DESIGN OF THE OPTICS AND ALIGNMENT OF THE ININ$^2$ NEUTRON DIFFRACTOMETER TO MEASURE GLOBAL TEXTURES

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ABSTRACT.

In studying global textures from bulk samples, which by their grain size can not be analyzed through the conventional X-ray methods, neutron low-resolution diffractometers are used to perform measurements of pole figures. With the purpose of performing such measurements, in this work a new optical design and adjustment of the neutron diffractometer of the ININ$^2$ is presented. An illustrative application of these features is given.

1. INTRODUCTION

X-rays and neutrons interact with matter in a different way. X rays do it with the electronic layers through the electromagnetic force, while neutrons interact with the nuclei through the nuclear and magnetic forces. It confers to the neutron diffraction different characteristics of X-rays.

Neutron diffractometers are used to carry out the following studies [1]:

a) Bulk analysis. For example, in determining global textures; due to the low absorption of the neutrons by studied samples.

b) Elemental analysis of compound materials near or contiguous in atomic number; as consequence of the distinctive properties of the effective cross section of the isotopes with atomic number.

c) Analysis of magnetic materials; since the neutronic spin interacts with the magnetic atomic moments.

The spectrum of neutrons diffracted by an ideal crystalline sample presents several maxima or peaks, which are gaussian shaped for low and medium resolution diffractometers. The quality of maxima lies upon instrumental properties; resulting a function of the physical characteristics of each parts that compose the diffractometer, the geometric relationships between them and the structural state of the analyzed material. The physical elements of the diffractometer together with their geometric relationships are amed “optics of the diffractometer”. The optics draw its effects on the peak, so much in their design like in their adjustment (alignment), in two parameters; the FWHM (width) and the intensity.

A fundamental request to measure pole figures, when using conventional detectors, is that the width of the inferior part of the peak must be smaller or equal than the width of the detector window. If the width of the inferior part of maxima can be consider approximately two times their FWHM, is possible to take as criterion to measurement of pole figures that two times the FWHM must be smaller or equal the width of the detector’s windows. The fundamental objective of this work is to obtain an optics satisfying this condition.

Two important aspects need to be remarked. The first one is that in order to eliminate its influence on the peaks, the alignment should be made with the maximum achievable precision, because it does not exist a mathematical function that a priori allows to know its effects [2]. The second is that only if the alignment is guaranteed it take sense to do the design of the optics.

2. THEORETICAL FOUNDATIONS

Figure 1 shows the conventional optics of a neutron diffractometer [3]. $S_1$, $S_2$, and $S_3$ are the Soller collimators, characterized by their angular divergence $\alpha_1$, $\alpha_2$ and $\alpha_3$. While the mosaic width $\beta$ characterizes the monochromator crystal [1].

In reference to the Fig. 1, Hewat [4] reports the following expression for the FWHM:

$$FWHM^2 = U \tan^2 \theta + V \tan \theta + W$$  \hspace{1cm} (1)

where:

$$U = \frac{4(\alpha_1^2 + \alpha_2^2 + \alpha_3^2 + \beta^2)(\alpha_1^2 + \alpha_2^2 + 4\beta^2) \tan^2 \theta_M}{(\alpha_1^2 + \alpha_2^2 + 4\beta^2)}$$  \hspace{1cm} (2)