Experimental report

15/09/2023

Proposal:	**1-04-241**	**Council:**	10/2022
Title:	Measurements of the double-differential neutron scattering yields ofUMo, U3Si2 and UAl as a function of the temperature		
Research area:	Nuclear and Particle Physics		

This proposal is a new proposal

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Samples: UAl
U3Si2
UMo

Instrument	Requested days	Allocated days	From	To
IN5	3	1	03/07/2023	05/07/2023

Abstract:

The present work is proposed in the framework of the NAUSICAA collaboration (ILL) which aims to measure double differential cross sections and to produce dynamic structure factor for the Joint Evaluated Fission and Fusion nuclear data library. Double differential cross section measurements on various materials (H2O, D2O, UO2, ThO2, Zry4) were already performed at the ILL facility in the framework of this project. Our new proposition aims to take advantage of the high-precision time-of-flight spectrometer IN5 to measure the fine structures of the phonon density of states (PDOS) of materials of interest for nuclear applications. The proposed materials (UMo, U3Si2 and UAl) have been selected to cover the needs related to research reactor (uranium alloy fuel). We wish to focus our investigations on UMo, U3Si2 and a UAl reference in support to studies devoted to the high-enriched to low-enriched uranium driver fuel conversion for the FRM-II (Munich), ILL (Grenoble) and JHR (Cadarache) research reactors.

Measurements of the double-differential neutron scattering yields of U_3Si_2 and UAl at room temperature

The present document provides a short description of the experiment performed on UAl and U_3Si_2 samples at the IN5 facility of ILL in July 2023. The double-differential neutron cross section was studied at T=296 K for an incident neutron energy of 3.55 meV. No measurements as a function of temperature were performed because of the lack of time (two days have been allocated).

Sample characteristics

Fig. 1. UAl sample with its Al sample holder wrapped in a Cd foil.

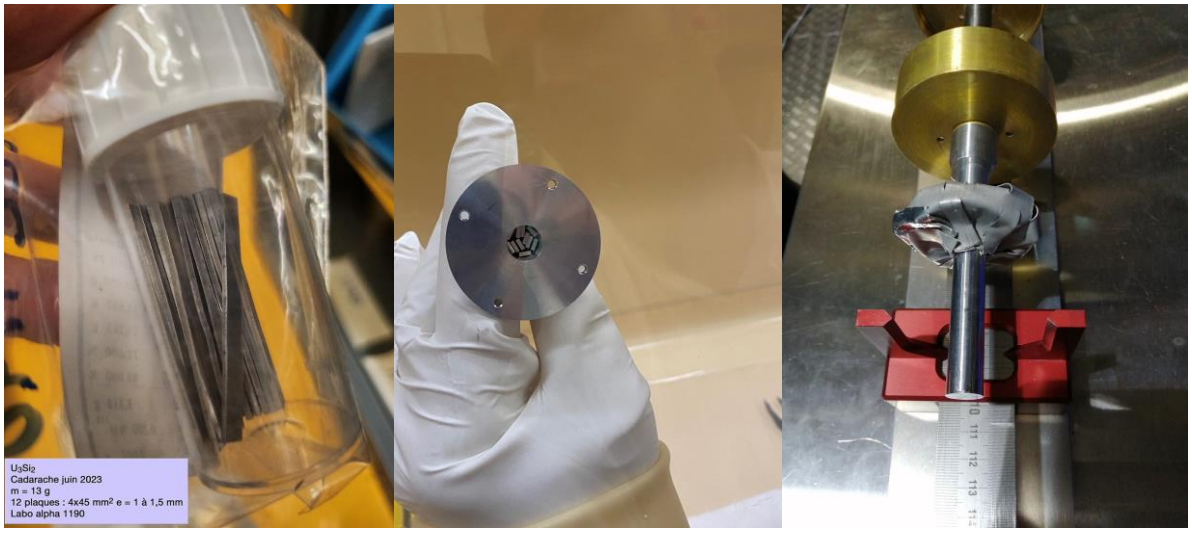

Fig. 2. U_3Si_2 sample with its Al sample holder wrapped in a Cd foil.

The UAl sample used for this experiment was composed of a stack of 20 UAl pellets in a double sealed Zry4 container (Fig. 1). The mass of the UAl sample was 19.36 g with a height and diameter equal to 94.98 mm and 8.05 mm, respectively. The thicknesses of the inner and outer ZrY4 containers were equal to 1.21 mm and 0.15 mm, respectively. A Zry4 rod (Diameter of 1 cm) was used for the container subtraction.

Table 1. Details of the experimental program (IN5 spectrometer)

Sample	Time	Run	Comments
Vanadium	1h30	239998 - 240001	ϕ=12 mm
Empty cell AU4G	4h00	240003 – 240011	941 cps/s
U3Si2	16h00	240012 - 240044	3150 cps/s
Zry4 rod	3h00	240353 - 240359	10000 cps/s
MV-100 AG3	2h30	240360 - 240365	
UAl	16h00	240366 - 240398	

The U_3Si_2 sample used for this experiment was composed of 11 U_3Si_2 rectangular samples (1.31 mm x 4.05 mm x 44.85 mm) place in an Al container AU4G (Fig. 2). For each sample, the tickness of U_3Si_2+Al is 0.610 mm and the thickness of the AlFeNi clading is 0.350 mm. Two Al tubes (AU4G and AG3) were used for the container substraction.

Experimental program

The experiments were performed on the IN5 (λ=4.8 Å, E=3.55 meV) spectrometer at room temperature (296 K) with a rectangular neutron beam (15 x 30 mm). A description of the experimental program is given in Table 1. It consisted in measuring sequentially Vandium, empty cell (AU4G), U_3Si_2, ZrY4-rod, MV-100 (AG3) and UAl samples. Raw data provided by the acquisition system were treated with the LAMP package developed at ILL.

Preliminary results

A precise experimental validation of the dynamic structure factors of UAl and U3Si2 is not possible because neutron cross sections of this material are not available in the international neutron libraries dedicated for reactor applications. The analysis and the interpretation of the data measured with the IN5 spectrometer will first consist in comparing the experimental phonon density of states (PDOS) with Monte-Carlo simulations. Figure 3 shows the PDOS obtained with the IN5 data. These results confirm that the PDOS are dominated by Aluminium. The extraction of the partial PDOS for U, Al and Si will be a challenging task.

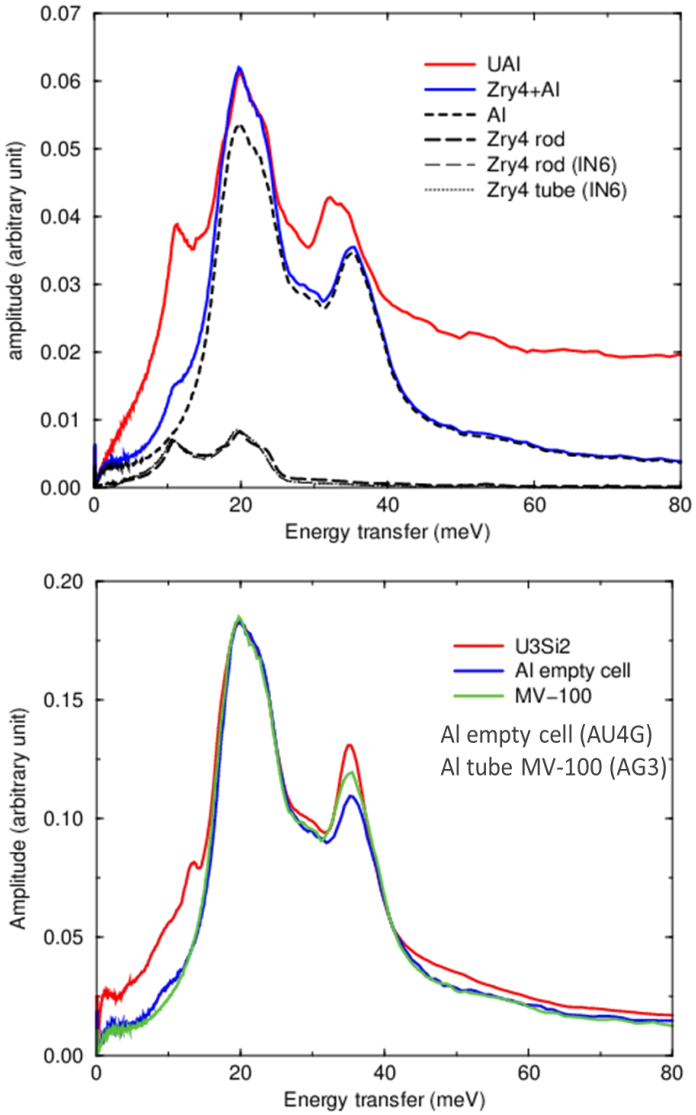

Fig. 3 : Experimental neutron-weighted multi-phonon spectra for UAl and U_3Si_2 measured with the IN5 spectrometer