30th Meeting of the
NEA Working Party on International Nuclear Data Evaluation Co-operation
May 17 – 18, 2018 • Paris, France

Meeting Summary

SG42

Thermal Scattering Kernel S(α,β): Measurement, Evaluation and Application

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SG42 Final Report

Thermal Scattering Kernel S(α,β)

Measurement, Evaluation and Application

1) Context

2) Theory: evaluation methods and tools

- **2.1) Thermal Scattering Law definition**
- **2.2) Main physics approximations used in LEAPR**
- **2.3) Improved TSL libraries using atomistic simulations**
- **2.4) A step forward for future TSL evaluations**

3) Experimental validation

- **3.1)Material properties**
- **3.2)Microscopic data**
- **3.3)Semi-integral data**
- **3.4)Integral data**
- **3.5)Facilities for TSL experiments**
- **3.6)Capability gaps**

4) Evaluation: progress on various materials and recent contributions to databases

- Reactor applications
- Criticality applications
- Neutron beam applications
- Cold neutron sources

5) Data format issues

- **5.1) TSL library format**
- **5.2) TSL uncertainties**

6) Summary and recommendations

APPENDIX if needed, such as LEAPR inputs and MCNP inputs of interest for this work

Development of evaluation methods and tools

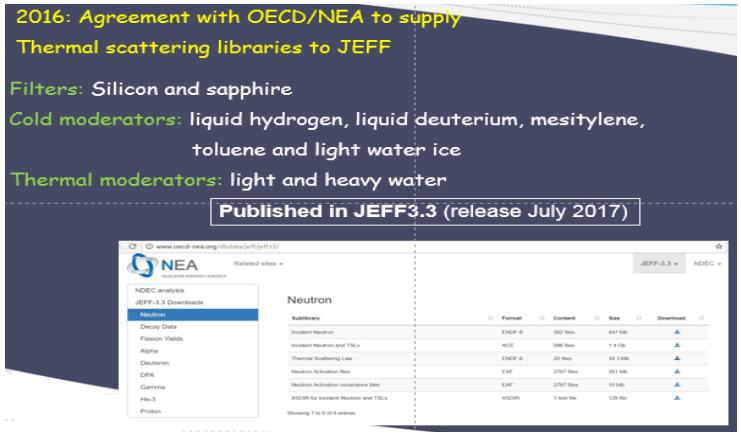
⇒ **The major development over the past 20 years is the implementation of atomistic simulation methods to support TSL evaluation**

TABLE XLVII: Summary of the origins of and recent changes to the thermal neutron scattering (`thermal_scatt`) sublibrary. Evaluations modified for ENDF/B-VIII.0 are given in bold. Note all files were modified to correct the MAT numbering of the sublibrary.

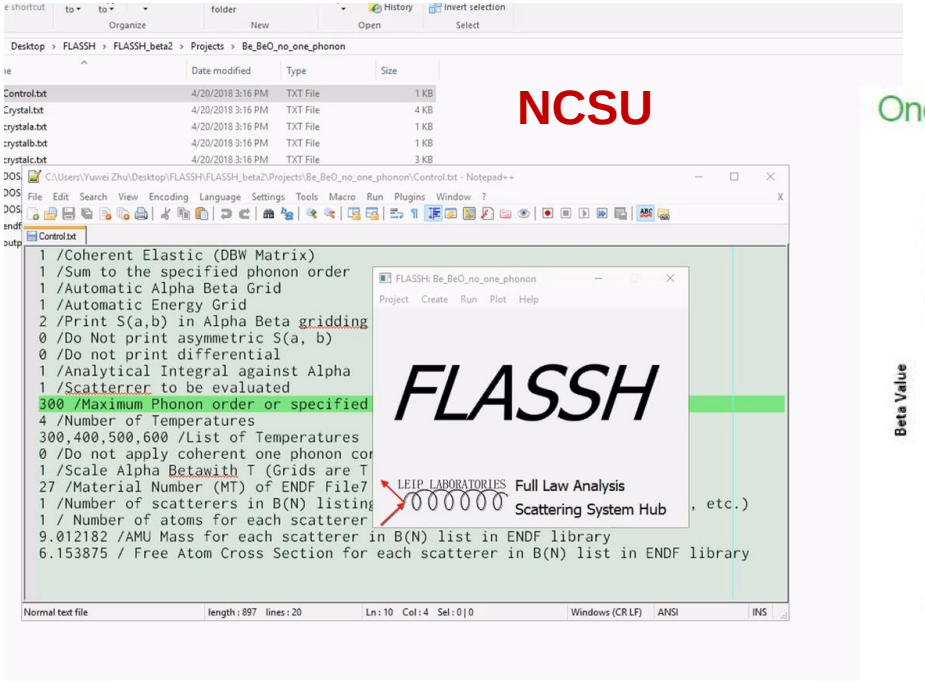
File name	Main source	Last mod.	Lab.	Year	Note
tsl-ortho-D.endf	ENDF/B-VII.0	2016	LANL	1993	
tsl-para-D.endf	ENDF/B-VII.0	2016	LANL	1993	
tsl-ortho-H.endf	ENDF/B-VII.0	2016	LANL	1993	
tsl-para-H.endf	ENDF/B-VII.0	2016	LANL	1993	
tsl-013_Al_027.endf	ENDF/B-VII.0	2016	LANL	2005	
tsl-026_Fe_056.endf	ENDF/B-VII.0	2016	LANL	2005	
tsl-Be-metal.endf	**ENDF/B-VIII.0**	**2016**	**NCSU**	**2016**	DFT/AILD
tsl-BeinBeO.endf	**ENDF/B-VIII.0**	**2016**	**NCSU**	**2016**	DFT/AILD
tsl-OinBeO.endf	**ENDF/B-VIII.0**	**2016**	**NCSU**	**2016**	
tsl-HinH2O.endf	**ENDF/B-VIII.0**	**2016**	**CAB (Argentina)**	**2016**	MD
tsl-HinIceIh.endf	**ENDF/B-VIII.0**	**2016**	**BAPL**	**2016**	DFT/AILD
tsl-OinIceIh.endf	**ENDF/B-VIII.0**	**2016**	**BAPL**	**2016**	
tsl-DinD2O.endf	**ENDF/B-VIII.0**	**2016**	**CAB (Argentina)**	**2016**	MD
tsl-OinD2O.endf	**ENDF/B-VIII.0**	**2016**	**CAB (Argentina)**	**2016**	
tsl-benzene.endf	**ENDF-269**	**2017**	**GA**	**1969**	Corrected spelling; No LEAPR inputs available
tsl-HinC5O2H8.endf	**ENDF/B-VIII.0**	**2016**	**NCSU**	**2015**	MD
tsl-HinCH2.endf	**ENDF/B-VIII.0**	**2016**	**NCSU**	**2015**	MD
tsl-l-CH4.endf	ENDF/B-VII.0	2016	LANL	1993	
tsl-s-CH4.endf	ENDF/B-VII.0	2016	LANL	1993	
tsl-graphite.endf	**ENDF/B-VIII.0**	**2016**	**NCSU**	**2016**	DFT/AILD
tsl-reactor-graphite.endf	**ENDF/B-VIII.0**	**2016**	**NCSU**	**2016**	
tsl-CinSiC.endf	**ENDF/B-VIII.0**	**2016**	**NCSU**	**2014**	DFT/AILD
tsl-SiinSiC.endf	**ENDF/B-VIII.0**	**2016**	**NCSU**	**2014**	
tsl-SiO2-alpha.endf	**ENDF/B-VIII.0**	**2016**	**NCSU**	**2011**	DFT/AILD
tsl-SiO2-beta.endf	**ENDF/B-VIII.0**	**2016**	**NCSU**	**2011**	

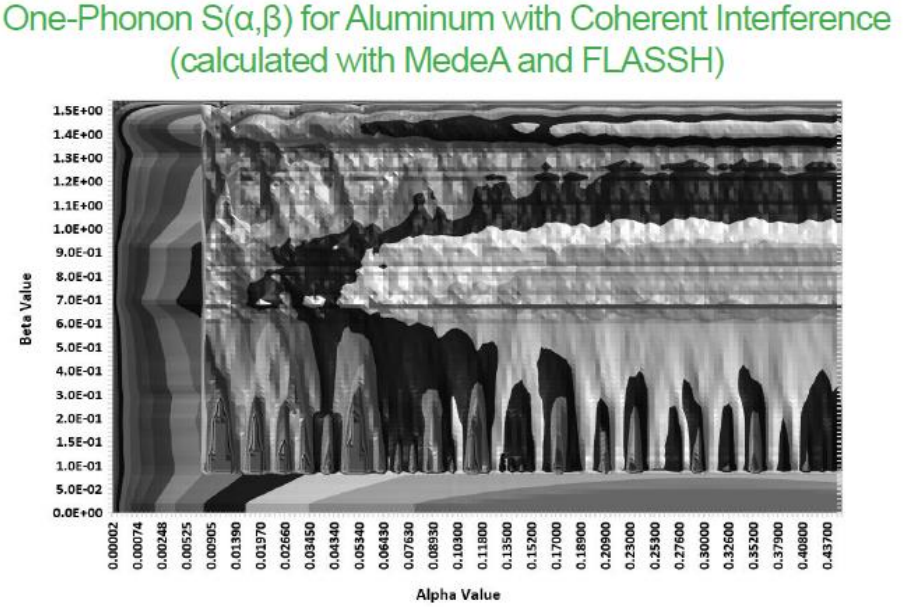
TABLE XLVII: Summary of the origins of and recent changes to the thermal neutron scattering (`thermal_scatt`) sublibrary. Evaluations modified for ENDF/B-VIII.0 are given in bold. Note all files were modified to correct the MAT numbering of the sublibrary.

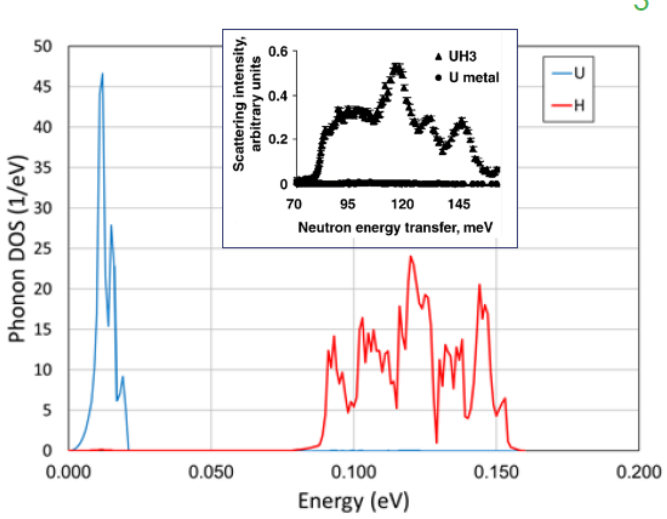
File name	Main source	Last mod.	Lab.	Year	Note
tsl-HinYH2.endf	**ENDF/B-VIII.0**	**2016**	**BAPL**	**2016**	DFT/AILD
tsl-YinYH2.endf	**ENDF/B-VIII.0**	**2016**	**BAPL**	**2016**	
tsl-HinZrH.endf	ENDF/B-VII.0	2016	LANL	1993	
tsl-ZrinZrH.endf	ENDF/B-VII.0	2016	LANL	1993	
tsl-OinUO2.endf	**ENDF/B-VIII.0**	**2016**	**NCSU**	**2016**	DFT/AILD
tsl-UinUO2.endf	**ENDF/B-VIII.0**	**2016**	**NCSU**	**2016**	
tsl-NinUN.endf	**ENDF/B-VIII.0**	**2017**	**NCSU**	**2017**	DFT/AILD
tsl-UinUN.endf	**ENDF/B-VIII.0**	**2017**	**NCSU**	**2017**	

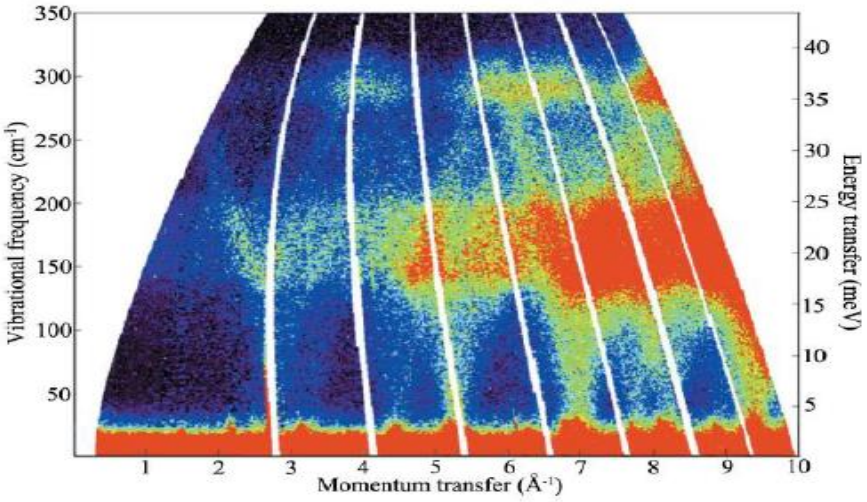


Development of evaluation methods and tools









Experimental data from: Roach et al., J. Appl. Cryst. (2003)

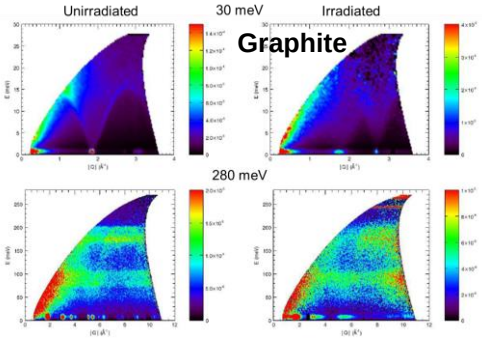
Theory-Measurements Connections

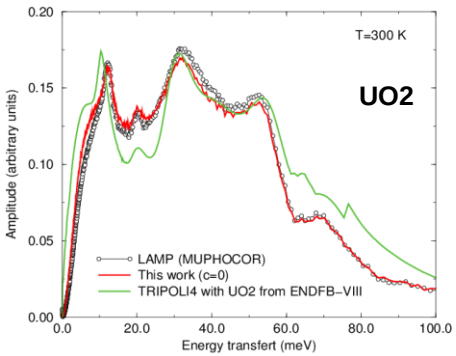
⇒ **Experimental validation of the double-differential neutron cross sections using TOF chopper spectrometers (inelastic measurements)**

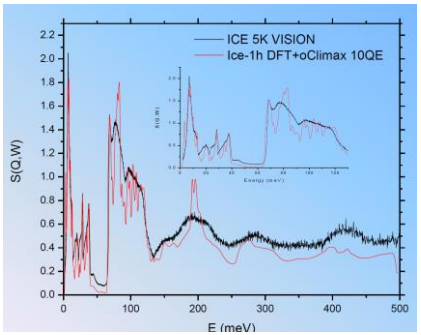
⇒ **Experimental validation of the neutron total cross section using transmission technique**

⇒ **Experimental validation using pulsed slowing down and die away experiments**

⇒ **Experimental validation using integral benchmarks**







Lawrence Livermore National Laboratory (LLNL)
Proof-of-Principle PNDA Experiment

Data covariance information and formats

Agenda

WPEC Subgroup 42

Thermal Scattering Kernel S(α,β):

Measurement, Evaluation and Application

and

WPEC Subgroup 44

Investigation of Covariance Data

in General Purpose Nuclear Data Libraries

and

WPEC Expert Group GNDS

Expert Group on the Recommended Definition of a

General Nuclear Database Structure (GNDS)

OECD Headquarters
Conference Center
2 Rue André Pascal,
Paris 75016

Room Chateau E

Starting at 2:00 pm – Ending at 18:00 pm

GNDS-1.9 & future TSL formats

Incoherent approximation of S(α,β) supported as in ENDF-6

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      <e_max value="5.000001" unit="eV"/>
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</incoherentInelastic>
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Proposal: A new subgroup on Advanced Thermal Scattering Law Analysis

- ⇒ **Continued growth in the area of thermal neutron scattering data motivates the formation of a new subgroup within the WPEC nuclear data collaboration**
  - ⇒ **The subgroup would be essential to continue international coordination on advanced TSL methods**
  - ⇒ **Act as the focal point with other WPEC subgroups (SG44, SG45, GNDS, etc.) in relation to data validation, covariance generation, and data formats, …**