# CO1-1 Development of Cold Neutron Interferometer with Perfectly Separated Paths

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**INTRODUCTION:** Neutron interferometry is a powerful technique for studying fundamental physics. A large dimensional interferometer for long wavelength neutrons has the advantage to increase the sensitivity to small interactions. Such a kind of interferometer was realized by using multilayer mirrors. Multilayer mirror is suitable for Bragg reflection of cold neutrons. We demonstrated Jamin-type interferometer for cold neutrons using beam splitting etalons (BSEs), which enables us to align the four independent mirrors within required precision [1]. Some interaction depends on the area enclosing the two paths of the interferometer, for example, gravitationally-induced quantum effect. Devices can be inserted between the two paths when the paths are separated spatially. For example, we can set an electrode between the paths for Aharonov-Casher effect [2]. The interferometer with separated paths is important.

**EXPERIMENTS:** We made BSEs with the gap of 0.2 mm. The neutron mirrors on the etalons have limited area in order to make two paths with perfect separation. By using cold neutron beam line MINE2 in JRR-3 at JAEA, which provides neutrons with the wavelength of 0.88 nm, Jamin-type geometry can be constructed with a couple of the BSEs. The multiplayer mirrors on the BSEs were fabricated with vacuum evaporation system in KURRI. The new vibration isolator was installed into MINE2. We observed clear interference fringes with the contrast of about 0.6. The phase of the fringes were drifted according to time. Now we are continuing studies about stability and applicability of the interferometer. Environment around the apparatus should be upgrade to be more stable.

**RESULTS:** We demonstrated the feasibility of cold neutron interferometer with perfectly separated paths. Now we are planning to apply this interferometer to study Aharonov-Casher effect.

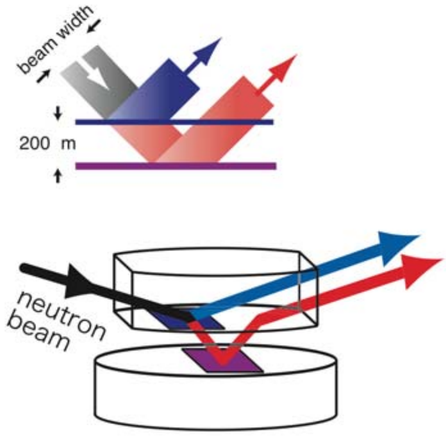


Fig. 1. BSE with the gap of 0.2 mm. The neutron paths are perfectly separated at proper incident angle.

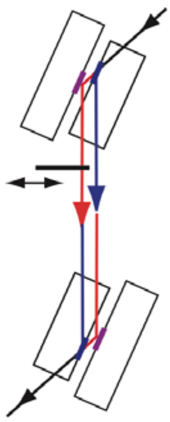

Fig. 2. Jamin-type geometry with two BSEs. Devices can be inserted between the separated paths.

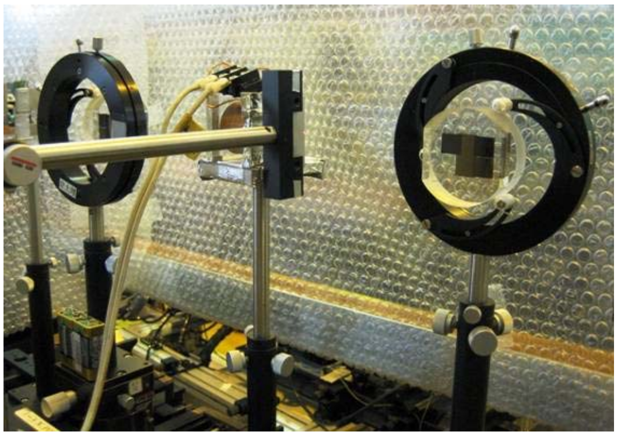

Fig. 3. The interferometer setup at MINE2. The BSEs are set on the vibration isolator.

**REFERENCES:**

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[2] A. Cimmino *et al.*: Nucl. Instrum. Methods Phys. Res. A **440** (2000) 579.

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# CO1-2 Development of Analyzing Method of Small-Angle Scattering for Size Distribution of Segregation Particles in Metal Alloy

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**INTRODUCTION:** Small-angle scattering (SAS) is one of very powerful tools to analyze nano-scale structure. However, standard analysis methods, such as Guinier analysis, Ornstein-Zernike analysis and so on, give us *average* size of particles and/or *average* length of density fluctuation in an observed system. It means that detailed particle shape, size distribution and position distribution are not obtained with the standard analyzing methods. To overcome the limitations in SAS, we are developing a new analyzing method which derives more information than the standard ones.

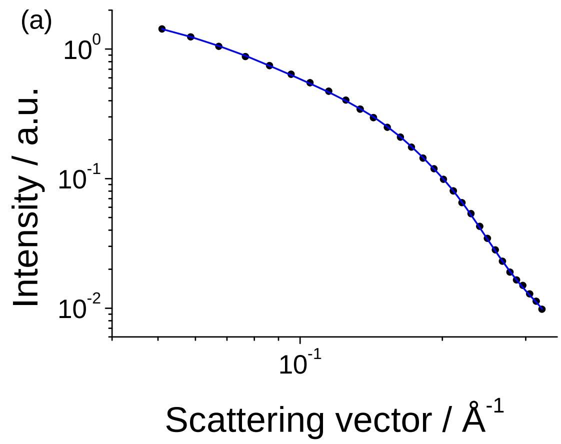
One of our goals in this project is to reveal a size distribution of segregated particles in a metal alloy with SAS. We are developing a computer program based on Monte Carlo algorithm to derive the size distribution from SAS data. In this report, we show our recent progress on developing the computer codes.

**DATA ANALYSIS:** We analyzed a size distribution of segregated Cu-domains in steel. Figure 1(a) shows Small-Angle Neutron Scattering (SANS) of steel in which Cu-domains are segregated. Because a neutron has strong penetrating power, it is very suitable probe to observe an inside structure of steel.

Our analyzing algorithm is as follows.

1. Give the initial distribution; usually normal distribution.(Distribution 1)
2. Calculate the SANS curve (SANS 1) with Distribution 1.
3. Compared SANS 1 with the experimental one.
4. *Randomly* select one size and change the number of particle with that size.(Distribution 2)
5. Calculate the SANS curve (SANS 2) with Distribution 2.
6. Compared SANS 2 curve with the experimental one.
7. If the SANS 2 is closer to the experimental one than SANS 1, we make SANS 2 and Distribution 2 new SANS 1 and new Distribution 1, and go to 4. If not, we ignore SANS 2 and go to 4 to make new Distribution 2.
8. Repeat 4-7 until calculated SANS curve well reproduce the experimental one.

**RESULTS:** The line in Fig. 1(a) shows our analyzing result. The calculated SANS curve well-reproduces the experimental one. Figure 1 (b) shows size distribution of Cu-domains corresponding to the calculated SANS curve. This distribution well agree with the distribution obtained with Atom-Probe method.



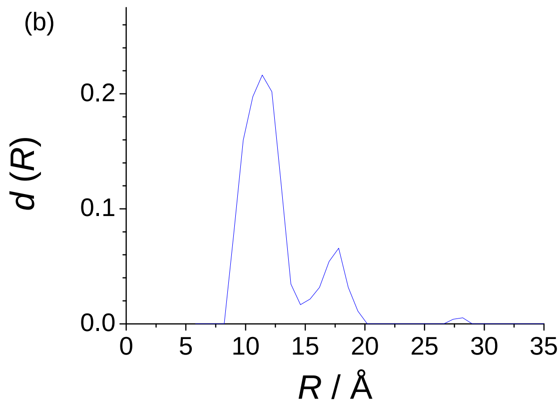




Fig. 1. (a) SANS curves. Closed circles and solid line show the experimental and the calculated ones, respectively. (b) The calculated size distribution.

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# CO1-3 Development of a High-Intensity Neutron Monochromator

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**INTRODUCTION:** Pyrolytic-Graphite (PG) is widely used as a high-integrated-reflectivity neutron monochromator. It is a very good monochromator material for moderate-resolution applications. However, applications such as small-angle neutron scattering (SANS) or reflectometer instruments need a wavelength-band of more than a few %, possibly about 10 %. In such cases, not only unreasonably high mosaicity of more than 2 degrees is required, but it must also be coupled with incident beam that has extremely high beam-divergence of about 0.1 radian. We are proposing to use strongly bent perfect silicone crystal plates coupled with a device that enhances beam divergence by using high-$Q_c$ supermirrors as a monochromator. We therefore developed such a device that has a beam deflector consists of supermirror plates and coupled the device to a stack of bent perfect silicone crystal (BPSC) plates as shown in Fig. 1. Note that it is a side view drawing therefore the outgoing neutron beam direction is upward at 45 degrees.

**EXPERIMENTS:** In the device, the reflection angle of a neutron is larger at a higher position to match with the angle of the corresponding crystal lattice plane of the BPSC plates.

Supermirrors of 4.5 $Q_c$ and 2 $Q_c$ have been fabricated at Kyoto University Reactor Research Institute (KURRI) using the sputtering machine there. The substrates were 8-inch diameter, 0.5 mm thick silicone wafers, and plates of 100 mm in length, 20 mm in width have been cut out from them.

The performance of the monochromator has been checked at the pulsed neutron facility at the Hokkaido University electron linear accelerator.

**RESULTS:** Beam profiles at the detector position, that was 150 mm from the exit of the BPSC of 120 mm in length, are shown in Fig. 2., without the deflector (top), and with one (bottom). The outgoing beam positions without the deflector showed large position shifts with the incident beam height and hence neutron wavelength bands. The colors of the curves correspond to the incident beam positions, from lower to higher positions in 5 mm step; starting from the green one rising at around 39 mm, with yellow one rising at around 52 mm corresponds to the highest position. When the deflector was put into the position, all the outgoing neutrons were overlapped at the same position resulted in a large intensity gain of 8. The wavelength band was also larger, about 3.6 %, corresponding to the larger diffraction angle at the BPSC.

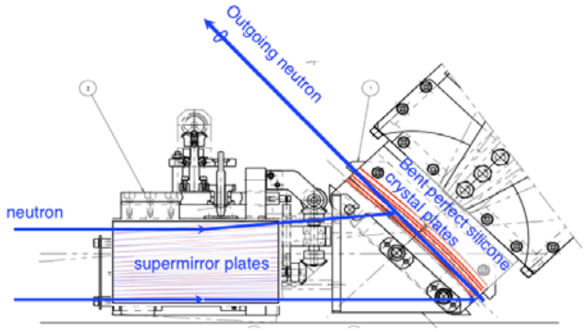


Fig. 1. Schematic layout of the monochromator consists of a supermirror deflector and a strongly bent perfect silicone crystal plate monochromator together with a part of goniometers.

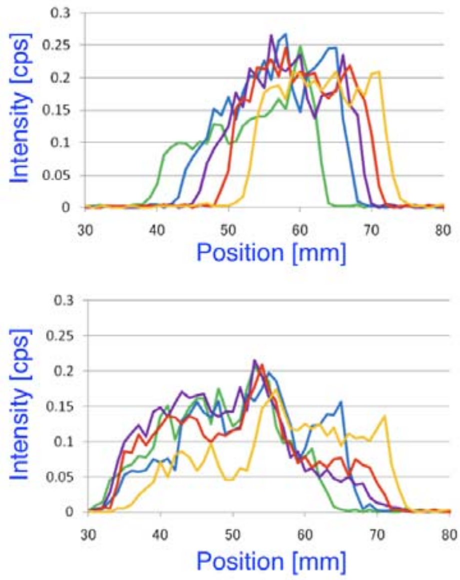


Fig. 2. Beam profiles at the aperture position, 300 mm from the BPSC without the deflector (top), and with one (bottom).

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（北海道大学・工）古坂道弘、石川直樹、佐藤多加志、奥澤康裕、藤田文行、本間彰、
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