CSO 202: Atoms Molecules and Photons, Lecture 2: Introduction

Consider the reaction:

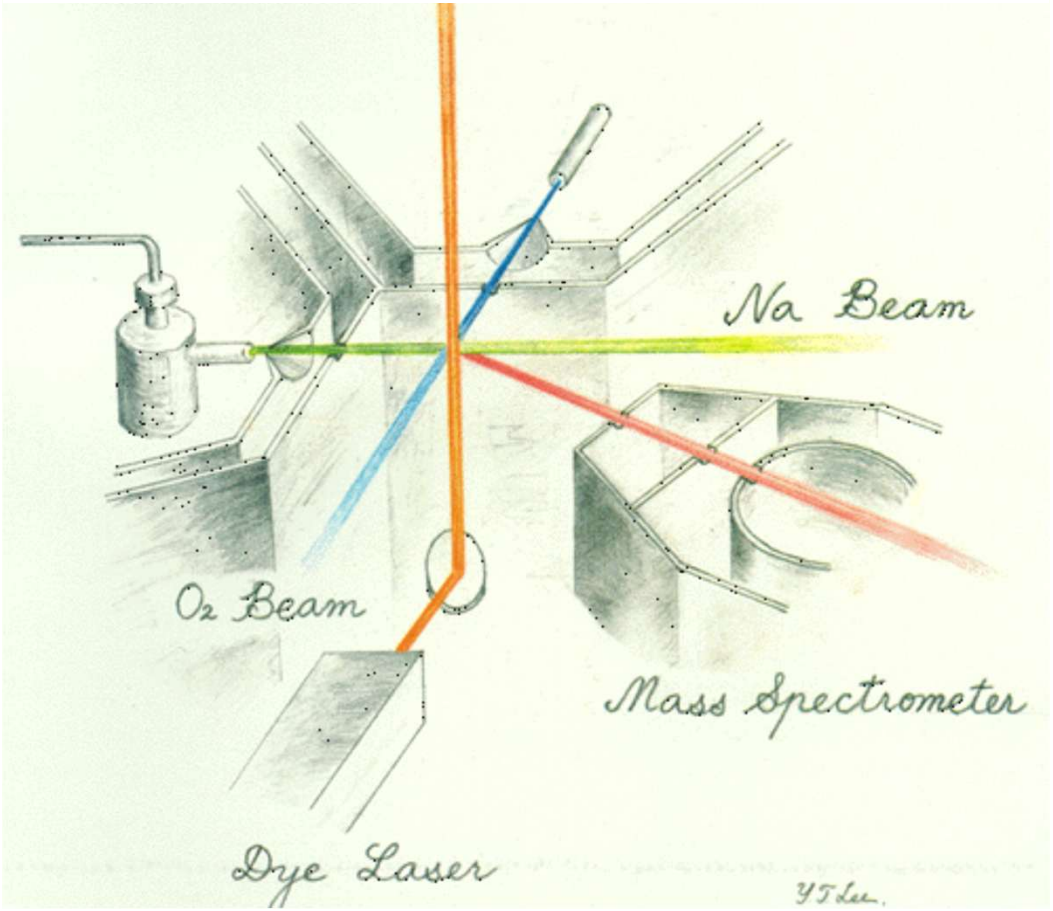
$F + D_2 \rightarrow DF + D$

This way of writing down chemical reactions, using arrows and symbols, is 'incomplete'

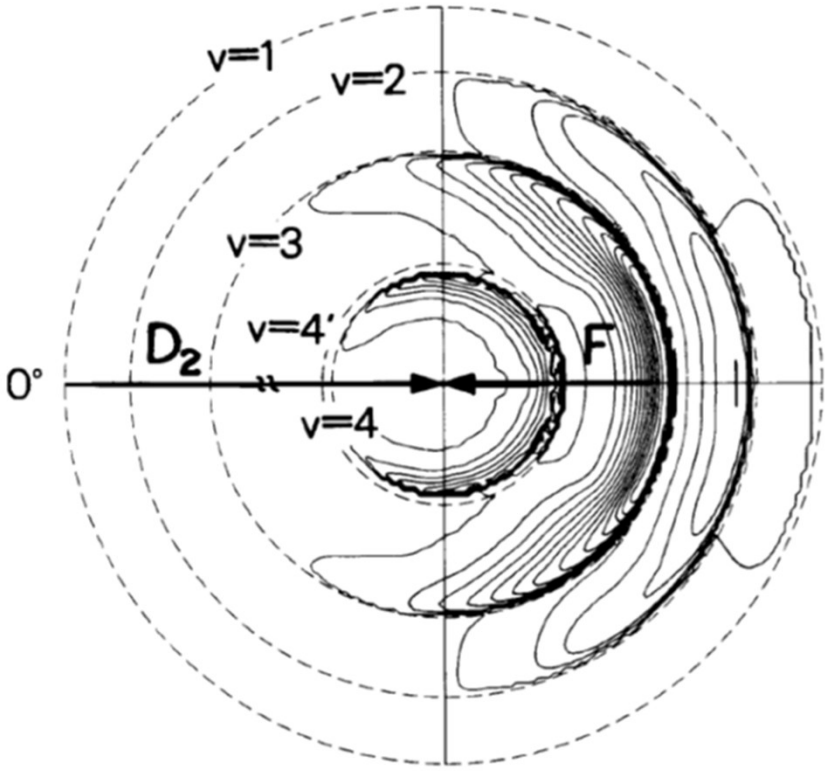
- Do rates depend on internal quantum states of the reactants?
- What are the internal quantum states of the products?
- What is the dependence of chemical reactivity on molecular orientation? Dependence on the impact of collision?
- What is the nature of reaction intermediates and their subsequent decay dynamics in case of complex polyatomic molecular reactants?

Answers can be found by doing experiments using crossed molecular beam technique

$2Na + O_2 \rightarrow Na_2O + O$



$F + D_2 \rightarrow DF + D$



The Nobel Prize in Chemistry 1986

Dudley R. Herschbach

Harvard University
Cambridge, MA, USA

Yuan T. Lee

University of California
Berkeley, CA, USA

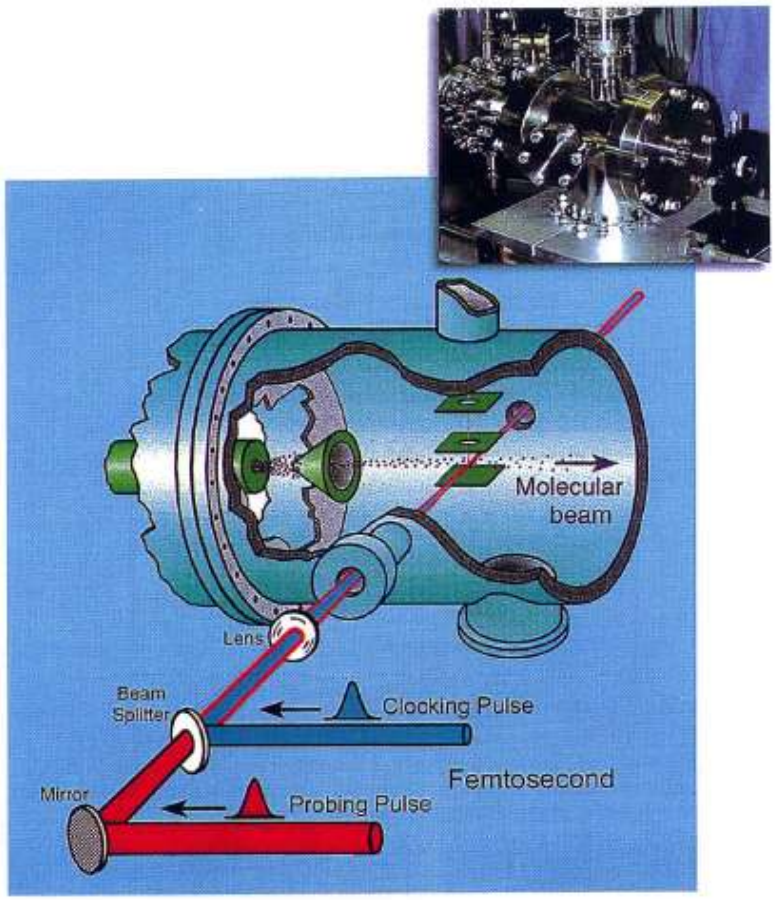
John C. Polanyi

University of Toronto
Toronto, Canada

"for their contributions concerning the dynamics of chemical elementary processes"

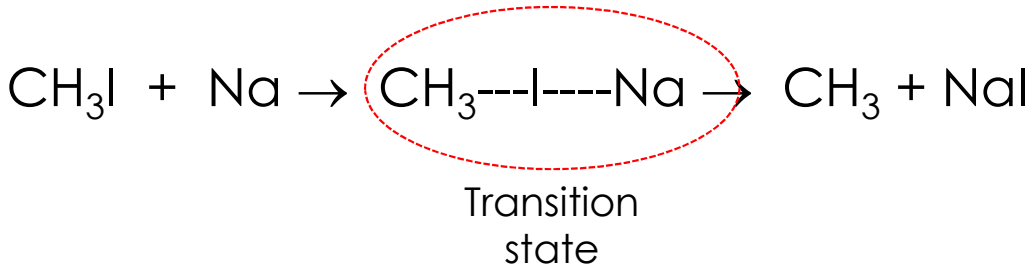
Module I (Part B) :

Ultrafast Chemical Reaction Dynamics with Ultrashort-Pulsed Lasers



Instructor:
Debabrata Goswami

Consider a chemical transformation



In any chemical reaction the motions of the electrons and nuclei of atoms determine how the molecules interact, and those interactions in turn create the forces that govern the reaction's dynamics.

If one can determine how molecular motions change during the critical transition phase, we can understand how new chemical bonds form and old ones disappear.

Question

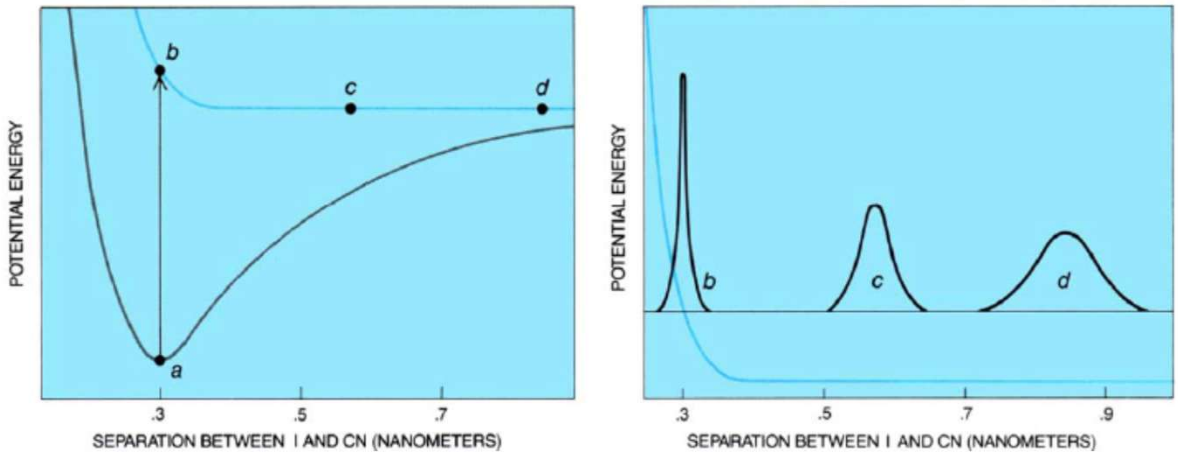
How can one study transition state(s) in real time?

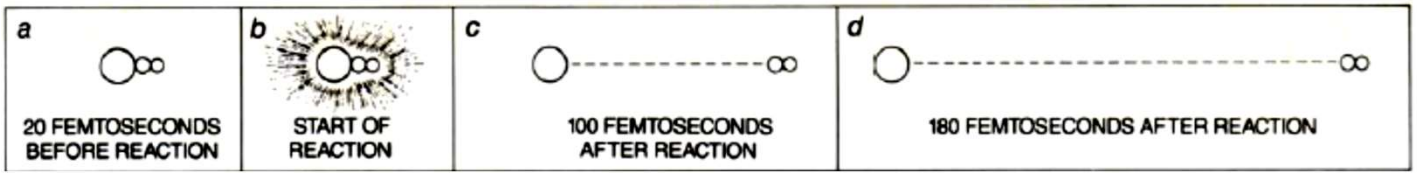
Answer

Need ultrafast probe and detection technique

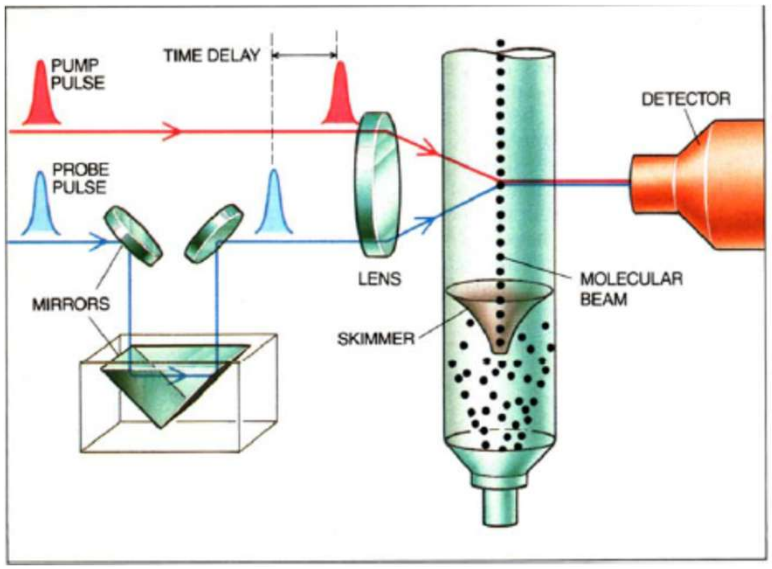
Consider a simple dissociation reaction

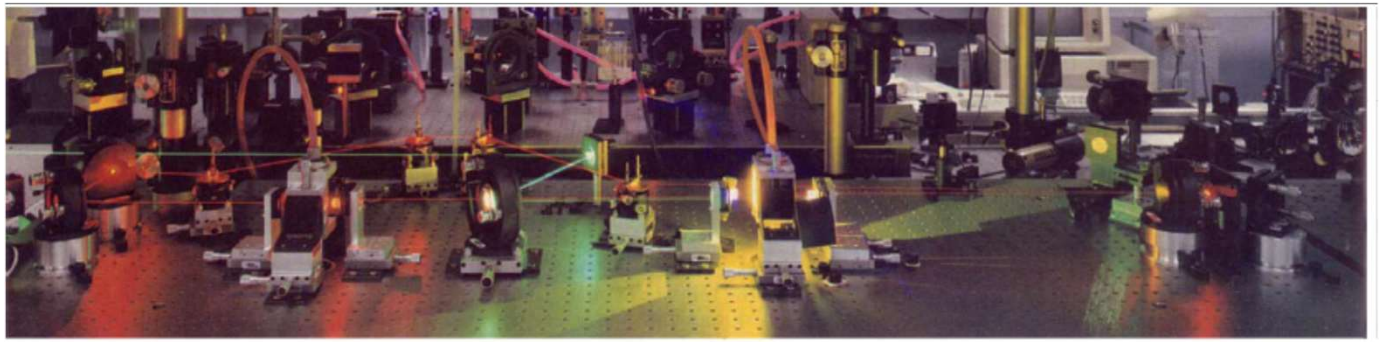
$ICN \rightarrow I + CN$





J. Chem. Phys., **1987**, *87(4)*, 2395





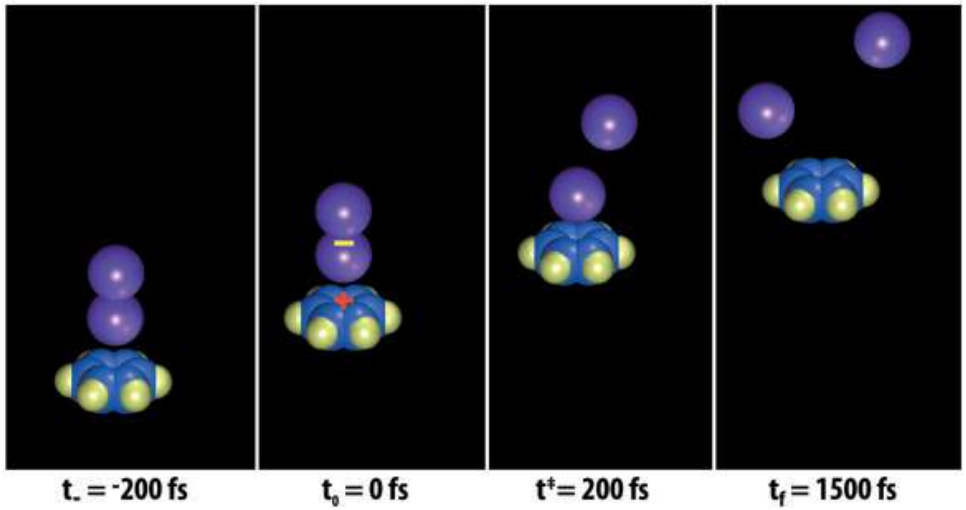
J. Chem. Phys., **1987**, *87(4)*, 2395

The Nobel Prize in Chemistry 1999

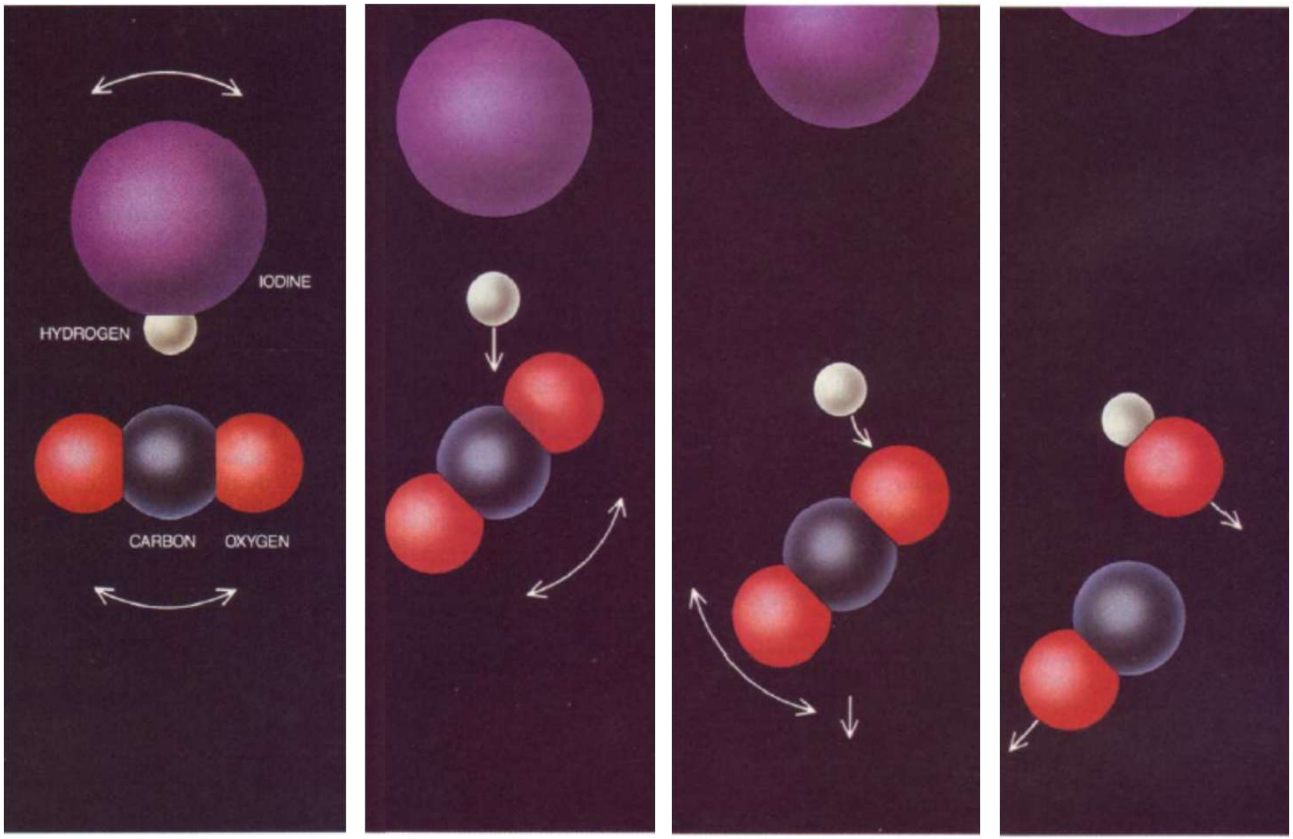
Ahmed H Zewail

California Institute of Technology, Pasadena, CA, USA

“for his studies of the transition states of chemical reactions using femtosecond spectroscopy"



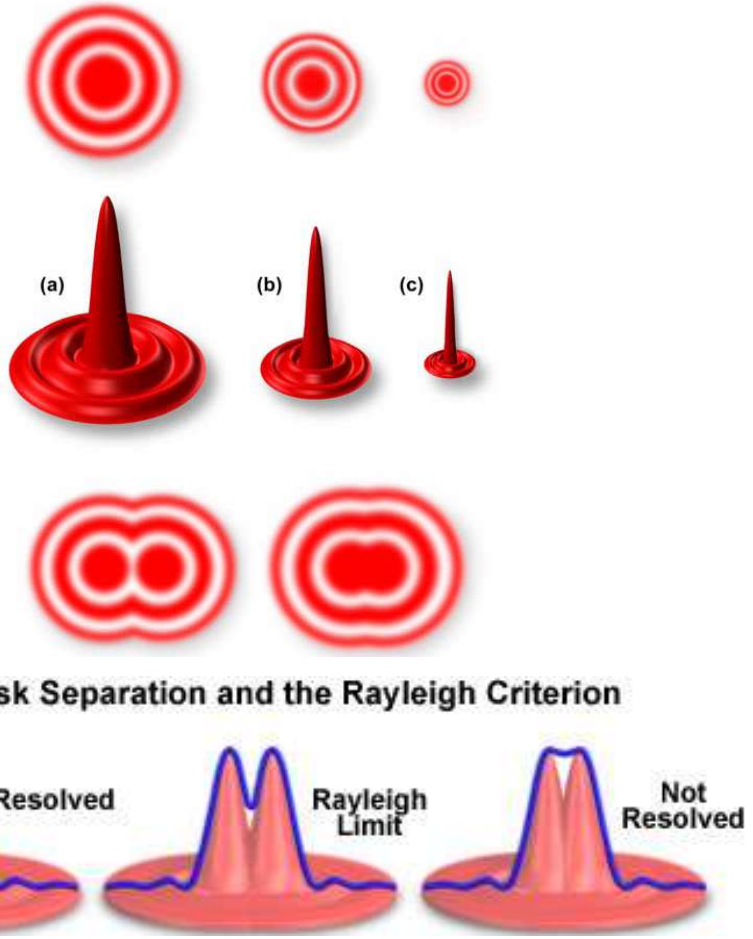
Molecular structures for a reaction in progress involving two molecules (bimolecular). The diatomic iodine molecule (I_2, top) is split by exchange of an electron with the ring molecule benzene (C_6H_6).



Molecular structures for a reaction in progress involving two molecules (bimolecular).

Module 2 :

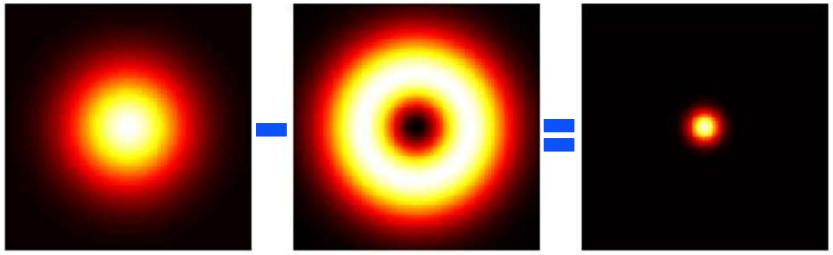
Super-resolution: Super-resolved Fluorescence Microscopy

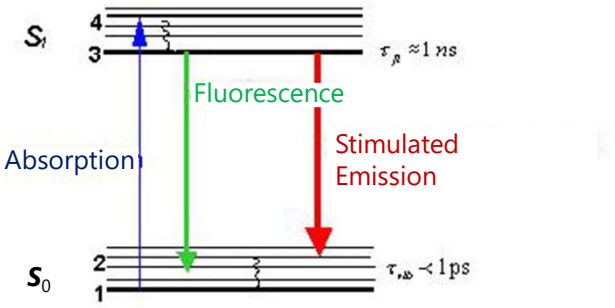


Instructor:
Debabrata Goswami

Stimulated Emission Depletion (STED) Fluorescence Microscope
Stefan W Hell

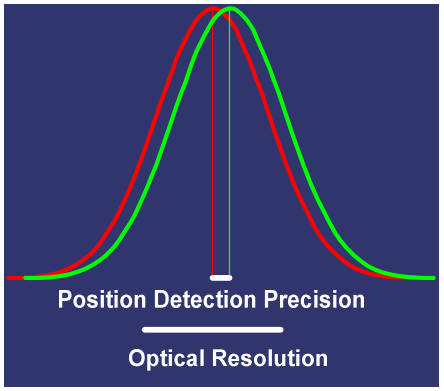
Making laser spot size – PSF - smaller by using Depletion effect of fluorophore.



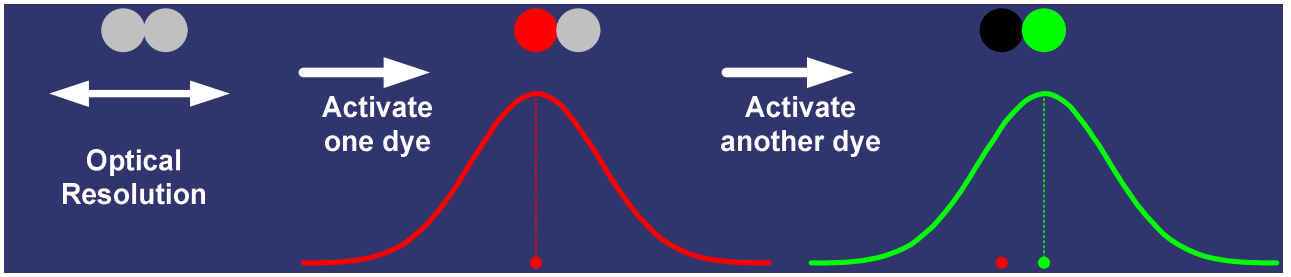


Photoactivated Localization Microscope (PALM)
Eric Betzig and William E Moerner

- Precision of localization of each dye is much better (~20nm) compared to optical resolution (~200nm)



- Activate one dye at a time and measure dye position by PSF, you can separate two dyes whose distance is less than optical resolution



- Need to image single molecule fast to increase performance

The Nobel Prize in Chemistry 2014

Stefan W Hell

Max Planck Institute, Göttingen, Germany

Eric Betzig

University of California, Berkeley, CA, USA

William E Moerner

Stanford University, CA, USA

"for the development of super-resolved fluorescence microscopy"

Let me start with
Module 1
first

MOLECULAR DYNAMICS OF ELEMENTARY CHEMICAL REACTIONS

Nobel Lecture. 8 December 1986

by

DUDLEY R. HERSCHBACH Born: June 18, 1932, US citizen (age 92)

Department of Chemistry, Harvard University, Cambridge, Massachusetts 02138, U.S.A.

Module I : Part-I

Chemical Reaction Dynamics with Molecular Beams

MOLECULAR BEAM STUDIES OF ELEMENTARY CHEMICAL PROCESSES

Nobel lecture, 8 December, 1986

by

YUAN TSEH LEE Born: Nov 18, 1936, Taiwanese by birth (age 87)

Lawrence Berkeley Laboratory and Department of Chemistry, University of California, Berkeley, CA 94720, USA

Note: CSO202 Course Resources contain all these three Nobel Lectures

SOME CONCEPTS IN REACTION DYNAMICS

Nobel lecture, December 8, 1986.

by

JOHN C. POLANYI Born: 23 January 1929, Hungarian-Canadian (age 95)

Department of Chemistry, University of Toronto, Toronto M5S 1Al. Canada

The 1986 Nobel Prize in Chemistry was awarded to **Dudley R. Herschbach**, **Yuan T. Lee** and **John C. Polanyi** for their contributions concerning the dynamics of chemical elementary processes.

Their research has been of great importance for the development of a new field of research in chemistry - reaction dynamics - and has provided a much more detailed understanding of how chemical reactions take place.