Time-resolved Photoemission spectroscopy with attosecond XUV & femtosecond DUV source based on high repetition rate OPCPA

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Dynamics of Topological insulator

For Ti sample Bi2Te3. Charge relaxation & relaxation dynamics observed by J.A. Sobota (2012)
The circular dichroism had been observed using circularly polarized light by Liu & Rohwer (2013)

Dynamics of Charge Density Wave

Up to now e-e interaction was never observed in condensed matter physics field due to temporal resolution problem.
Pure electronic process would be density resolved using attosecond pulse.
We will focus on the dynamics of conventional solid attosecond pulse in start hit energy bandwidth in brand T = 9 fs.

Motivation

Weyl/3D TI

Weyl Wells. Feb. 2017

Investigation of Fermi surface
Emergent temperature dynamics

ARTOF

ARTOF schematic

- Acceptable Rep. rate up to 1 MHz
- 22 acceptance angle with 0.00 degree angular resolution
- 6 - 1600 eV kinetic energy range with 0.1 meV energy resolution

Beam lines

High Harmonic beam line

1. X-ray chamber
- 8 - 200 per nanosecond or pulse gas
2. Toroidal mirror chamber
- 8 - 16 degree focusing
3. X-ray analysis chamber
- 72 - number targets

OPCPA design

Driving laser at 300 kHz

Specification

- Output power > 15 W (>12 W after CEP slow loop) with 300 kHz Rep. rate
- Pulse duration ~ 6 fs is measured by SPIDER
The spectral phase well defined over the range 650-850 nm

High Harmonic Generation

HHG w/ Ne gas

- 23 at FWH 300 kHz, 1.7 fs
- Ne gas used
- Gas flow rate 80 SCCM
- Nozzle size < 100 nm

HHG spectrum

6 eV beam line

4th harmonic generation

- 4th harmonic from BBO crystal
- 6.02 eV (~296 nm centered)
- 20 meV (~0.5 nm) bandwidth

Pulse compression

- ~70 fs FWHM

6 eV beam line - Topological Insulator: Bi2Te2Se

- Clear Dirac cone structure & polarization dependence
- Circular Dichroism observed
- Difference between high circular pol. and left circular pol.

Summary

- We report the construction of femto & attosecond beam line for ARPES measurement.
- XUV pulse is being generated from Ar or Ne gas using OPCPA at 300 kHz repetition rate via HHG scheme.
- Circular dichroism measurement using 6 eV UV is providing spin dependent electron behavior of topological insulator.
- Further development of the system in the combination of attosecond pulse & ARTOF technique will be a great opportunity to investigate electron-electron interaction of solid state materials.

Measured 3D image

6 eV Beam line

- ARTOF: 3D image $n_x, n_y, E_l$ by a single measurement – the best for dynamics
- $B_0 T_0 S_0$ measurement:

Momentum($p$)

Circular Dichroism

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