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Inelastic scattering measurement option of TOF-USANS instrument at J-PARC

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Abstract

In a TOF-USANS instrument based on a double crystal diffractometer of Si perfect crystals with (1 1 1) fundamental reflection, monochromatic neutrons of wavelength λ and its harmonics (λ/n, $n = 3,4,5,7$) by the first crystal enter a sample, and scattering beams from the sample are analyzed by the second crystal. The neutron beams of these entire wavelengths are used in the normal mode to measure USANS intensity effectively. On the other hand, the TOF-USANS instrument would be considered to be a crystal-monochromator-type direct geometry inelastic-instrument, including the analysis by the second crystal. Therefore, by installing a band definition chopper to choose specific wavelength as option, it would be thought that quasi-elastic and inelastic scattering measurements become possible.

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1. Introduction

The characterization from nanometer to micrometer scale by scattering technique is very important to study hierarchical structure in material science, polymer science and so on. Therefore, measurements of wide q range ($q = 4\pi \sin(\phi/2)/\lambda$, ϕ is the scattering angle) are necessary using several instruments such as ultra-small-angle neutron scattering (USANS) based on double-crystal diffractometer (DCD) and pin-hole small-angle neutron scattering (SANS) apparatus. About small q, the reactor USANS method can reach to 10^{-4} nm order [1,2]. However, frequently, measurement of the smaller-q region becomes necessary. Carpenter et al. [3] proposed TOF-type USANS instrument based on the use of harmonics in SNS, which was discussed in terms of its extension toward the lower-q region. Recently Aizawa reported the TOF-USANS performance for JSNS, J-PARC [4]. In this paper, we discuss an inelastic-measurement option of TOF-USANS instrument at JSNS, J-PARC.

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2. Inelastic-measurement option

The DCD consists of (+,−) nondispesrsive setting of symmetric Bragg case of perfect channel-cut Si crystals with 3-bounce reflections. In order to lead neutron beams to the DCD, a pre-monochromator of PG, which is set in a 3Qc supermirror guide tube of the beam port, is used. The beam port sees the coupled moderator of 25 Hz. Fig. 1(a) shows an example of TOF–distance diagram for the normal mode of the TOF-USANS instrument at No. 13 beam port proposed in JSNS, J-PARC. A moderator to pre-monochromator distance of 18.5 m, a pre-monochromator to first crystal distance of 1.5 m, a first crystal to a sample distance of 0.5 m, a sample to a second crystal distance of 0.5 m and a second crystal to a detector distance of 2 m are assumed in the diagram. In order to measure USANS intensities effectively and extend accessible q minimum and q maximum, monochromatic neutron beam with $\lambda = 0.255$ nm for Si (1 1 1) reflection and its harmonics are used simultaneously [4]. USANS intensities are measured by rotation of the second crystal angle ω as a function of deviation from the Bragg angle of incident neutron wavelength, i.e. step scan, on a detector. In the

normal mode, the measurement is done using a 0-dimensional detector and the attention is an elastic scattering. Therefore the data is a set of ω and detected time for fundamental and harmonics reflection on the detector. On the other hand, if we use a band definition chopper to select specific wavelength neutron beams, the instrument can be considered to be a crystal-monochromator type direct-geometry inelastic instrument with an analyzer crystal. Therefore a capability of qausi-elastic and inelastic scattering measurements from a sample arise. Fig. 1(b) shows an example of such a situation for (1 1 1) fundamental reflection by operating a 25 Hz disk chopper for selecting the wavelength of 0.255 nm. The mosaic spread of typical PG is 0.25°. This causes wavelength

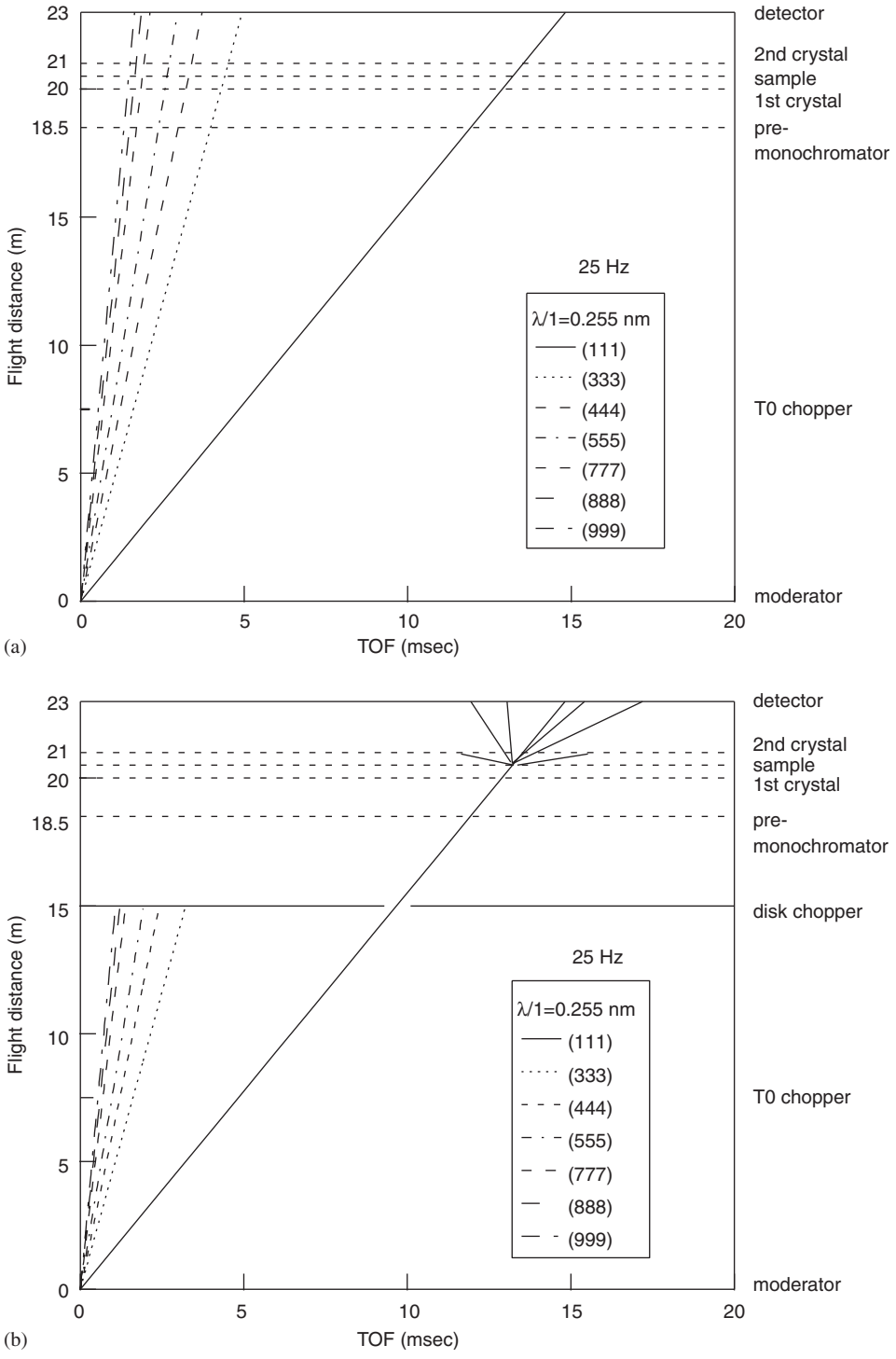

Fig. 1. TOF–distance diagram of the TOF-USANS instrument at No. 13 beam port proposed in JSNS, J-PARC, (a) normal mode and (b) inelastic measurement option. One frame width is 40 ms.