# Experimental report

03/02/2020

**Proposal:** 1-04-172 **Council:** 4/2019

**Title:** Measurements of the double-differential neutron cross-section of U inUO2 up to 1600 K

**Research area:** Nuclear and Particle Physics

**This proposal is a resubmission of 1-04-155**


**Main proposer:** Gilles NOGUERE

**Experimental team:** Shuqi XU
Alain FILHOL
Gilles NOGUERE
Emmanuel FARHI

**Local contacts:** Jacques OLLIVIER


**Samples:** UO2

| Instrument | Requested days | Allocated days | From | To |
|---|---|---|---|---|
| IN5 | 5 | 0 | | |
| IN6-SHARP | 5 | 4 | 16/01/2020 | 20/01/2020 |


**Abstract:**

The present experimental work is proposed in the framework of an experimental project started mid-2014 at the Institute 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 (OECD/NEA). Our new proposition is part of a multi-year program plan on actinides. The first step of this program is devoted to UOX fuel. Experiments on a UO2 samples were already performed at the ILL facilities (IN4 and IN6 spectrometers) from room temperature up to hot power conditions. Generalized densities of states were successfully extracted at T=300, 600 and 900 K. The present proposal aims to study the acoustic and optical modes of the Uranium and Oxygen in UO2 up to 1600 K.

## Measurements of the double-differential neutron cross-section of U inUO2 up to 1600 K

The present document provides a short description of the experiments performed on a UO2 sample at the IN6 facility of ILL in January 2020. The double-differential neutron cross section was studied at T=294, 314, 350, 420, 880, 1200 K and 1675 K for an incident neutron energy of 3 meV.

### Sample characteristics

The UO2 sample used for this experiment was prepared at ILL by using four depleted UO2 pellet (0.3% U235) provided by CEA Cadarache. Characteristics of the UO2 pellets are given in Fig 1. The final UO2 sample has a cylindrical shape. It is composed of a stack of four UO2 pellets placed in a Nb sample holder ($\phi$=9 mm, e=50$\mu$m).


Fig. 1. Characteristics of the four UO2 pellets

### Experimental program

The experiment were performed on the IN6 ($\lambda$=5.12 Å, E=3 MEV) spectrometer. Various temperatures from 294 to 1675 K were investigated. A description of the experimental program is listed in Tables 1. It consisted in measuring sequentially UO2, vanadium and dummy samples. Two different neutron beam positions were used during the experiments. Data were collected during the cooling period from 1675 K to room temperature in order to verify the consistency of the results and the possible effect of the heating on the UO2 sample (oxidation …). Preliminary results indicate that time-of-flight data measured before and after heating at the same incident neutron energy are consistent. 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 | Temp. | Time | Run | Comments |
|---|---|---|---|---|
| **UO2** | 294 K | 15h | 220304 - 220333 | 1st beam position |
| | 314 K | 5h | 220469 - 220499 | 2nd beam positionCooling from 1675 to 300 K |
| | 350 K | 5h | 220442 - 220469 | 2nd beam position<br>Cooling from 1675 to 300 K |
| | 420 K | 2h | 220431 - 220442 | 2nd beam position<br>Cooling from 1675 to 300 K |
| | 600 K | 1h30 | 220417 - 220425 | 2nd beam position<br>Cooling from 1675 to 300 K |
| | 900 K | 30min | 220411 - 220414 | 2nd beam position<br>Cooling from 1675 to 300 K |
| | 1200 K | 11h | 220336 - 220358 | 1st beam position |
| | 1200 K | 11h | 220362 - 220383 | 2nd beam position |
| | 1675 K | 12h | 220385 - 220408 | 2nd beam position |
| **Vanadium** | 300 K | - | 219868 - 219875 | From previous exp. |
| **Dummy** | 300 K | 5h | 220294 - 220303 | 1st beam position |
| | 1675 K | 10h | 220256 - 220275 | 1st beam position |

**Preliminary results**

A precise experimental validation of the Thermal Scattering Laws of UO2, available in the international neutron libraries dedicated for reactor applications, was never reported in the literature. Therefore, the analysis and interpretation of the data measured with the IN6 spectrometer will first consist in comparing the experimental results with Monte-Carlo simulations. Fig. 2 compares the generalized density of states obtained with the IN6 data and with the Monte-Carlo code TRIPOLI-4. The simulation was performed by using prior densities of states of U in UO2 and O in UO2 calculated with the VASP code at the North Caroline State University (see the US library ENDF/B-VIII). Posterior densities of states were optimized to get a nearly good agreement with the IN6 data. Improved results will be presented at the next JEFF meeting (OECD/NEA).

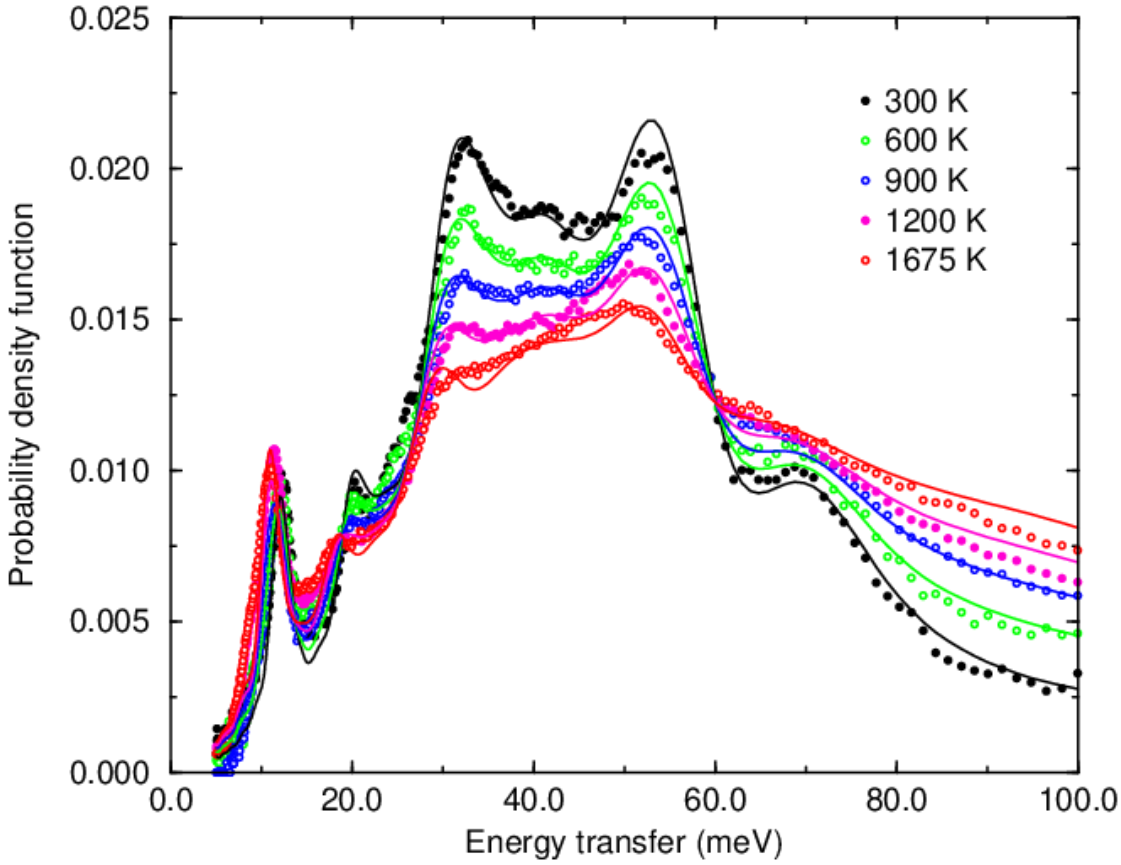


Fig. 2. Comparison of the experimental density of states of UO2 measured at 300, 600, 900, 1200 and 1675 K. The solid lines represent the Monte-Carlo simulations performed with the TRIPOLI4 code after optimization of ab initio U(UO2) and O(UO2) density of states.