First result of EDXRD experiment using a gamma-ray TES calorimeter with Sn absorber

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We report the first result of energy dispersive X-ray diffraction (EDXRD) experiment at a synchrotron facility using a gamma-ray TES calorimeter with Sn absorber. Details of the calorimeter is presented by T.Oshima's talk. We successfully detected a diffraction pattern of a NaCl crystal 2θ = 8 deg, however the energy resolution was significantly degraded to 567 eV at 32 keV due to a malfunction of the TES bias line inside the adiabatic demagnetization refrigerator. Our primary goal is to analyze a phase diagram of complex crystal structures like Bi under the extreme high pressure situation.

Also check T. Oshima's talk.

I. Science Goals

1. Detection of the atomic gamma-ray from SNR [The et al 2006]

Proof of the nucleosynthesis for interior stellar and supernova variation under high pressure situation of Bi.  To execute this, we need to overcome these task:

- Preparation of TES calorimeter with high resolution
- Develop automatic analysis system: need for the real time spectrum analysis
- Complete wiring & shield setup: suppress electrical noise.

2. Structure

- Restrictions of heat capacity
- Width of transition edge

We selected Sn (Z=50) as an absorber: superconductor and small heat capacity: also used at LNL (52 eV@60 keV) [Cunningham et al 2002]

3. Experiment

3.1 Energy Dispersive X-ray Diffraction

On Bragg's law, by fixing angle θ, and irradiating "white" X-ray, we can detect the grating spectra.

Bragg's law: $\lambda = 2d \sin \theta$

In the extreme high pressure experiment, it is essential to use the EDXRD method because of its instrumental structure. In this field, Ge detector has been applied to detect grating spectra.

3.2 ADR

Heat Switch

He insert gate

Salt pill (FAA)
Superconducting coil (2T@4.0 A)

He tank (7T)

Experimental stage

shield room

~3m

Setup

- Synchrotron facility at KEK in Japan
- Two collimators are fixed at 2θ = 8°
- Standard sample: NaCl powder
- Upstream collimator: 0.05 × 0.3 mm
- Downstream collimator: 0.03 × 0.03 mm
- Detector size: 0.63 × 0.67 mm
- Scan diffraction beam with XZ-table

References

Shinozaki et al, 2006, Rev. Sci. Ins. 77, 4
W.Klement et al, 1963, Phys. Rev. 131, 2; Cunningham M.F. et al, Appl. Phys. Lett, 81,1

II. Detector – gamma ray TES microcalorimeter

- Pulse & Spectrum

Detection of the atomic gamma-ray from SNR [The et al.2006]

4. First Result

We applied the gamma ray TES microcalorimeter above to a detector of EDXAD at 2θ = 8 deg.

We successfully detected the diffraction spectrum with a standard sample of NaCl powder.

However, circuit trouble made larger noise, smaller pulse height, and longer τ. As a result, energy resolution was degraded to ΔE = 567 eV at 32 keV.

5. Future Strategy

We applied a gamma ray TES microcalorimeter for EDXRD and detected the first light of the diffraction spectrum. In the next step, we plan to obtain better quality spectrum under high pressure situation of Bi. To execute this, we need to overcome these task:

- Complete wiring & shield setup: suppress electrical noise.
- Automatic analysis system: need for the real time spectrum analysis
- Longer holding time, easy-to-use ADR system.

And, preparing for astrophysical future mission ...

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