Experimental report

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Proposal: 1-04-184 **Council:** 10/2019

Title: Measurements of the double-differential neutron cross section of ThO2 , U3O8 and UAl at room temperature

Research area: Nuclear and Particle Physics

This proposal is a new proposal

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Samples: U3O8
ThO2
UAl

Instrument	Requested days	Allocated days	From	To
IN5	5	0		
IN6-SHARP	5	2	21/09/2020	23/09/2020

Abstract:

The present work is proposed in the framework of an experimental project started mid-2014 at the Institut Laue-Langevin which aims to measure double differential cross sections and to produce dynamic structure factor for the Joint Evaluated Fission and Fusion nuclear data library of OCDE/NEA. This library aims to fulfill the nuclear data needs for nuclear reactor applications. Double differential cross section measurements on light water (H2O), heavy water (D2O) and uranium dioxide (UO2) were already performed at the ILL facilities in the framework of this project [2-5].

Our new proposition is part of a multi-year program plan on actinides. The main goals are to investigate the neutron scattering properties of ThO2, U3O8 and UAl and to extract phonon densities of states (PDOS) at room temperature. PDOS are one of the main physical quantities involved in the neutronic simulations of thermal neutron transport.

Measurements of the double-differential neutron cross section of ThO_2 , U_3O_8 and UAl at room temperature

The present document provides a short description of the experiment performed on a ThO2 sample at the IN6 facility of ILL in September 2020. The double-differential neutron cross section was studied at T=294 K for an incident neutron energy of 3.12 meV. No measurements were performed on the other samples (U_3O_8 and UAl) because of the lack of time (two days have been allocated).

Sample characteristics

The ThO2 sample used for this experiment was composed of a stack of 12 ThO2 pellets in a double sealed ZrY4 container (Fig. 1). The mass of the ThO2 sample was 45.232 g (ρ=9.3 g/cm^3) with a height and diameter (without ZrY4 container) equal to 9.312 cm and 8.1558 mm, respectively. The thicknesses of the inner and outer ZrY4 containers were equal to 1.25 mm and 0.42 mm, respectively. A ZrY4 rod (Diameter of 1 cm) and a ZrY4 tube (outer diameter of 9.56 mm; thickness of 1.21 mm) were used for the container subtraction.

Fig. 1. ThO2 sample in the ZrY4 container with its Al sample holder wrapped in a Cd foil.

Experimental program

The experiments were performed on the IN6 (λ=5.12 Å, E=3 MEV) spectrometer at room temperature (294 K). A description of the experimental program is listed in Table 1. It consisted in measuring sequentially ZrY4-rod, ZrY4-tube, vanadium, empty-cell and ThO2. The empty cell measurement confirms the negligible background contribution due to the sample environment. Raw data provided by the acquisition system were treated with the LAMP package developed at ILL.

Table 1. Details of the experimental program (IN6 spectrometer)

Sample	Time	Run	Comments
ZrY4 rod	9h	227814 – 227832	180 cps/s
ZrY4 tube	10h30	227833 - 227854	40 cps/s
Vanadium	2h30	227855 - 227860	500 cps/s
Empty cell	3h30	227861 - 227866	5 cps/s
ThO2	17h00	227868 - 227901	600 cps/s

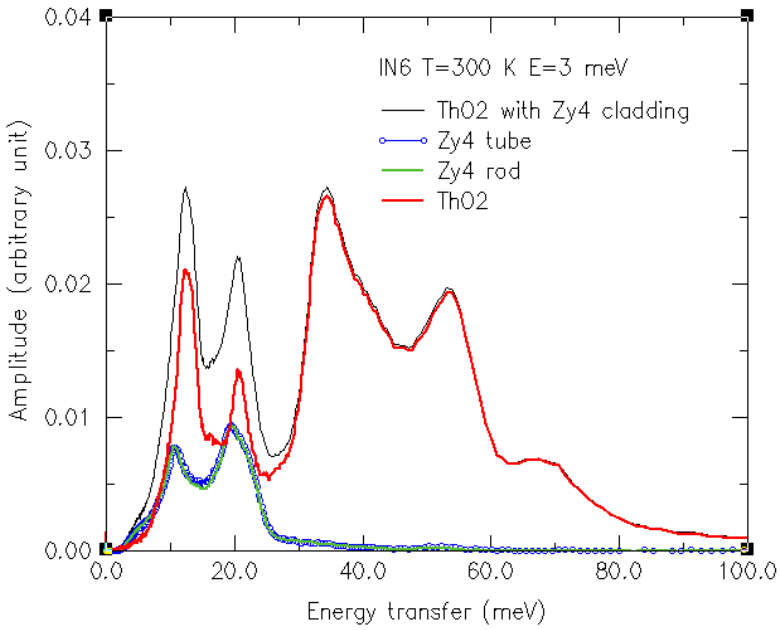

Fig. 2. Experimental PDOS for ThO2 with and without the subtraction of the ZrY4 contribution.

Preliminary results

A precise experimental validation of the Thermal Scattering Laws of ThO2 is not possible because the neutron cross sections of this material is not available in the international neutron libraries dedicated for reactor applications. The analysis and interpretation of the data measured with the IN6 spectrometer will first consist in comparing the experimental phonon density of states (PDOS) with Monte-Carlo simulations. Figure 1 shows the PDOS obtained with the IN6 data. It indicates that the ZrY4-rod and ZrY4-tube provide the same experimental PDOS. This result will allow testing the multiple neutron scattering correction with Monte-Carlo simulations. The final experimental PDOS of ThO2 (red line) will allow an accurate determination of the characteristics of the phonon modes.