Oak Ridge National Laboratory
Oak Ridge, TN

SUBJECT: Report on Foreign Travel to Vienna, Austria
DATE: November, 2019
TO: Dr. Angela Chambers, Nuclear Criticality Safety Program Manager, National Nuclear Security Administration / NA-511
FROM: Marco Pigni

MEETING TITLE: Technical Meeting of the International Nuclear Data Evaluation Network (INDEN) on Actinide Evaluations in the Resonance Region (website : https://www-nds.iaea.org/index-meeting-crp/TM-INDEN-2019/)

MEETING LOCATION: Vienna, Austria

MEETING DATES: October 21 – 24, 2019

ATTENDEES ON BEHALF OF NCSP: Marco Pigni

MEETING PURPOSE: To discuss the evaluation work for major fissile actinides with high priority for the INDEN project, form a working group of evaluators to contribute to the project and determine deliverable and timelines

MEETING BENEFITS TO THE NCSP: ORNL has been performing work in key nuclear data work areas such as improving neutron cross-section evaluation for fissile and structural materials and developing SAMMY software for neutron and charged particle cross-section evaluations. Pigni's accomplishments in each of these work areas is important for supporting ORNL M&S and R&D efforts for nuclear technology applications. As a result of Pigni's accomplishments, the IAEA has invited Pigni to participate in two IAEA Consultants' Meetings. Therefore, participation in the IAEA meetings is needed to demonstrate technical leadership in these nuclear data work areas as well as facilitate program development and collaborative work efforts that will support ORNL/RNSD program development efforts.

PURPOSE OF TRAVEL: See attached report

Persons Contacted at IAEA: Working group attendees

Presentations, Chair Responsibilities, Etc.:
See attached report

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Updates to R-matrix Evaluations for Fissile Actinides: ^{233,235}U, ^{239}Pu

Marco T. Pigni

The R-matrix evaluation of the reaction cross section for fissile actinides such as ^{233,235}U and ^{239}Pu is taken into consideration over an extended neutron energy region, for instance, up to several keVs, where the measured cross sections possess a rapidly varying resonant behavior. The resonance-like structure from the quasi-bound state of the compound nucleus can be measured and evaluated fairly easy since the experimental resolution is higher than the spacing of the level states. However, as the energy increases, the number of levels is so large that only fluctuations related to very closely spaced levels can be measured. Under the assumption measured data for all reaction channels are available, these data can be evaluated with a relatively simple method (R-matrix) although, in the keVs neutron region, the large number of resonance parameters needed to describe the cross-section fluctuations can be a limiting factor in satisfying the average statistical properties of the resonance parameters. The renewed interest in evaluating the cross section over an extended neutron region derives from the following reasons.

- Especially for fissile actinides, criticality benchmarks can be very sensitive to the cross-section fluctuations
- The current evaluated nuclear data files do not entirely describe the cross-section fluctuations available in the measured data

In the presented work, preliminary results of the R-matrix fit of ^{239}Pu cross sections in the keV neutron energy region were shown. The evaluation procedure consisted in generating fitted resonance parameters satisfying statistical properties derived from the resonance parameters below 2.5 keV (current energy limit of the ENDF/B-VIII.0). By fitting high-resolution transmission data, the ^{239}Pu cross sections were extended to about 20 keV. Cumulative plots of the number of levels as well as resonance strengths were generated. From this set of resonance parameters, the highly fluctuating behavior of the S-matrix function was shown together with S-matrix functions averaged by different size energy intervals (50, 100, 250, 500 eV).

Additional results focusing on coupling the thermal and the resolved resonance region to the newly evaluated prompt neutron fission spectra (PFNS) were presented. The recently released ENDF/B-VIII.0 was based on evaluations performed within the international collaboration CIELO aiming to improve nuclei of fundamental importance such as ^{235}U and ^{239}Pu. The ^{235}U R-matrix evaluation (ORNL) was updated with the latest thermal constants and PFNS improving the benchmark performance of the thermal solutions. However, for ^{239}Pu evaluation the focus was in the high energy range and the prediction on the thermal solution benchmarks was underpredicted. Within IAEA coordinated research activities, newly evaluated PFNS showed a reduction of 1.8% on the average energy: PFNS($\langle$Eav$\rangle$=2.08 MeV). These changes were combined to recent

work on ^{239}Pu R-matrix evaluation (ORNL) aimed to update the thermal constants. This led to improved benchmark performance in the thermal solutions.