Available online at www.sciencedirect.com

ScienceDirect

Physics Procedia 88 (2017) 354 – 360

Physics Procedia

8th International Topical Meeting on Neutron Radiography, Beijing, China, 4-8 September 2016

A study on inhomogeneous neutron intensity distribution origin from neutron guide transportation

Yu Wang, Guohai Wei, Hongli Wang, Yuntao Liu, Linfeng He, Kai Sun, Songbai Han*, Dongfeng Chen*

Neutron Scattering Laboratory, China Institute of Atomic Energy, Beijing 102413, China

Abstract

The uniformity of the neutron intensity spatial distribution at the sample position will directly affect the neutron imaging quality. But the unexpected inhomogeneous spatial distribution phenomenon always appears in the neutron radiography facilities installed at the end of neutron guide. In this paper, the source of this phenomenon has been analyzed through geometrical optics and confirmed by Monte Carlo simulations, and several optimization solutions are also proposed.

Peer-review under responsibility of the organizing committee of ITMNR-8

*Keywords:*neutron radiography, neutron guides, intensity space distribution, McStas simulation

1. Introduction

The neutron radiography technique (Kardjilov et al., 2011; Strobl et al., 2009; Banhart, 2008; Banhart et al., 2010; Strobl et al., 2011) is based on the mapping of the attenuation function for a neutron beam transmitting a sample. It can be widely applied in various fields such as industry, geology, archaeology, medicine, etc. …, lots of the neutron imaging facilities have been constructed all over the world.

For neutron imaging facilities installed at the end of the neutron guides (Maier-Leibnitz and Springer, 1963), the neutron intensity distribution in the vicinity of the sample position is generally inhomogeneous (Hilger et al, 2006; Garbe et al., 2011), which leading to the flat field image with stripes or grids and directly affecting the

* Corresponding author: Tel: +86-10-69358015; fax: +86-10-69357787;
E-mail addresses: hansb@ciae.ac.cn (Songbai Han), dongfeng@ciae.ac.cn (Dongfeng Chen)

Peer-review under responsibility of the organizing committee of ITMNR-8
doi:10.1016/j.phpro.2017.06.048

neutron imaging quality. In order to ameliorate it, the way such as placing graphite 5 to 10 mm thickness at the guide exit has been tried （Hilger et al, 2006）, and some better uniformity could be achieved at the expense of the lower neutron intensity. Its derived negative effects even hindered the application of neutron guides in the new-built neutron imaging facilities （Garbe et al., 2011）. The similar phenomenon has also been encountered in the SANS instruments （Radulescu et al., 2012）, which has the similar optical flight path as the imaging facility.

But the true reason has not been studied systematically. In this paper, the origin of the optical aberration is analyzed based on geometrical optics theory, and confirmed by Monte Carlo simulations. And finally the method to overcome the inhomogeneous is put forward and discussed.

2. Geometrical optical analysis of the origin of inhomogeneous intensity space distribution

In general, the pinhole geometry is usually applied in the present neutron radiography facilities, where the beam collimation is performed by the combination of an aperture and a long distance L from the aperture to the sample position, as shown in Fig.1. The intensity distribution is connected closely with the divergence distribution. The divergence distribution of the neutron passing through the aperture D is therefore analyzed firstly, and then the intensity space distribution will be discussed.

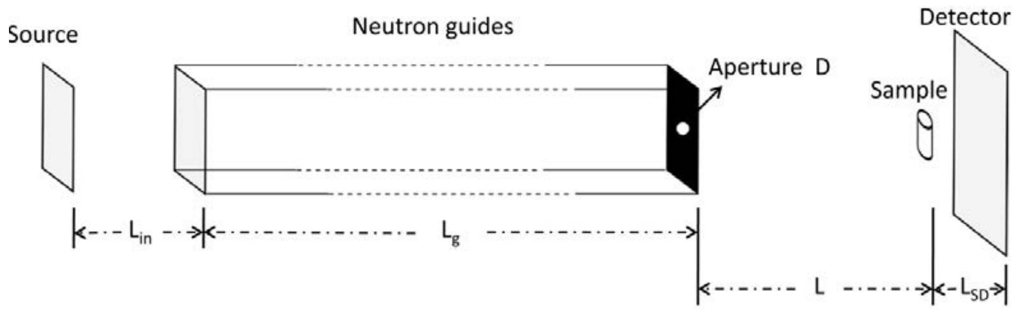

Fig. 1 Sketch map the simple geometry of the neutron radiography facility

For simplifying the explanation, we only deal with the inhomogeneous distribution of the neutron beam intensity in the horizontal direction. Counterclockwise rotation angle is defined to be positive in this section, and only the positive angle range is taken into account for the symmetric geometry.

For any point M at the exit of the neutron guide around focal aperture D, the component of the neutrons reaching to the point M are mainly two parts: the direct incident neutrons from the source, and the reflective neutron (with different number of reflections) from the neutron guide walls, as shown in Fig.2 (symmetric geometry).

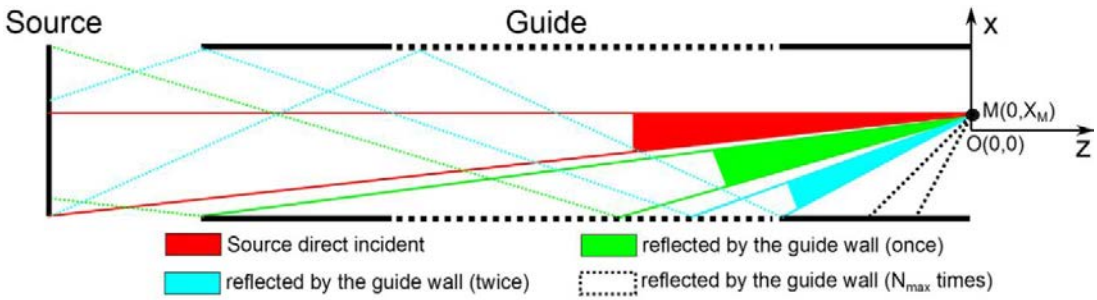

Fig. 2 (color online) The component of the neutrons reaching to the point M