Tata Institute of Fundamental Research
Survey No. 36/P, Gopanpally Village, Serilingampally, Ranga Reddy Dist., Hyderabad – 500 046

Seminar

Multidimensional sensing and spectroscopy in two extremes: using weak fields in quantum regime and strong fields in high harmonic regime

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The progress in quantum optics utilizes a unique photon state configuration for engineering of the ultimate light-matter interactions with relatively simple material systems. It results in a broad range of photonic applications including radiation sources, quantum communication, information, computing and nanotechnology. The development of the ultrafast multidimensional nonlinear spectroscopy that has been enabled by progress in ultrafast optical technology provides a unique tool for probing complex molecules, semiconductors, nanomaterials by classical light fields. I will show how new quantum phenomena in complex systems can be studied and controlled using advances in both quantum optics and nonlinear spectroscopy. In particular, I investigate how to probe, control, and image the dynamics of these complex systems using quantum light and reveal the material information, which is not accessible by conventional classical photonics tools. In the second part of the talk I will discuss a novel method for monitoring electronic coherences using ultrafast spectroscopy and create quantum states of light in high harmonic regime. This method is based on the time-domain high-order harmonic spectroscopy where a coherent superposition of the electronic states is first prepared by the strong optical laser pulse using a three-step mechanism introduced by Lewenstein and Corkum. The coherent dynamics can then be probed by the higher order harmonics generated by the delayed probe pulse. The main advantage of the method is that only optical (non X-ray) laser is needed. In addition, a semi-perturbative model based on the Liouville space superoperator approach is developed for the bookkeeping of the different orders of the nonlinear response for the high-order harmonic generation using multiple pulses. Coherence between bound electronic states is monitored in the harmonic spectra from both the first and the second order responses. The nature of the multi-wave mixing in high harmonic regime allow to modify the statistics of light and give rise to quantum squeezing between higher harmonics suitable for higher signal-to-noise ratio measurements of electronic properties in multi-eV range.

Monday, Nov 7th 2022

12:00 PM (Tea/Coffee at 11:45 AM)

Auditorium, TIFR-H