What really occurs in the dynamical process of the PIPT in strongly correlated soft crystals?

Shin-ya KOSHIHARA

FRC Tokyo Tech. & ERATO, JST

Non-Equilibrium Dynamics Project

Acknowledgements

- **JASRI/SPring-8:** use of the CCD detector (marccd165)
- **RIKEN/SPring-8:** use of the pulsed YAG laser system (PowerLite8000)
- **SUNY Buffalo:** use of the heat-load chopper
- **Structural Biology Group, Photon Factory:** use of cryogenic systems

Co-workers

KEK

- Hiroshi Sawa
- Hiroshi Kawata
- Takeharu Mori
- Shigeru Yamamoto
- Kimichika Tsuchiya
- Tatsuro Shioya
- and all Photon Factory Staffs

TITECH/ERATO

- Ken Onda
- Tadahiko Ishikawa
- Yoichi Okimoto
- Mitsuru Ito
- Desheng Fu
- M.Ito Group

Tohoku Univ.

- Takahisa Arima

The Univ. of Tokyo

- Kenjiro Miyano

Kyoto Univ.

- Hideki Yamochi &

- Korea Advanced Institute of Science and Technology (KAIST) (Korea)
  - Hyotcherl Ihee
- The Univ. of Chicago (USA)
  - Keith Moffat
- Univ. Rennes 1 (France)
  - Eric Collet
  - Herve Cailleau
- Oxford Univ. (UK) and Max Planck (Hamburg)
  - Andrea Cavalleri
- UC Berkley (USA)
  - Robert Schoenlein
- The Univ. of Copenhagen (Denmark)
  - Martin Nielsen
- State University of New York at Buffalo (USA)
  - Philip Coppens
  - Milan Gembicky

Mission of my talk

From the view point of
'strongly correlated soft materials science',
what can (will?) be realized
by pump-probe experiments
'based on new light source' in IMSS?

Examples

1. **Laser-SR Technology has really opened the door for new phenomena in correlated soft materials (Melting of the Iced Charge;CO in EDO (THz) and NSMO (X-ray))**

2. **Laser-SR technology has kicked off the "soft materials dynamics" for molecular (CO) transport based on dynamical structure (Molecular Movie of Mb)**

Important Merit of *Strongly Correlated Soft Materials* :

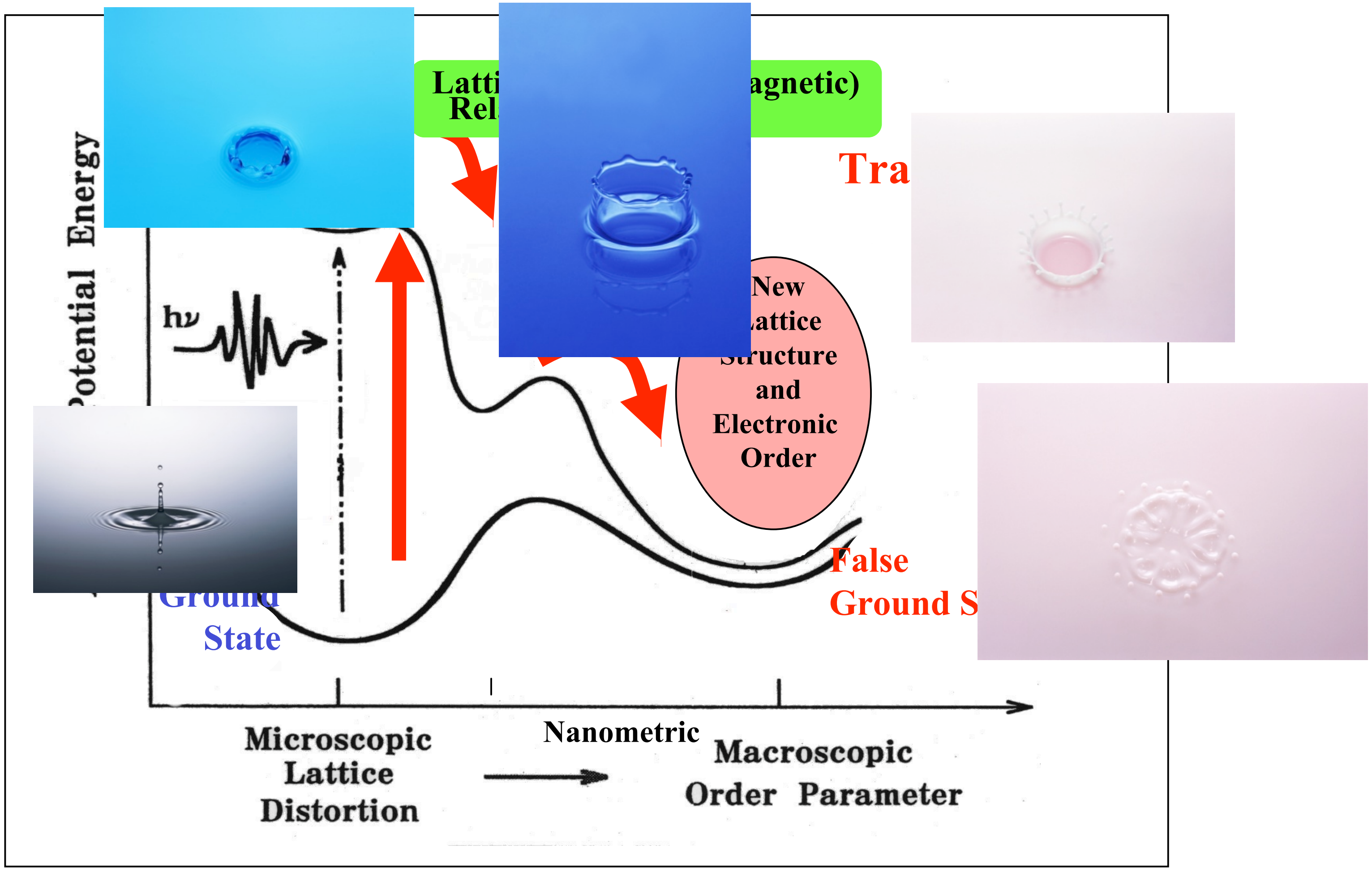
Artificial control of the phase of materials by dynamical way.

(Photonic Cooperativity : Photo-Induced Phase Transition, Photo-Domino)

Why Attractive？

1：**Highly Sensitive** *(Cooperative control)*

2：**Very fast and Exotic Response,**
It expands from fs-Ms, according to the kind of combined excitation,
(Charge(Spin)-Lattice excitation ?
transport in protein and/or other molecules?)



fs: Electronic ps: Phonon

ns-Ms: Combined with movement of atomic systems

Time Scale

Self-amplification of excited state

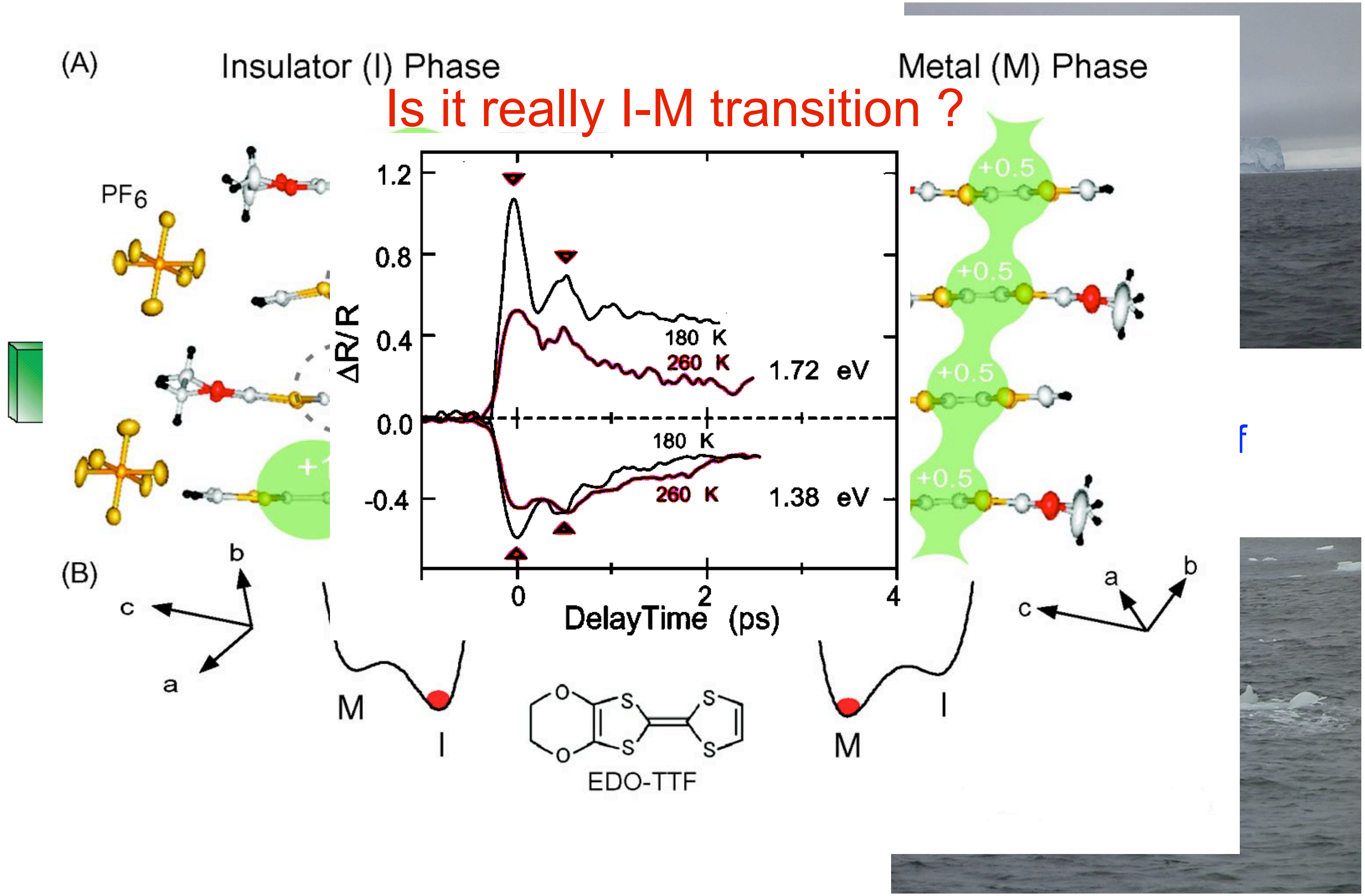
(Theoretical expectation, K. Nasu (2001))

Basic Problem :

PIPT can realize what cannot be achieved by thermodynamics ?

Why $(EDO)_2PF_6$ is important for the study of Photo-Domino effect?

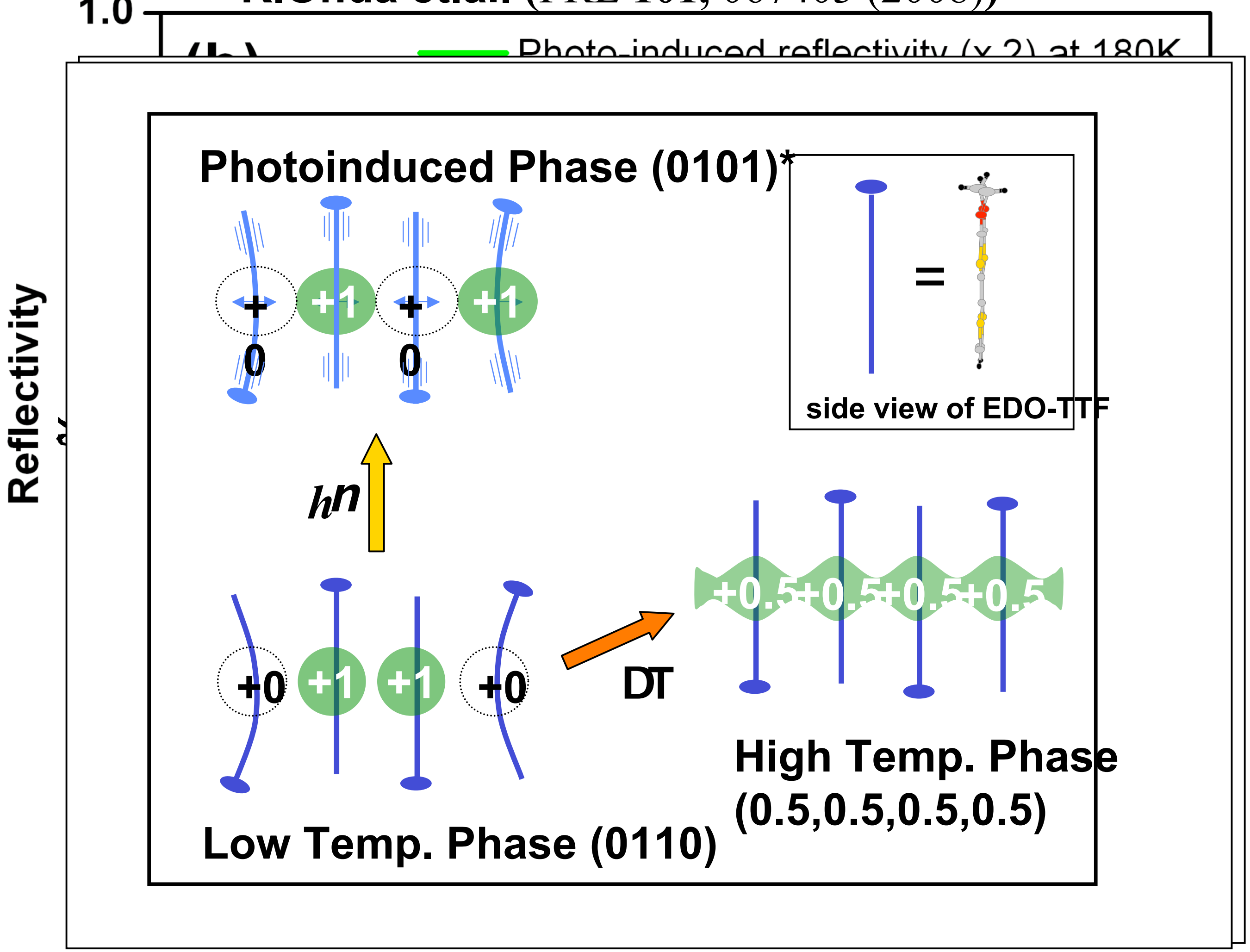
Is it really I-M transition ?



M.Chollet et.al., Science 307 (2005) 86.

100fs time-resolved reflection spectra in wide photon (VIS-THz) energy region

K.Onda et.al. (PRL **101**, 067403 (2008))

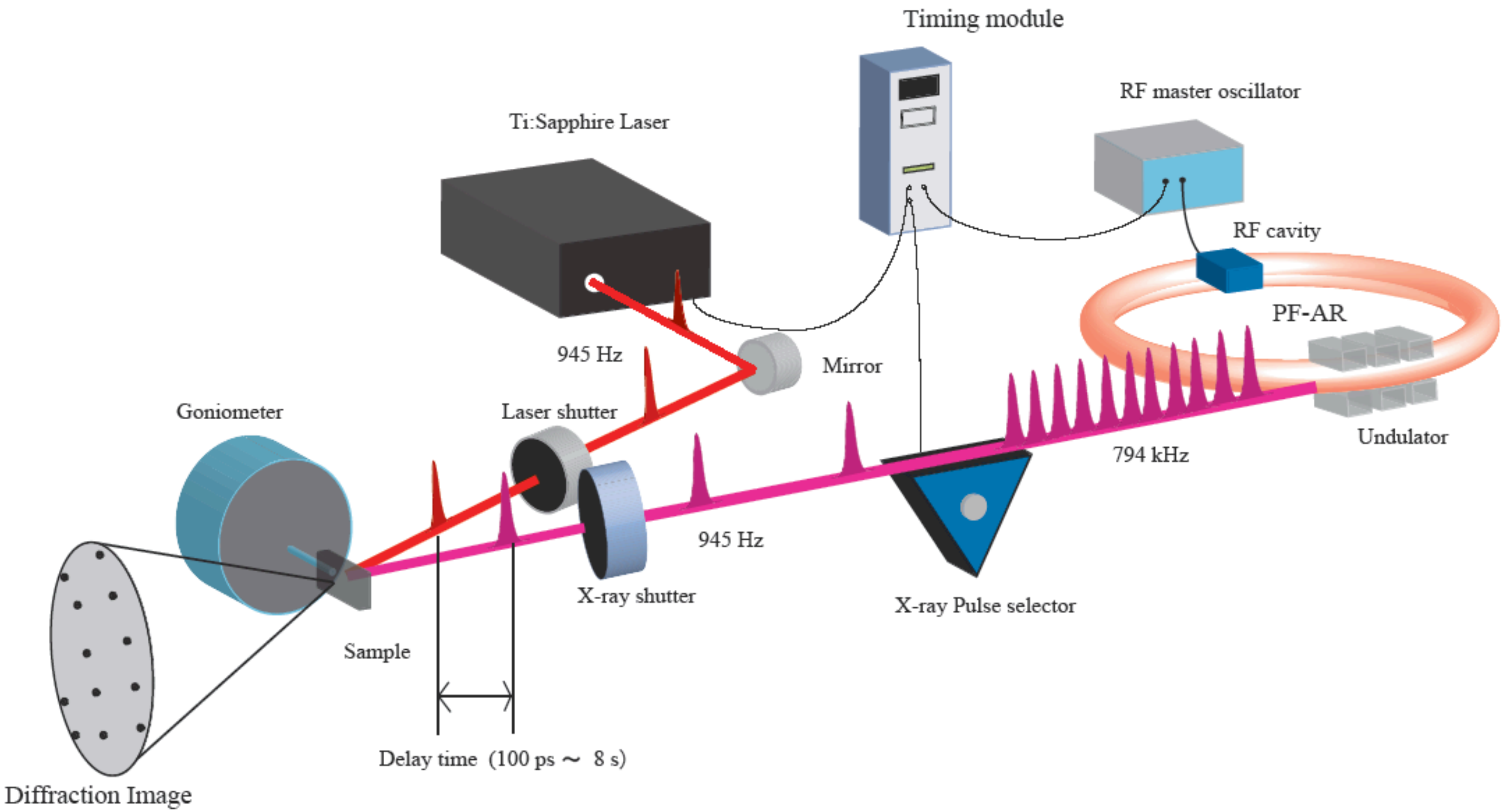


K.Onda
(Tokyo Tech.)

S.Ogihara

PIPT phase cannot be achieved by thermal excitation
False Ground State !（Collaboration with Prof. Yonemitsu G.)

Laser-SR technology (Molecular Movie) has kicked off the new materials based on dynamical structure



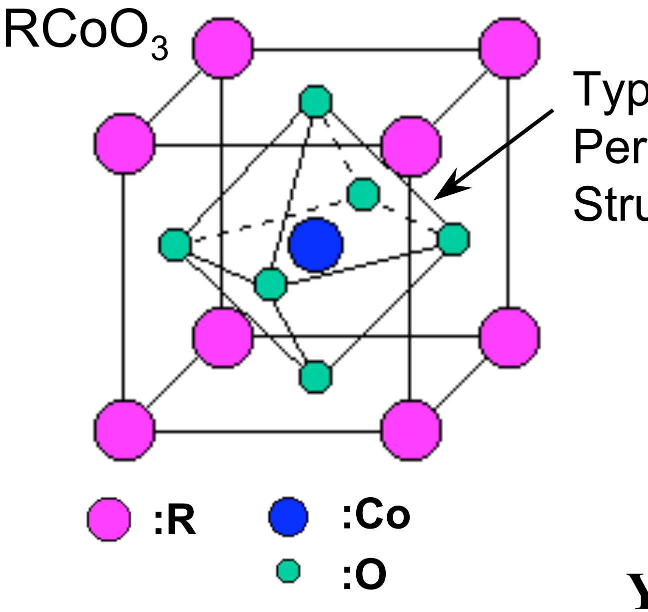
Nozawa et al. (2007) J. Synchrotron Rad. 14, 313.

Co oxides with Perovskite structure: $Pr_{1/2}Ca_{1/2}CoO_3$

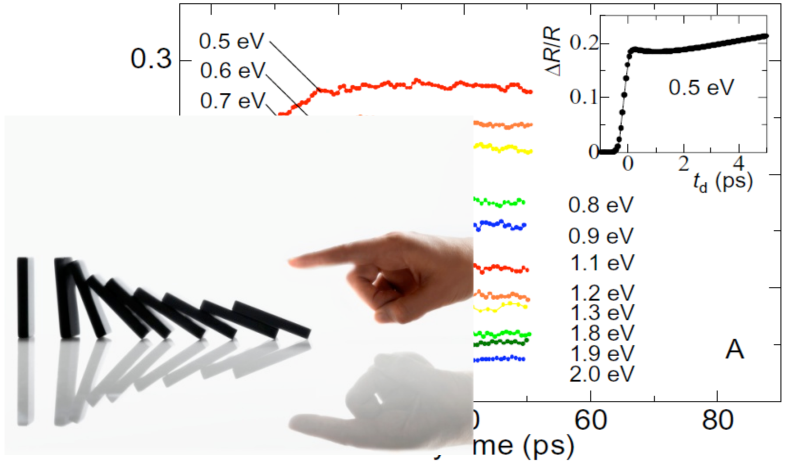
(Estimation of the speed of the photo-induced M-I domain wall based on the direct observation of movement of it)

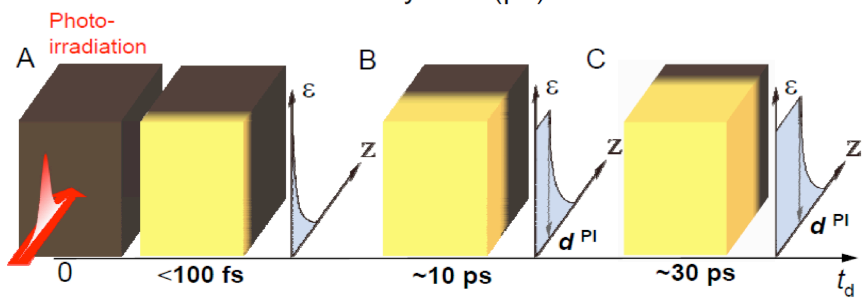
Transport property

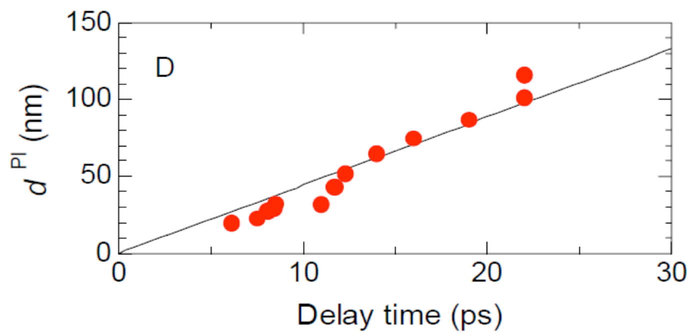
- **M-I transition around 90 K**
- **The first oreder phase ransition with hysteresis**



Y.Okimoto

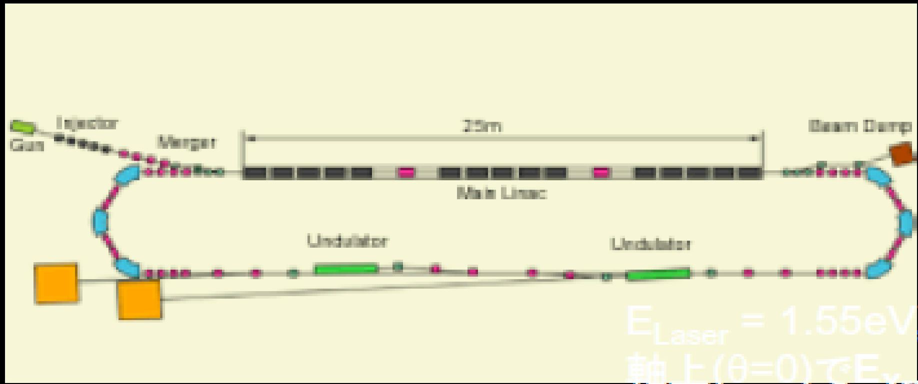






M. Itoh et al, physica B vol. 25 p. 902, 1999

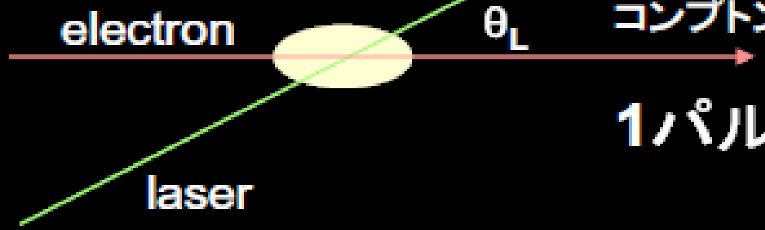
Laser-Compton X-ray source at ERL test facility (60-150MeV)



$E_{Xray} = 2\gamma^2 E_{Laser}(1-\cos\theta_L)/(1+\gamma^2\theta^2)$

$Flux = (N_L N_e/wh)(L_{eff}/L_b)\sigma_c$

E_{Laser} = 1.55eV, $E_{electron}$ = 60 MeV (γ=117), θ_L = 90 degree のとき、
軸上(θ=0)でE_{Xray} = 42.4 keV



レーザーパルス(1.55eV, 1mJ)のフォトン数：　$N_L = 4 \times 10^{15}$ photons
電子バンチ中の電子数(60MeV, 1nC)：　$N_e = 6 \times 10^9$ electrons
電子バンチの水平幅：　$w = 50 \times 10^{-6}$ m
電子バンチの高さ：　$h = 50 \times 10^{-6}$ m
コンプトン散乱断面積：　1×10^{-28}

1パルスあたり、

Flux = 1×10^6 phs/pulse/10%b.w.

10kHzのとき、

Flux = 1×10^{10} phs/sec/10%b.w.

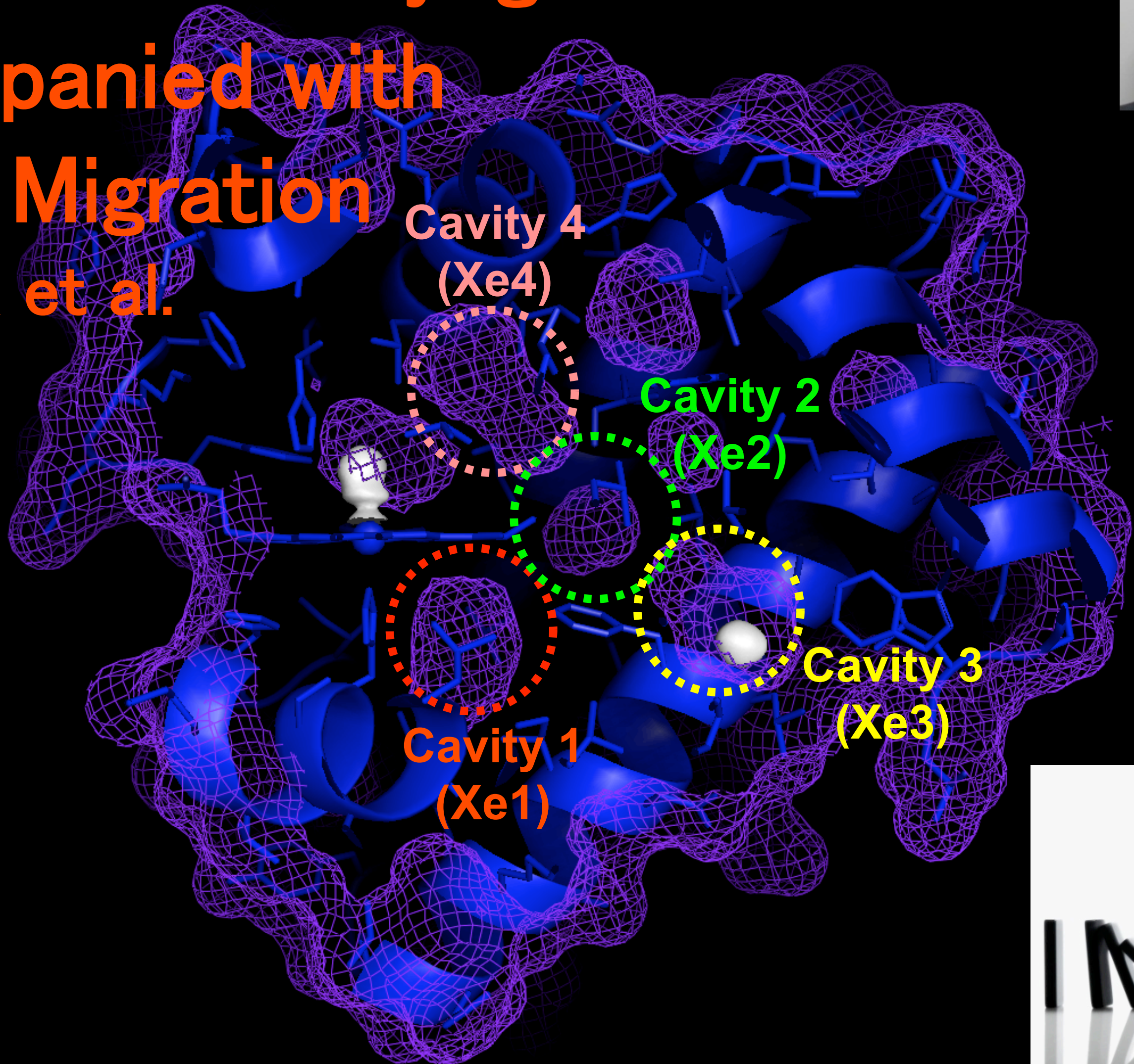
PFで計画しているコンパクトERLをレーザーコンプトン光源として使用した場合のX線光子数の見積り

Slow Concordant Dynamics in Whole Units of Myoglobin Accompanied with Ligand Migration

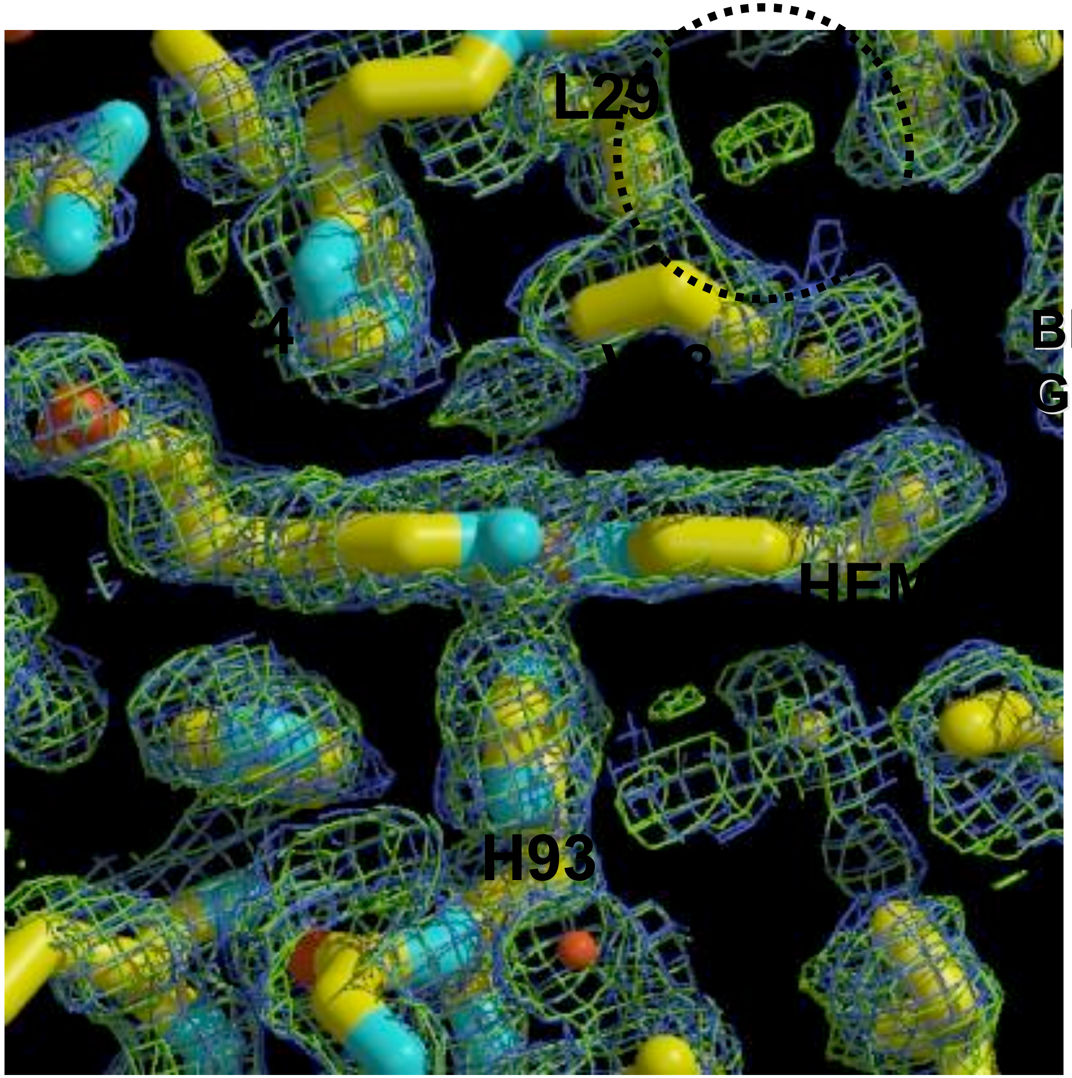
A.Tomita et al.

A.Tomita

S.Adachi



Subnanosecond-resolved 2*F*o-*F*c map of photolysed myoglobin-CO contoured at 0.8s



Blue: Laser OFF
Green: Laser ON, +300 ps

Initial stage of slow PIPT has electronic origin.

New structural science is surely stimulating materials scientists

Materials Synthesis

Materials Design

Combination with dynamical SX, neutron and NMR will be key !

CT Complexes

CO Soft Systems

e-e Correlation

e-e long correlation

e-l correlation

molecular transport

Quantum Para
(PRL 100, 227601 2008)

Mb:Protein

Materials Characterization (Facility science)

PIPT and Photo-ferro
(Science 300, 613 2003)

CO and Ultrafast PIPT

Giant Piezo

Concordant breathing motion

Thank you for your attention !

CM: Yamada Conf. for PIPT
Nov. 11-15, 2008 in Osaka,

Please visit our Home-page :http://www.pipt.jp

PIPT3 (2008)

LXIII Yamada Conference