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A New Beam Line for Practical Neutron Optical Devices

Jun-ichi Suzuki[1*], Kazuhiko Soyama[1], Seiji Tasaki[2] and Toru Ebisawa[2]

[1] Japan Atomic Energy Research Institute (JAERI), Tokai, Ibaraki 319-1195, Japan
[2] Research Reactor Institute, Kyoto University (KURRI), Kumatori, Osaka 509-0494, Japan
*E-mail: suzuki@neutrons.tokai.jaeri.go.jp

Abstract

We have constructed a new beam line specialized in evaluating the performances of practical neutron optical devices at the Japan research reactor JRR-3M. We show a concept and a design of the new beam line.

1. Introduction

To make neutron beam intensity higher is an eternal subject of the neutron research community. In order to overcome a part of this subject, neutron optical devices (refractive devices) have been developed for the last several years in Japan [1] and also in the world [2]. From this year (2000) the project entitled as "The Development and Application of Neutron Optics" (NOP) has been organized by several institutes of Japan [3]. In the NOP project we have developed not only refractive devices but also reflective, imaging and polarizing devices and have also tried to make these optical devices practicable for neutron research.

A part of the results obtained in the NOP project has been reported in this meeting by Oku *et al.* [4]. They have developed compact optical devices and succeeded in actually proving the principles of the devices. In order to prove only the principle of the compact devices no special beam line has been necessary. They could use neutron spectrometers such as a small-angle scattering instrument for the studies. However, in order to evaluate the performances of practical and complex devices, which will be larger, it has been required to prepare a special beam line with intense neutrons and large space. We have then constructed a new beam line (NOP beam line) specialized in the purpose at the Japan research reactor JRR-3M in the JAERI. The JRR-3M is the most intense neutron source in Japan. However, all beam ports have been already occupied by other neutron scattering instruments. Therefore, we have produced an additional beam line at the C3-1-2 beam port with a neutron bender.

In the latter sections we show a design of the neutron bender and a layout of the beam line.

2. Neutron Bender

We have constructed a cold neutron bender with three beam channels using sequential garland reflections to supply neutrons to the new NOP beam line (CH1: first channel) and other two instruments (CH2 and CH3: second and third channels) for spin interferometry and reflectometry, *etc.* In order to reduce a loss of neutrons with large divergence this bender adopts a new idea relating to a mirror arrangement, in which each bender section consists of three straight mirrors approximating parabolic shape [5].

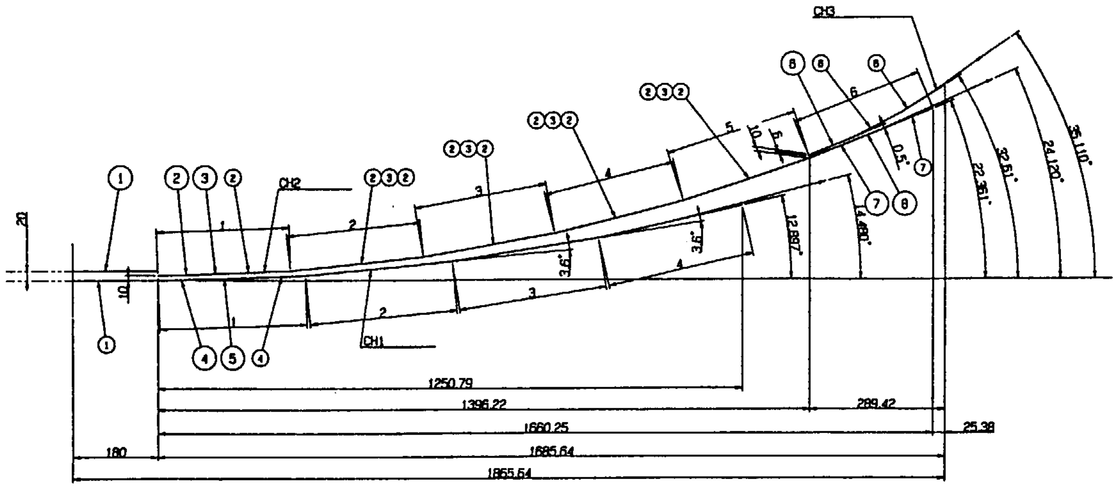

Fig. 1 The whole arrangement of mirrors in a neutron bender of a NOP beam line. The number in a circle denotes a mirror No.

Figure 1 shows the whole arrangement of mirrors in the bender. The bender consists of 37 straight mirrors with different types and sizes. The mirrors of No. 1 are nickel guide mirrors. The mirrors of No. 6 are monochrometors with a period of 15 nm. The others are 3Q NiC/Ti supermirrors with reflectivity higher than 90%. Substrates of all mirrors are silicon wafers with 1.5 mm in thickness. The effective sizes of the mirrors are described in Table I.

Table I Effective mirror sizes coated on silicon substrates.

Mirror No.	Mirror Size
1	45 mm×90 mm
2	45 mm×110 mm
3	45 mm×65 mm
4	45 mm×121 mm
5	45 mm×74 mm
6	45 mm×110 mm
7	45 mm×110 mm
8	45 mm×65 mm

Reflection numbers N_{ref} of the bender are 4 for the CH1 and 6 for the CH2 and CH3. Total bent angles θ_b are 14.48°, 24.12° and 35.11° for the CH1, CH2 and CH3, respectively. Expected minimum wavelengths λ_{min} for the CH1, CH2 and CH3 are 0.72, 0.8 and 1.0 nm, respectively. A beam cross section of the CH1 is 9.5 mm in width and 45 mm in height. Beam heights of the CH2 and CH3 are the same as that of the CH1. However, the beam width of 45 mm is shared for the CH2 and CH3 at the sixth bender section. These parameters are summarized in Table II. Beam transmission through the bender estimated from calculations is about 0.6.

Table II Parameters of a bender; N_{ref}: reflection number, θ_b: total bent angle, λ_{min}: minimum wavelength, and beam size, where $w_1+w_2=45$.

Channel No.	N_{ref}	θ_b (°)	λ_{min}	Beam Size (mm^2)
1	4	14.48	0.72	45×9.5
2	6	24.12	0.8	w_1×9.5
3	6	35.11	1.0	w_2×9.5

3. Layout of a NOP Beam Line

Figure 2 shows a layout of the NOP beam line. A neutron beam transmitted through the bender is monochromatized by a mechanical velocity selector. On the beam line we will evaluate the performances of practical neutron optical devices such as a sextupole superconducting magnet with a bore of 50 mm in diameter as a magnetic lens, which is under design, or complex devices such as this magnet combined with supermirrors. For neutron imaging, neutron imaging plates and the imaging devices, which have been developed in a different team of the NOP project, will be used.

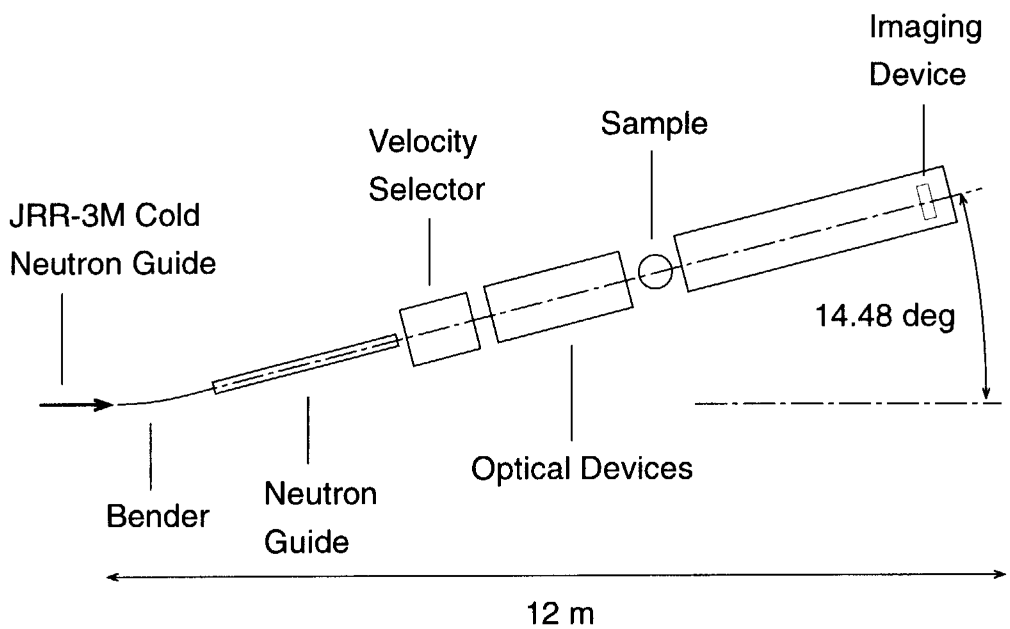

Fig. 2 A layout of a NOP beam line.

4. Summary

We have constructed a new beam line specialized in evaluating the performances of practical neutron optical devices at the Japan research reactor JRR-3M. We hope that the neutron optical devices to be developed and evaluated using this beam line in the NOP project will be used in the world in the near future.

Acknowledgements

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