Photon-induced near-field electron microscopy

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NATURE| Vol 462| 17 December 2009

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Ph08d023
04/09/2010

Background

- optical near field microscopies enable spatial resolution beyond the diffraction limit

- cannot give atomic scale resolution

- electron – photon interactions enhanced via nanostructures

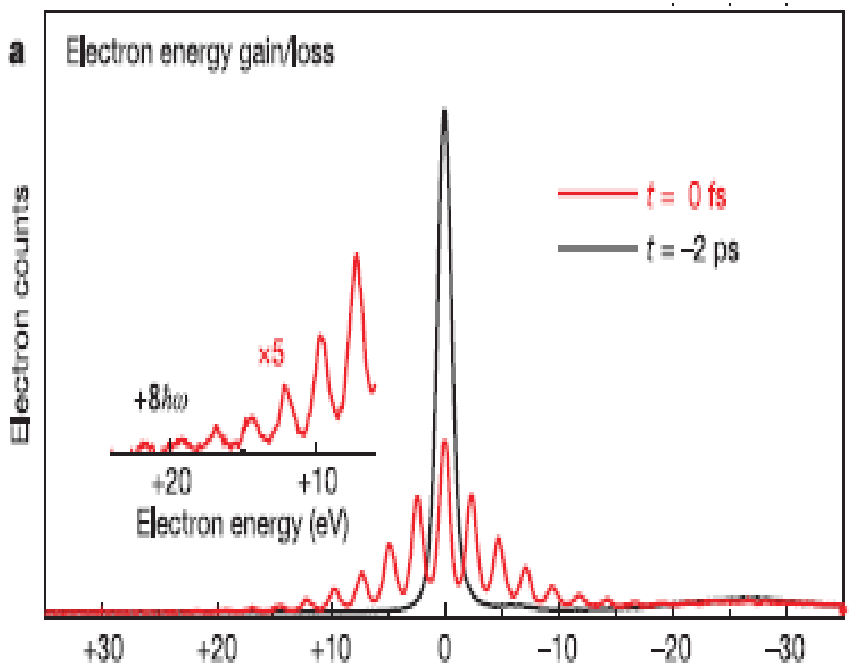
- Possibility of studying evanescent EM fields with electron pulses and resolving these fields both spatially and temporally

- when images, diffraction, or electron spectra are time-resolved in electron microscopy, photons are used to initiate a change for the study of ultrafast dynamics, which occur on the pico second timescale

- prior to the structural changes electronic distributions are altered, with their dynamical changes in the femtosecond timescale

- In free space an electron cannot absorb radiation because of the lack of energy momentum conservation

Interaction of electrons with the photon field



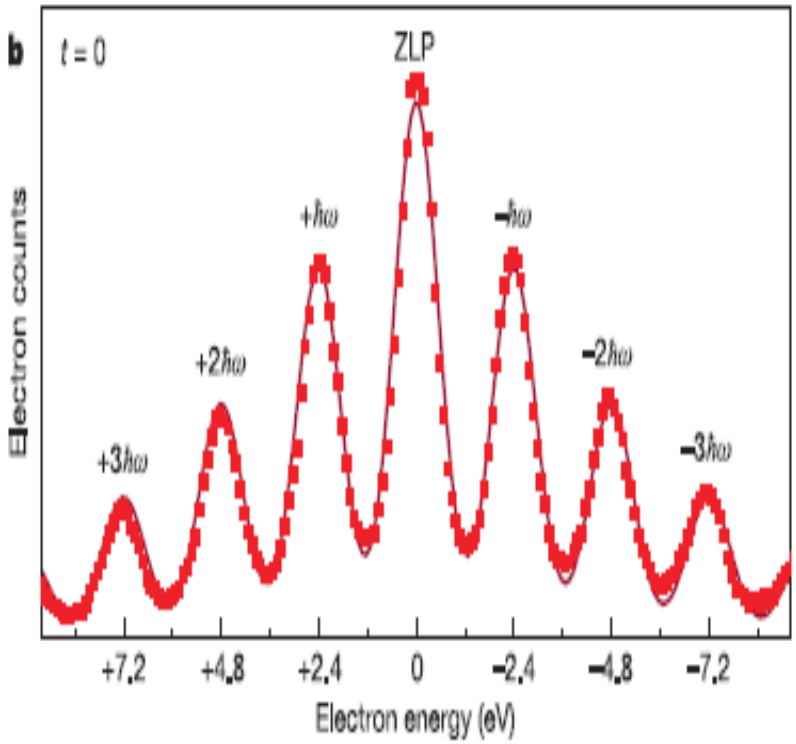
Peak irradiance = 100 GW/cm2

Atleast 8 photons were absorbed/emitted by the electrons

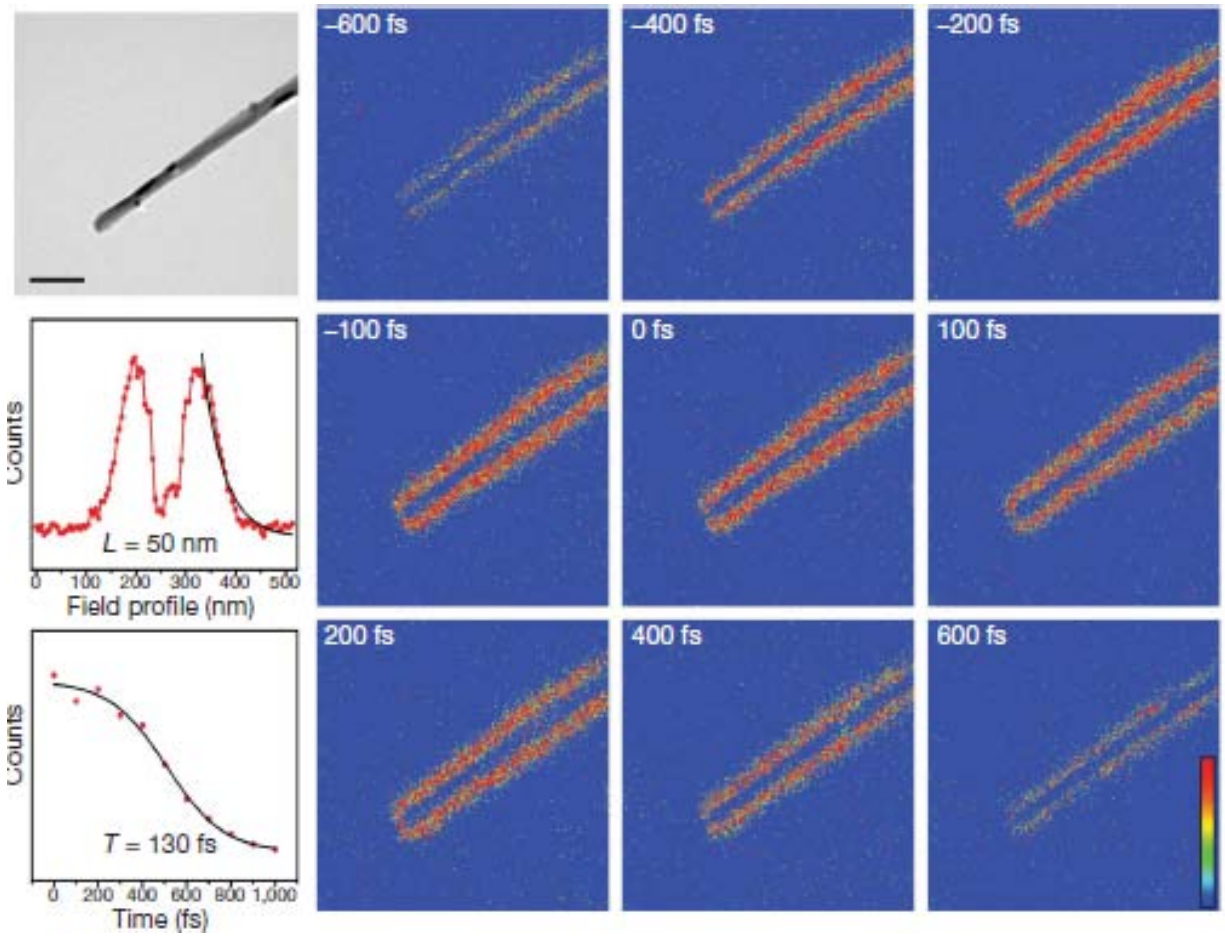
A few hundreds of attosecond interaction time with nanomaterial

Plasmon peaks in NZL curve at 6 and 25 eV

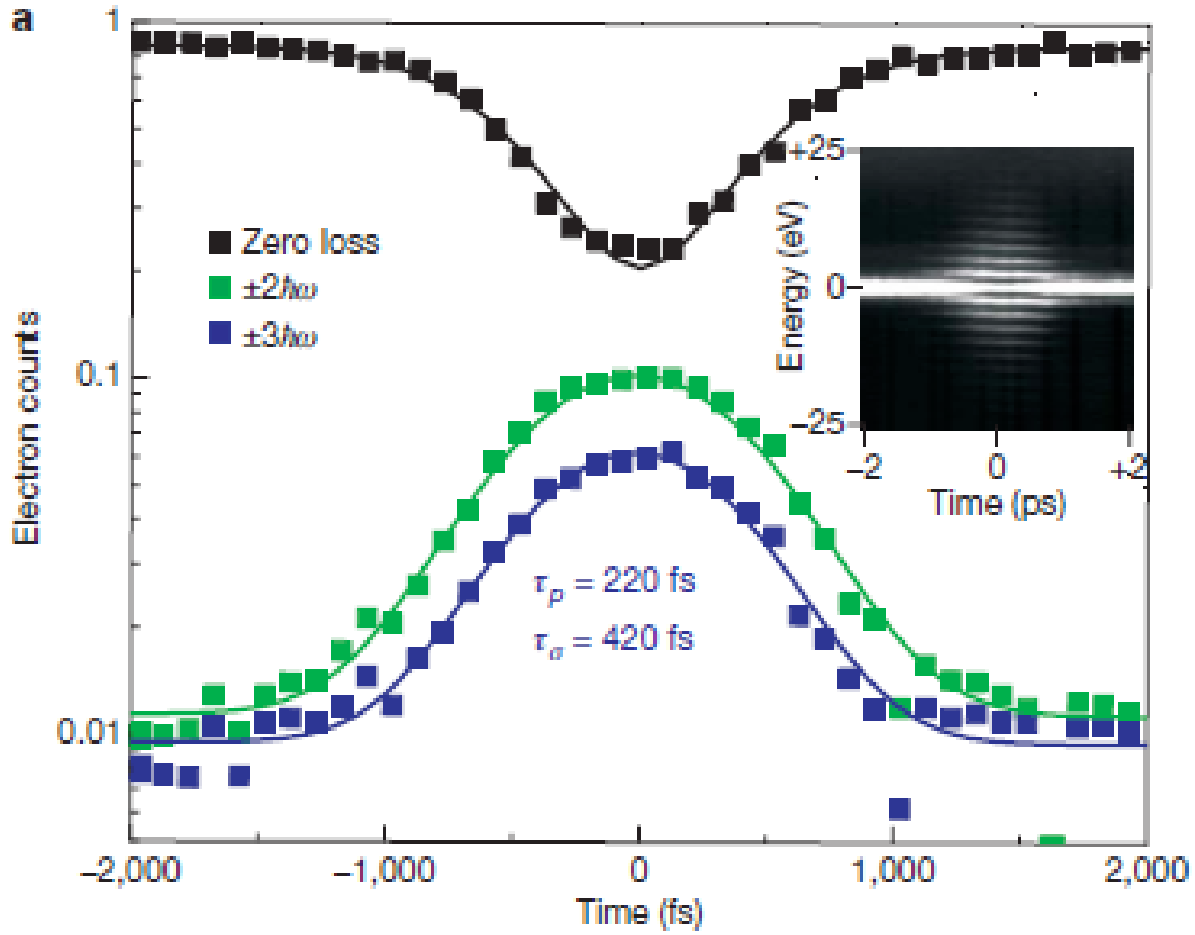
Absorption and emission of definite quanta of the photon



Temporal and spatial distribution of evanescent field about a MWNT Duoe to the photon-matter interaction

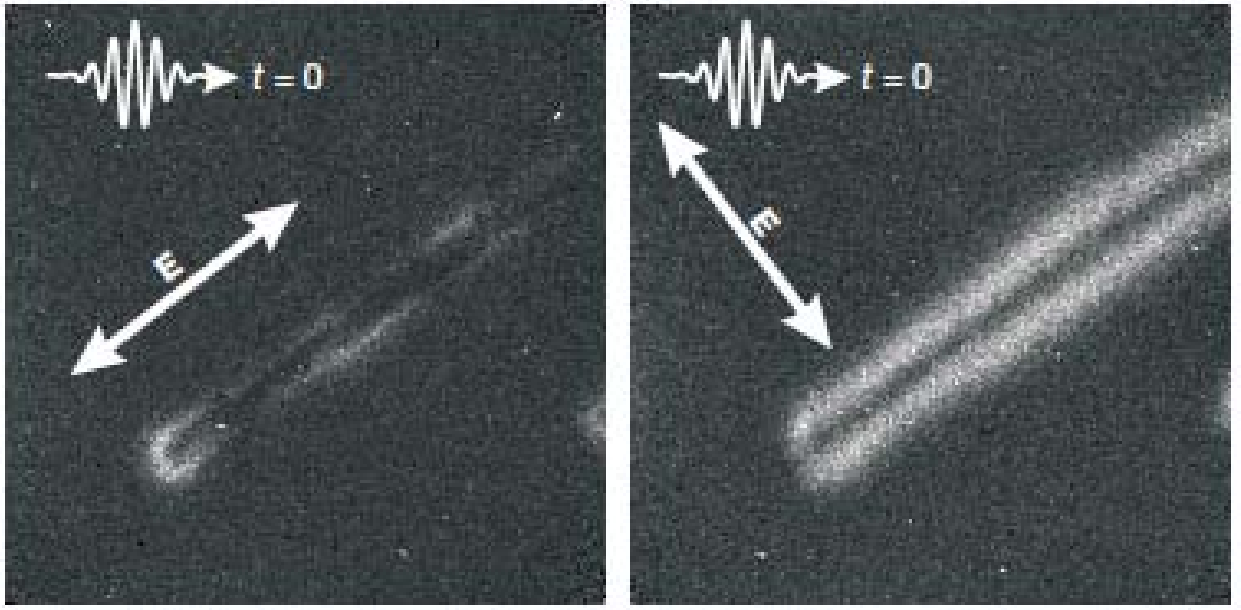


Photon pulse relaxation and field relaxation



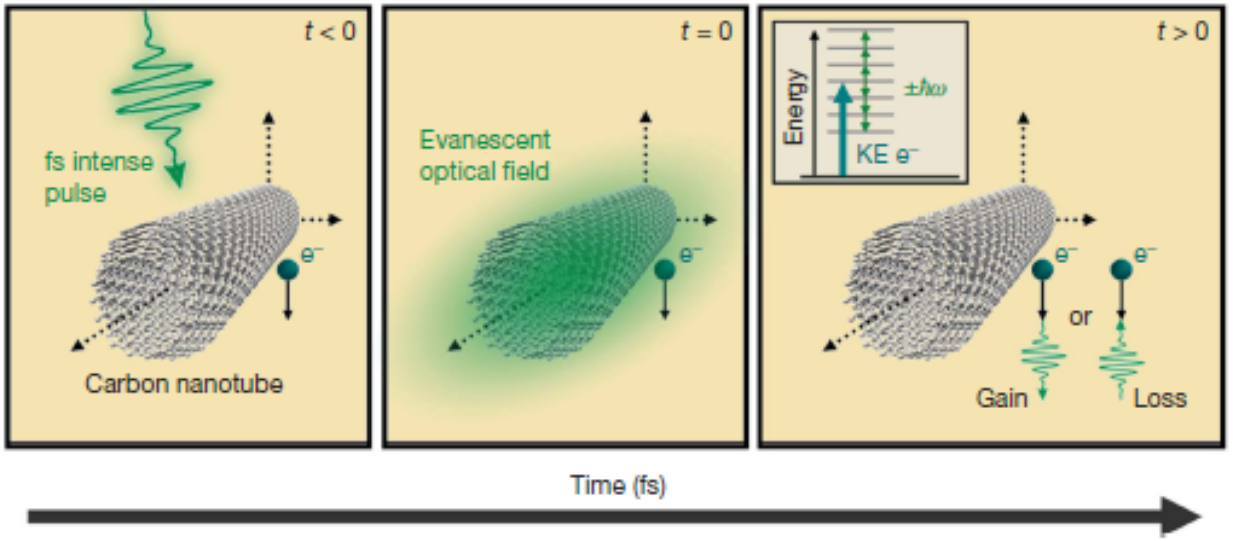
Linear contour plot of the data fitted by the Gaussian

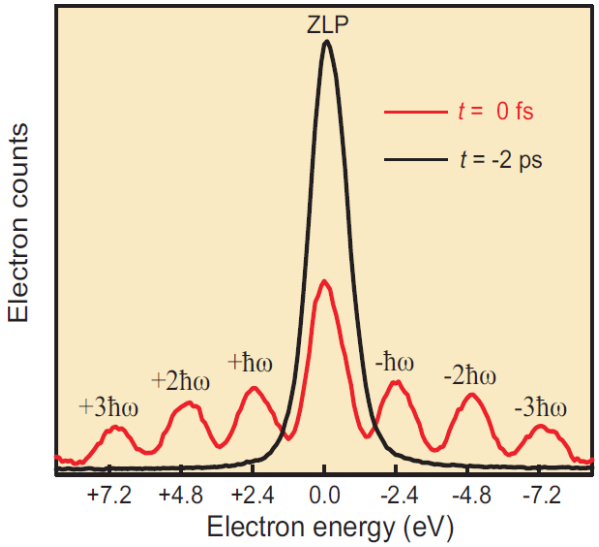
Polarization dependence of the evanescent field

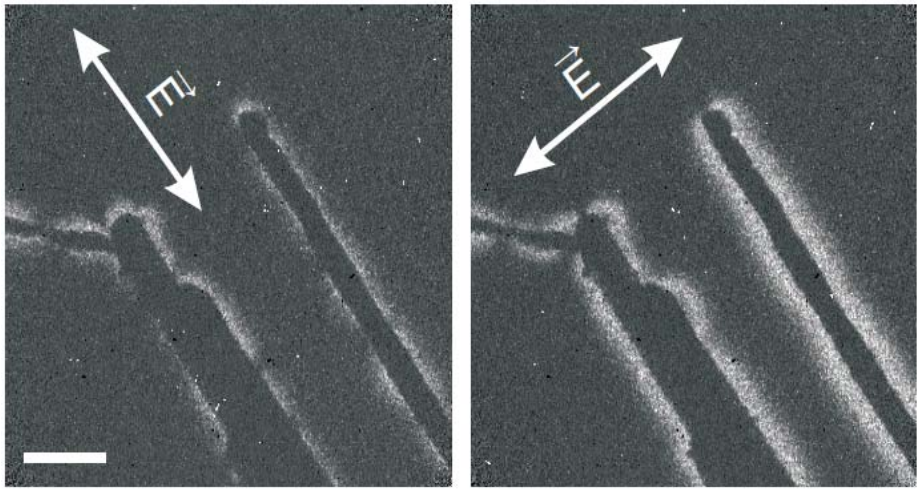


- As the nanotube diameter is much less than the wavelength of light(519 nm), the field is confined by the dimensions of the tube, and this confinement setup an oscillating dipole in the structure.
- The intensity of the evanescent field falls off exponentially with distance from the surface
- But absorption/emission process occurs only when both the electrons and photons are overlapped in space at the nanostructure and in time at t=0

Physical depiction of the interaction between the electron, photon and the evanescent field







- Irradiance needed in case of Ag nanowire was an order of magnitude lower 10 GW/cm2

- Consistent with the stronger near field formed in the metallic nanowire and with the difference in material property

Conclusions

- nanostructure mediated electron-photon interaction is observed

- the evanescent field was studied using this interaction

- utility of such an evanescent field in imaging is demonstrated using the energy filtered images

- Dependence of polarizability of the photon on the femto second field was studied, thus established the role of confinement

thank you all