition of the harmonics gave rise to a single attosecond pulse of duration ~ 100 as.

References :

1. R. Rajpoot, A. R. Holkundkar, and J. N. Bandyopadhyay, J. Phys. B: At. Mol. Opt. Phys. 53, 205404 (2020).
2. R. Rajpoot, A. R. Holkundkar, and J. N. Bandyopadhyay, J. Phys. B: At. Mol. Opt. Phys. 54, 225401 (2021).
3. A. R. Holkundkar, and R. Rajpoot, Phys. Scr. 95, 085607 (2020). [4] Q. Lin, J. Zheng, and W. Becker, Phys. Rev. Lett. 97, 253902 (2006).

Student Talk (ST7): **Sanket Sen**

Title: **Dissociation dynamics of C 1s Auger decayed doubly charged camphor molecule using soft x-ray radiation**

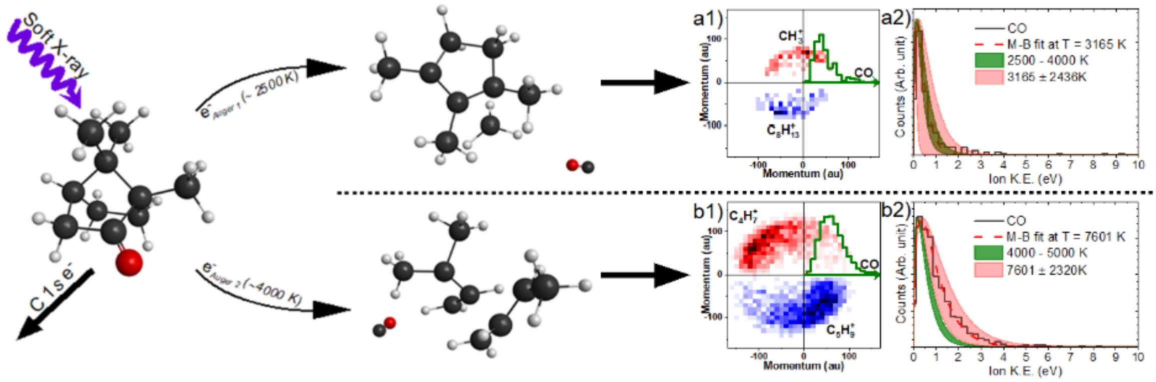


Fig. 1 (Left) Schematic of the molecular dynamics simulation for the identified pathways, $CH_3^+ + C_8H_{13}^+ + CO$ & $C_4H_7^+ + C_5H_9^+ + CO$. The energy deposited post Auger decay replicated as the bath temperature. (Right) (a1 & b1) The Newton diagrams of the experimental data referred to the direction of neutral CO. (a2 & b2) The kinetic energy distribution of the neutral CO, with M–B fit is performed. The light red area represents the error incorporated and olive area shows the temperature range for the fragmentation channel in the MD simulations.

Irradiating camphor molecules with soft X-ray synchrotron radiation ionises C 1s electron and excites the molecule to its doubly charged state following Auger decay [1]. In this work [2], we studied the dissociation dynamics that follows the Auger decay, using velocity map imaging technique integrated with photoelectron-photoion-photoion coincidence to record the 3-D momenta of the ionic fragments [3,4]. Internal energy of the molecule post Auger decay and its redistribution affects the ensuing dynamics. Molecular dynamics simulation, at various internal energies (temperature as the corresponding parameter) [5,6], complements the experimental study.

Camphor molecular dication can fragment via various pathways, which is observed in the experiment. Two of the experimentally observed channels could be correlated to the simulations with a good match between angular distributions of the ionic fragments. Unique signatures of the internal energy deposited into the molecular ion were observed in the experimental kinetic energies of the neutral CO, emitted in the first step of the two step deferred charge separation fragmentation pathways, hinting towards the energy state of the molecular ion prior to dissociation. However, a thorough theoretical study is essential to decipher exact fragmentation pathways.

References:

1. de Castilho, R. B. et al. Rapid Commun. Mass Spectrom., 2014, 28, 1769–1776
2. Sen, S. et al. Phys. Chem. Chem. Phys., 2022, 24, 2944
3. Mandal, S. et al. Phys. Chem. Chem. Phys., 2020, 22, 10149–10157
4. Gopal, R. et al. Rev. Sci. Instrum., 2018, 89, 086107
5. Kukk, E. et al. Phys. Rev. A: At., Mol., Opt. Phys., 2015, 91, 043417
6. Itälä, E. et al. J. Phys. Chem. A, 2016, 120, 5419–5426

FRIDAY, 30TH SEPTEMBER, 2022 (DAY 3)

Invited Talk (IT18): Prof. Arup Lal Chakraborty

Title: Yet to be given

Invited Talk (IT19): Dr. Joe Philip Ninan

Title: Precision calibration of astronomy spectrographs using Laser Frequency Combs

Over the last decade, introduction of laser frequency comps have revolutionized the calibration accuracy of astronomy, high resolution spectrographs. The ability to calibrate the stellar spectrum to previously unprecedented levels are pushing the boundaries of the parameter space where we can discover new exoplanets. The discoverability of earth like planets around sun-like stars are now within the reach of humanity.

In this talk, I shall give an overview of how laser frequency combs are used in astronomy spectrographs. What are its current strengths and weaknesses? What does an astronomer's dream wavelength calibrator look like?

Invited Talk (IT20): Dr. Ravindar Kumar Banyal

Title: High-contrast Imaging & Spectroscopy of Extrasolar Planets

From prehistoric times people speculated about the existence of 'other worlds' beyond the solar system. However, the technology to detect planets around other stars have only matured in the last quarter of the previous century. Today, exoplanet discoveries have become a routine. Thanks to a half-dozen methods used for detecting planets both from ground and space observatories. A majority of these planets are discovered by indirect methods such as Doppler and transit methods. The direct imaging of the exoplanets allows a detailed study of the orbital, physical and chemical properties of the planets, which helps us to understand how planets form and evolve. There are two major challenges to direct imaging: 1) a huge brightness difference between the star and the intrinsically faint planet and 2) the instability of Earth's atmosphere which adversely impacts the telescope resolution. In this talk, I will discuss how these challenges are overcome by combining adaptive optics and coronagraphy to achieve high-contrast imaging by carefully isolating the starlight from the planet. I will also describe some clever observational strategies and post-processing algorithms used for suppressing speckle noise.

Invited Talk (IT21): Dr. Saurabh Raj
Title: A single molecule insight into DNA-protein interactions

Studying cells and biomolecules at the single molecule level has now become a rule, since this technique allows for the measurement of distribution of events rather than an ensemble average. Methods such as magnetic and optical tweezers are becoming the standard to characterize the kinetics of processive enzymes and develop a mechanistic model. Helicases are a broad family of enzymes that perform crucial functions in DNA replication and have a role in almost every aspect of DNA and RNA metabolism. Here I present the multifaceted application of Magnetic tweezers to understand the kinetics of these helicases. The magnetic tweezers provide a convenient, moderately throughput assay (tens of enzymes can be monitored simultaneously), which can be used to study these enzymes at high resolution (single base pair) in a variety of conditions and using a wide range of substrates (double-stranded DNA and single-stranded RNA). In addition, I will introduce the possibility of single-molecule DNA sequencing using magnetic tweezers.

Invited Talk (IT22): Dr. Sankar De

Title: Vector Magnetometry with electromagnetically induced transparency

The coherent interaction of the electric fields with the atomic medium which leads to phenomena like electromagnetically induced transparency (EIT) are highly sensitive to the external magnetic fields. Using this fact, magnetic field with good spatial resolution and high sensitivity can be measured. In addition to the magnetic field strength, knowing the direction of the magnetic field is also important. Combining the coherent optical effects like EIT with the longitudinal and transverse magnetic fields create an opportunity for developing an EIT based atomic vector magnetometer which is sensitive to the direction of the magnetic field. In our laboratory, we have developed an apparatus to study the effects of static longitudinal and transverse magnetic fields in a hyperfine Λ-type EIT system. We have shown how the EIT resonance is highly sensitive to the magnetic field direction as well as the polarization direction of the applied electric fields. The selection rules of the EIT resonances can be controlled by controlling the polarization components of the laser fields with respect to the quantization axis. On the theoretical front, apart from developing a numerical solution to support the experimental observation, a toy model consisting of nine level Zeeman sub-system, has been derived in order to analytically understand the phenomena.

Reference:

1. Bankim Chandra Das, Arpita Das, Dipankar Bhattacharya and Sankar De, Journal of the Optical Society of America B, 38, 584 (2021).

Student Talk (ST8): Krishna Joshi

Title: Observation of exceptional points in Anderson-localizing systems

Non-Hermitian transport of photons in optical lattices has shown many intriguing phenomena and become vital part of the photonics.[1] In deterministic systems with deliberately introduced optical gain and loss, the existence of singular points also called ”Exceptional points (EP)” in parameter space has shown lasing over in it. At EP, the eigenvalues and eigenmodes of the system coalesce and become degenerate.[2, 3] Such degeneracy is also called non-Hermitian degeneracy. The existence of such singular point can also confirmed via the drastic modification in physical parameters and have been systematically in couple optical cavities and waveguides.

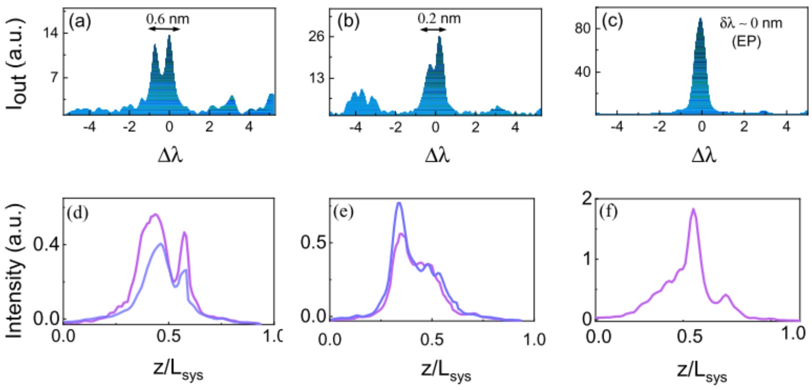


Figure 1. **Experimentally measured spectro-spatial characteristics of Anderson localized lasing modes around and at an exceptional point (EP)**: (a-c): Eigenvalue spectra with mentioned splittings ($\delta\lambda$). (d-f): corresponding spatial intensity distribution.

Here, we experimentally demonstrate lasing over exceptional points in quasi-one-dimensional Anderson localizing structures with optical gain.[4] Simultaneous spectro-spatial analysis of emission modes revealed coupled lasing modes in several configurations. Systematic analysis of spectral splitting and associated eigenfunctions revealed simultaneous coalescence of eigenvalues and eigenvectors. The former was directly measured in the spectra, while the latter was endorsed by observation of asymmetric amplification in one of the two cavities. The square-Lorentzian lineshape certified Anderson-localized lasing over exceptional points. Enhanced functionality manifested as manyfold increase in lasing intensity at the exceptional point.

References:

1. El-Ganainy, R., Makris, K. G., Khajavikhan, M., Musslimani, Z. H., Rotter, S., and Christodoulides, D. N., “Non-Hermitian physics and pt symmetry,” Nature Physics 14(1), 11–19 (2018).
2. Ozdemir,¨S,. K., Rotter, S., Nori, F., and Yang, L., “Parity–time symmetry and exceptional points in photonics,” Nature materials 18(8), 783–798 (2019).
3. Wiersig, J., “Review of exceptional point-based sensors,” Photonics Research 8(9), 1457–1467 (2020).
4. Joshi, K., Kumar, R., and Mujumdar, S., “Anomalous localization and transport behavior of amplifying periodic-on-average random systems at critical disorder,” Physical Review A 105(3), 033505 (2022).

Student Talk (ST9): Anagha Sreedharan

Title: Rotation of polarization and spin modes in a uniaxial crystal plate

Coupling of the intrinsic spin and, intrinsic and extrinsic orbital angular momentum (AM) degree of freedom in a paraxial beam of light, during free-space propagation, due to focusing, propagating though an optical fiber or an optical crystal has revolutionised our understanding of light and light-matter interactions during the past more than two decades [1]. One of the manifestations of the coupling of the different AM degrees is shifting or rotating mode structure [2 – 4]. Apart from the spatial separation of the spin and orbital AM components in a beam of light, respectively leading to the appearance of spin-Hall (SH) and orbital-Hall (OH) effects, recent reports of spin-orbit optical Hall effect [5] and spin-orbit mapping [6] further exploits the fundamental aspects of the spin-orbit (SO) interaction to understand and apply its various aspects.

The superposition of transverse and longitudinal optical fields in an anisotropic medium results in the appearance of optical torque that has led to the rotation of spin polarization in the transverse plane [7]. The correlation between the inhomogeneously polarized beam and its total angular momentum is due to the spin-orbit interaction [8]. Here we present simulation and experimental results on the polarization and transverse spin mode rotation due to propagation of a paraxial beam of light through a tilted-rotated uniaxial crystal plate. We observe that both the polarization of ellipticity and ellipse orientation angle and hence the rotation of the optical mode pattern as a function of the tilt angle (Θ) and the optic axis (OA) orientation (φ) of the crystal plate. The (Θ,φ) degrees of freedom of the crystal plate provides the necessary coupling between the transverse and longitudinal phase difference to the polarized light beam propagating through the crystal. The resultant inhomogeneously varying polarization distribution at the output of the crystal plate reveals many interesting topological features.

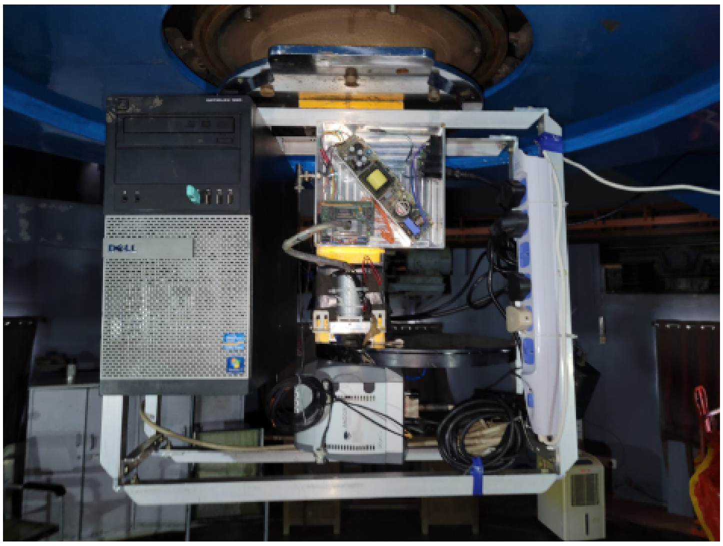
References:

1. K. Y. Bliokh, F. J. Rodríguez-Fortuño, F. Nori, and A. V. Zayats, Nat. Photonics 9, 796 (2015).
2. V. S. Liberman and B. Y. Zel'dovich, Phys. Rev. A 46, 5199–5207 (1992).
3. D. L. P. Vitullo, C. C. Leary, P. Gregg, R. A. Smith, D. V. Reddy, S. Ramachandran, and M. G. Raymer, Phys. Rev. Lett. 118, 083601 (2017).
4. T. P. Chakravarthy, D. N. Naik and N. K. Viswanathan, J. Opt. 19, 105607 (2017).
5. S. Fu, C. Guo, G. Liu, Y. Li, H. Yin, Z. Li and Z. Chen, Phys. Rev. Lett. 123, 243904 (2019).
6. L. Fang, H. Wang, Y. Liang, H. Cao and J. Wang, Phys. Rev. Lett. 127, 233901 (2021).
7. El Ketara, M., Kobayashi, H. and Brasselet, E., 2021. Nature Photonics, 15(2), pp.121-124.
8. Sreedharan, A. and Viswanathan, N.K., 2022. Optics Letters, 47(15), pp.3768-3771.

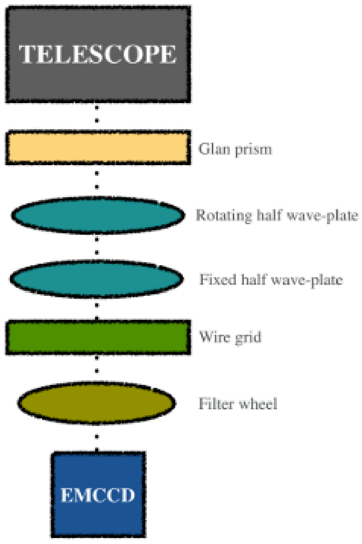
Student Talk (ST10): Aravind K.

Title: Polarimetric observation of cometary bodies

Comets are the primordial remnants of the Solar system containing pristine materials that were present in the proto-Solar nebula. Generally termed 'dirty snowballs' as they are built up of both dust and ice. These objects are inactive and non-detectable during a larger part of their orbit as the ambient temperature is not high enough to sublimate the volatiles. As the comet moves closer to the Sun, the volatile materials present in it sublimate, also pushing out the dust present in it. The light observed from a comet is composed of two components, the fluorescence emission from the gas and the Sun light scattered by the dust particles present in it. As the light scattered by the dust particles are polarised, polarisation measurement in cometary bodies has been a preliminary technique to probe the dust particles. It is observed that the degree of polarisation varies with the Sun-Target-Observer (STO) angle, also known as phase angle. Also, the characteristic phase-polarisation curve of distinct comets varies. Such a difference between distinct comets would be due to the variation in the physical and chemical composition of the dust present in these comets. Hence, the polarisation-phase curve of each comet, clubbed with dust modelling techniques, can be used to get a general understanding of the properties of the dust present in them.
The polarimetric observation of comets are performed using the in-house developed EMCCD based optical imaging polarimeter (see Figure 1) mounted on the 1.2 m Mt. Abu telescope. In this talk, brief details regarding the working of the instrument, data analysis and science interpretation of the results obtained from the observation of a few comets would be discussed.



(a) EMPOL instrument mounted on the 1.2 m Mt.Abu telescope



(b) Schematic representation of the components present in EMPOL.

Figure 1: EMCCD based optical imaging polarimter, EMPOL.

Student Talk (ST11): Sandeep Kumar

Title: Ultrafast photothermal THz-hysteresis in a spintronic emitter

Femtosecond laser excited FM/NM spintronic heterostructures utilizing the ISHE effect[1, 2] have emerged as a potential candidate for powerful and broadband THz radiation sources [3, 4]. The advantage with spintronic emitters is that by playing with various choices of the materials and the parameters involved, one can optimize the THz power[5], polarization, bandwidth and so on [6]. I will describe our recent study on a Fe/Pt spintronic THz emitter (STE), where we investigated the ultrafast excitation-fluence dependent THz polarity reversal by measuring the THz-hysteresis loop[7]. The nature of the study is described in Fig. 1. We used Ti:sapphire femtosecond laser pulses providing pulses at 1 kHz, ~35 fs and ~800 nm. THz pulses and their spectrum generated from femtosecond laser excited Fe/Pt bilayer is presented in Fig. 1(a). In Fig. 1(b), peak THz amplitude emitted from the Fe/Pt heterostructure is plotted as a function of varying external magnetic field at different excitation-fluences which resembles the usual M-H hysteresis loops measured by the conventional vibrating-sample magnetometer technique. The varying excitation-fluence consequently switches the polarity of the THz signal at a certain value (see inset 1(b)) due to the ultrafast-photothermal effect. The results from THz-hysteresis clearly demonstrate an all-optical route for ultrafast induced magnetization switching which is important for the realization of the high-speed data processing schemes beyond the conventional state-of-art methods.

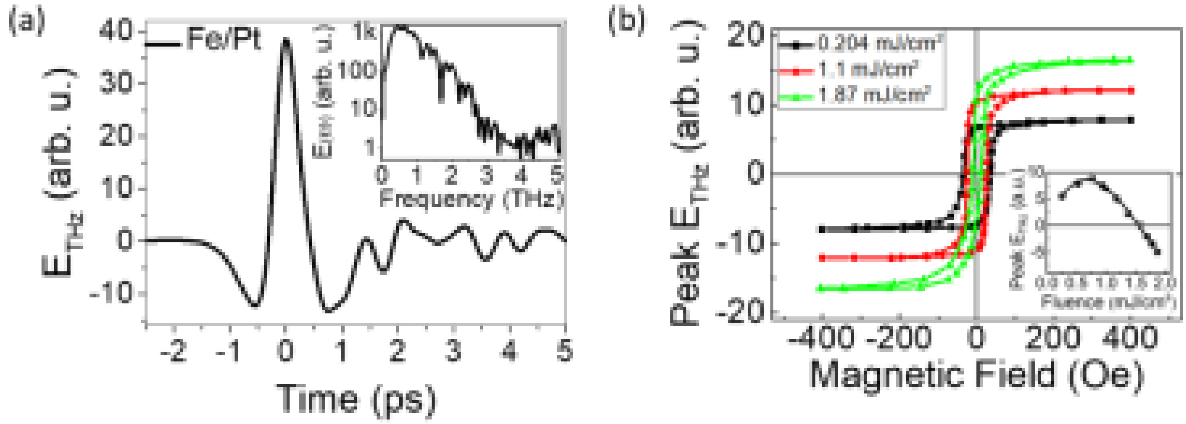


Fig.1. (a) Typical time-domain THz signal from Fe/Pt bilayer STE. Inset: corresponding Fourier spectrum. (b) THz hysteresis loops at three representative fluence values of 0.204, 1.1, 1.87 mJ/cm^2, measured by recording the peak THz amplitude with respect to the varying applied magnetic field. Inset: Peak THz as a function fluence, and complete THz phase reversal at ~1.5 mJ/cm^2.

References:

1. K. Ando, et. al, Journal of Applied Physics, 109 (2011) 103913.
2. S. Kumar, et. al, iScience, 25 (2022) 104718.
3. T. Seifert, et. al, Nature Photonics, 10 (2016) 483.
4. S. Kumar, et. al, Pramana, 95 (2021) 75.