Ultracold Molecules and Controlled Chemistry

Overview:

Atomic and molecular phenomena at temperatures close to absolute zero have become a frontier area of experimental and theoretical research in Physics and Chemistry. This is due to the spectacular progress achieved in recent years in cooling and trapping of a large variety of atoms and molecules at temperatures in the micro Kelvin and nano Kelvin regimes. The success in creating quantum degenerate gases of atoms and molecules has revolutionized Atomic, Molecular, Optical (AMO) Physics and Physical Chemistry and led to dramatic advancements in precision spectroscopy and controlled chemistry.

This level of control on chemical reactions is unprecedented and is contributing new mechanistic insights into chemical reaction dynamics and new ways of looking at chemistry itself. Leading researchers like Prof. Wolfgang Ketterle (MIT) who shared the 2001 Nobel Prize in Physics for creating Bose-Einstein condensates of atoms are actively involved in ultracold Chemistry experiments. This new regime of chemistry also requires new theoretical formulations and novel methods to describe how external fields couple reactant and product quantum states.

Course participants will learn these topics through lectures and tutorials. Also case studies and assignments will be shared to stimulate research motivation of participants.

Objectives:

1. Explore precision spectroscopy and controlled chemistry with ultracold molecules
2. Understand mechanistic details of chemical reactions at cold and ultracold temperatures
3. Explore new theories of chemical reactions and how alignment, confinement and external field effects influence reactivity at ultracold temperatures
4. Motivate students and researchers to undertake cutting-edge research in frontier areas of chemistry and physics.

Modules	December 16 – 20, 2019 (5 days): 10 hrs Lectures and 10 hours Tutorials (Modules: 15) December 21, 2019: Examination Number of participants for the course will be limited to fifty.
Registration Fees	The participation fees for taking the course for all modules is as follows: **Participants from abroad:** US $500 **Academic Institutions:** Students: Rs.2,000/- Faculty/Researchers/Scientists: Rs.5,000/- **Industry:** Rs.20,000/- The above fee includes all instructional materials, computer use for tutorials, 24 hours free internet facility. The participants will be provided with accommodation on payment basis. Last Date to Apply: October 16, 2019
Who can attend	• Student at all levels (BTech/MSc/MTech/PhD) or Faculty from reputed academic/technical institutions and Universities. • Executives, engineers and researchers from manufacturing, service and government organizations including R&D laboratories.
Mode of Registration	All prospective participants need to do web registration for the course on GIAN (http://www.gian.iitkgp.ac.in/GREGN) portal. After the mandatory web registration, the shortlisted participants will be informed by email to register for the course by making full payment of the course registration fee by NEFT (Account holder name: The Registrar, IIT Ropar, Account No.30836125653; IFSC Code: SBIN0013181; Bank: SBI; Branch Name: IIT Ropar) before the last date of registration. Please send an email to course coordinator in case of any question: dhilip@iitrpr.ac.in

Course Contents

1. Why ultracold molecules and Controlled Chemistry?
2. Theoretical description of ultracold collisions – I
3. Methods for creation of cold and ultracold molecules
4. Experimental studies of cold and ultracold reactions and inelastic collisions
5. Theoretical description of ultracold collisions – II
6. Geometric phase effects in ultracold reactions
7. Resonant and quasiresonant scattering at ultracold temperatures
8. Future research directions and Bose-enhanced chemistry

Teaching Faculty

Dr. Balakrishnan Naduvalath
Professor
Department of Chemistry
University of Nevada
Las Vegas, Nevada USA

Dr. Balakrishnan Naduvalath is Professor of Chemistry at University of Nevada, Las Vegas (UNLV). He received BS (1985) and MS (1987) in Chemistry from University of Calicut (India) and PhD in Theoretical Chemistry from Indian Institute of Technology, Kanpur (1993). He carried out postdoctoral research at University of Copenhagen, Denmark (1993-1996) and at Harvard-Smithsonian Center for Astrophysics, Cambridge, MA (1996-2001). He has authored/co-authored over 140 peer-reviewed research publications and six book chapters. His research interests are directed to the description of atomic and molecular collisions and chemical reaction dynamics in overlapping areas of Chemistry, Physics and Astrophysics. He has carried out pioneering research in ultracold chemistry and he is an elected Fellow of the American Physical Society since 2009. Naduvalath serves as a Review Editor for the Open Access Journal *Frontiers in Physical Chemistry and Chemical Physics*.

Dr. T. J. Dhilip Kumar
Associate Professor & Head
Department of Chemistry
IIT Ropar, Punjab India

Dr. Dhilip Kumar is an Associate Professor and Head of the department in IIT Ropar. Prior to joining IIT Ropar, he did his Master and Doctoral studies in Indian Institute of Technology Madras (IITM). After completing Ph.D. in 2006, he worked as a postdoctoral research fellow at the University of Nevada, Las Vegas in the field of fundamental studies on H_2 storage materials and then, from 2008 to 2010 he worked as post-doctoral fellow at the University of Michigan, Ann Arbor on the modeling of atmospheric nitrate reactions. His doctoral work was adjudged the best thesis in Physical Chemistry for the year 2006 by IIT Madras. Dr. Kumar's research interests include ultracold chemistry, atmospheric chemistry and designing gas storage materials.

Course Coordinator

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