

# Principle and Application of Ultrafast and Nonlinear Spectroscopy

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## Overview:

The invention of laser opens up the new door to study the light-matter interaction. The fundamental processes of interaction of light with matter is of outmost importance to realize the fate of such interaction processes. Under low light field condition, such interactions are linear with the power of the field. However, under high intensity light new properties are emerged, which are not linear with the light intensity, and falls under the preview of non-linear spectroscopy. With the advent of ultrafast laser, a varieties of powerful non-linear spectroscopic techniques have been developed, such as, TG-OKE, CARS, 3PEPS, to name a few. The enormous progress of non-linear spectroscopy over the past five decades witnessed its uniqueness and capability to reveal important molecular information, which could not be achieved otherwise, and applied to a diverse filed from material sciences to medical sciences. Basically, with such advanced techniques, one can reveal the material properties and spectroscopic information, which could not be achieved by traditional linear spectroscopy.

## Objective:

The primary objective of the proposed course is to introduce the students, in a span of two weeks, the basics of light-matter interaction and the concept of non-linear processes in materials. The basic concepts of nonlinear optics, such as nonlinear susceptibility, nonlinear polarisation, frequency mixing, phase matching condition, etc. will be discussed to start with. We plan to have twelve lectures and seven tutorials within the time frame mentioned below. The lectures will be given by Professor T. Tahara, who along with the local host/coordinator of IIT Kanpur will conduct the tutorials.

**Course Details:** *Number of participants for the course will be limited to 50*

<b>Course Instructor</b>	<b>Professor Tahei Tahara</b> , Chief Scientist, RIKEN, Japan
<b>Duration</b>	<b>Course Duration:</b> February 26 to March 05, 2019 <b>Contact Hours:</b> 20 hrs lectures and 7 hrs tutorials/laboratory
<b>Modules</b>	<b>Module A: Light-matter interaction</b> <b>Module B: Non-linear Optical Processes</b> <b>Module C: Ultrafast Spectroscopy</b>

<b>You can attend if You are</b>	Executives, scientists, engineers and researchers from manufacturing, service and government organizations including R&D laboratories. Students at MSc/MTech/PhD level or faculties from academic institutions and research organization.
<b>Registration Fee</b>	<p><b>Participants from abroad:</b> All modules: US \$500</p> <p><b>Participants from India:</b> <i>Industry:</i> Any of two modules: Rs. 10,000/-; All modules: Rs. 20,000/- <i>Academic Institutions/Research Organizations:</i> All modules: Rs. 5,000/-</p> <p>The above fee includes all instructional materials, computer use for tutorials, 24 hr free internet facility. The participants will be provided accommodation on payment basis.</p>

## Tentative Lecture Schedule:

<b>Module A: Light-matter interaction</b>	<b>February 26, 2019</b>	Classical picture of the light matter interaction 1 Quantum picture of the light matter interaction
	<b>February 27, 2019</b>	Coherence and spectroscopy Case studies on light-matter interaction and spectroscopic methods
<b>Module B: Non-linear Processes</b>	<b>February 28, 2019</b>	Nonlinear optical process and nonlinear spectroscopy Diagrammatic representation of nonlinear process
<b>Module C: Advanced Spectroscopy</b>	<b>March 01, 2019</b>	Femtosecond time-resolved fluorescence, absorption, and infrared spectroscopy
	<b>March 02, 2019</b>	Femtosecond time-resolved stimulated and impulsive stimulated Raman spectroscopy
	<b>March 04, 2019</b>	Interface-selective even-order nonlinear vibrational and electronic spectroscopy
	<b>March 05, 2019</b>	Case studies on linear and non-linear spectroscopic techniques

### Course Coordinator and Contact Details for Registration

**Dr. Pratik Sen**  
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Indian Institute of Technology Kanpur  
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## Details of the Expert:

### Professor Tahei Tahara



**Professor Tahei Tahara** is Chief Scientist and Director of Molecular Spectroscopy Laboratory in RIKEN, and a member of RIKEN Science Council. Dr. Tahara has published approximately 150 original papers and 30 Reviews, and served as Editorial Advisory Board Member of Journal of Physical Chemistry (2010-2012), Editorial Board Member for Journal of Chemical Physics (2013-2015), and Advisory Editorial Board Member of Chemical Physics (2012-present). Dr. Tahara organized a number of international meetings, including 16th International Conference on Time-Resolved Vibrational Spectroscopy (2013), and served as a member of International Advisory Committee of International Conference on Time-Resolved Vibrational Spectroscopy (2008-present), International Steering Committee of International Conference on Raman Spectroscopy (2010-2016) and International Steering

Committee of Asian Spectroscopy Conference (2015-present). Dr. Tahara is currently Head of Division of Advanced Laser Spectroscopy in the Spectroscopical Society of Japan, Board of the Spectroscopical Society of Japan, Steering Committee of Japan Society for Molecular Science, and Board of Japan Society for Molecular Science, and Advisory Committee of Institute for Molecular Science. He is currently Project Leader of JSPS/MEXT KAKANHI project on Innovative Area “Soft Molecular Systems” which consists of 45 PI’s over Japan, and Head of RIKEN Pioneering Project “Molecular Systems Research” which consists 15 PI’s inside/outside of RIKEN. He has received Award of Research Foundation for Opto-Science and Technology (1995), Morino Science Award (2000), TRVS Outstanding Young Researcher Award (2001), IBM Japan Science Prize (2004), The JSPS Prize (2006), Commendation for Major Contribution (A) of RIKEN (2008), Chemical Society of Japan (CSJ) Award for Creative Work (2012), Commendation for Major Contribution (A) of RIKEN (2013), and Distinguished Asian Visiting Speaker Award of University of Alberta, Canada (2013).

### Dr. Pratik Sen



**Dr. Pratik Sen** earned his Ph.D. degree from Indian Association for the Cultivation of Science, Kolkata, India in 2006. Then he moved to RIKEN, Japan for his post-doctoral research work as a JSPS fellow. Presently he holds the position of Associate Professor in Department of Chemistry, Indian Institute of Technology Kanpur, India. Dr. Sen has published about 80 original research articles and one book chapter with an h-index of 23. Dr. Sen is the recipient of several awards and fellowships namely Young Faculty Research Fellowship of Ministry of Electronics & Information Technology, Government of India (2018), Fellow Indian National Young Academy of Science, INYAS (2016) P. K. Kelkar Fellowship from IIT Kanpur (2015) INSA Medal for Young Scientist in Chemical Sciences (2012) for his work on ultrafast

spectroscopy. He has graduated 5 Ph.D. students and 6 more are in progress. Dr Sen’s current research interests include ultrafast spectroscopy, protein fluctuation dynamics, structure and property of binary systems, nonlinear spectroscopy, surfaces and interfaces.