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INDC International Nuclear Data Committee

Summary Report of

First Research Coordination Meeting on

Minor Actinide Nuclear Reaction Data (MANREAD)

International Atomic Energy Agency (IAEA)
Vienna, Austria

19 – 23 November 2007

Prepared by

Franz Käppeler
Forschungszentrum Karlsruhe, Karlsruhe, Germany

and

Alberto Mengoni
IAEA Nuclear Data Section, Vienna, Austria

September 2008

IAEA Nuclear Data Section, Wagramer Strasse 5, A-1400 Vienna, Austria

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Abstract

The first Research Co-ordination Meeting of the MANREAD (Minor Actinides Neutron Reaction Data) was held at the IAEA Headquarters in Vienna from 19 to 23 November 2007. A summary of the discussion which took place at the meeting is reported here. In addition, a task assignment list of the experimental data assessment activities was agreed, and is provided together with the plan for future CRP activities.

September 2008

TABLE OF CONTENTS

1. INTRODUCTION

Participants at the First Research Coordination Meeting (RCM) on Minor Actinide Nuclear Reaction Data (MANREAD) were welcomed to the IAEA by N. Ramamoorthy (Director-NAPC, IAEA). He recalled the interests of the Agency that include strategies foreseen for future development and employment of nuclear power generation, underlining the use of nuclear energy systems where the consistent amounts of minor actinides (MA) are contained in nuclear fuel.

Mengoni introduced the Coordinated Research Project (CRP) on MANREAD. The recommendations from the International Nuclear Data Committee (INDC) were reported: "The emphasis of the Coordinated Research Project should be on the encouragement, facilitation and co-ordination of ongoing and planned measurement activities, emphasizing international co-operation."

The conclusions of a Consultants' Meeting held on 23 and 24 November 2006 were also noted: "The general aim of the MANREAD CRP is to deliver a well-documented set of experimental data that forms a reference database for evaluators of minor actinide data."

Finally, RCM participants were provided with a summary of the CRP objectives, list of participants and other administration-related information.

2. PRESENTATIONS

T BELGYA – Institute of Isotopes, Hungarian Academy of Sciences, Hungary

Thermal neutron capture cross-section measurements using a cold neutron beam

The PGAA-NIPS experimental facilities of the Budapest Research Reactor (BRR) were presented. The neutrons produced by the 10-MW BRR are cooled by a liquid hydrogen cold source and are guided to the PGAA-NIPS facility by super mirror guides. The gammas emitted from the neutron capture activated samples are detected by a Compton-suppressed Hyperpure Germanium detector (HPGe) system. The activation by cold neutrons avoids the influence of the first resonance of most isotopes, including ^{241}Am, and thus provides independent data from the usual instrumental neutron activation for thermal cross-sections. The use of the beam chopper option improves the detection conditions.

Neutron capture cross-sections are determined by several methods based on partial gamma-ray cross-section measurements. Until now, we have measured the partial gamma-ray and derived the thermal cross-sections of most stable elements and a few radioactive targets, such as ^{99}Tc and ^{129}I.

New intensities were calculated for the primary calibration reaction of $^{14}N(n,\gamma)^{15}N$ based only on basic principles, which may have influenced the high-energy detector efficiencies. The ground-state capture cross-section of ^{241}Am using in-beam and activation experiments with different conditions and targets will be measured in collaboration with the Institute for Reference Materials and Measurements (IRMM) and Commissariat à l'Énergie Atomique (CEA). Further experiments have been suggested to clarify the contradictions of existing capture cross-sections for ^{237}Np. We need to obtain about 10 mg of ^{237}Np from IRMM in order to proceed with this experiment.

L SZENTMIKLOSI – Institute of Isotopes, Hungarian Academy of Sciences, Hungary

Chopped-beam PGAA facility at Budapest

The use of the chopped-beam technique is an option for in-beam cross-section measurements at the Budapest PGAA-NIPS facility. If the half-life of the interesting decay is between seconds and days, the time evolution of the activation can be followed on-line and the gamma decay peaks can be separated from the prompt neutron capture peaks by means of the beam chopper. The background conditions and the selectivity of the gamma ray spectrometry have also been substantially improved recently. For short half-lives, the on-line detection is advantageous over the conventional decay measurement; hence the longer acquisition time improves the statistical precision. The technique has an important advantage over activation in a reactor core: as the beam is free of epithermal neutrons, the effect of low-energy resonances can be completely avoided.

Successful standardization measurements are reported on many stable targets, as well as on ^{99}Tc, ^{129}I and natural uranium. The latter have been used as input data to level scheme and cross-section studies for transmutation. The selection criteria for the ideal targets were discussed. The cross-section measurements at thermal and sub-thermal energies are feasible on a couple of actinide isotopes of Am, Pu, Np, provided that sufficient target is available.

We are also investigating the possibility of measuring the cross-section deviation from the 1/v-law in the region of 10-25 meV, by using a time-of-flight setup with a small duty cycle chopper disk and a comparator nuclide with proven 1/v-behaviour.

R. VLASTOU – National Technical University of Athens (NTUA), Greece

Proposed ^{237}Np(n,2n) cross-section measurements at the Athens Tandem Accelerator NCSR "Demokritos"

The Nuclear Physics group at NTUA is involved in neutron-induced reaction cross-section measurements at the n_TOF facility at CERN, as well as at the 5 MV tandem accelerator laboratory at NCSR "Demokritos" in Athens. The neutron beam at "Demokritos" is produced by the ^{2}H(d,n)^{3}He reaction from 4 to 11.5 MeV, with a 4x10^{6}n/cm^{2} s fluence. Recent experimental activities were reported concerning cross-section measurements of ^{232}Th(n,2n), ^{241}Am(n,2n), ^{191}Ir(n,2n),^{174}Hf(n,2n) and ^{72,73}Ge(n,p) reactions, performed from the threshold of each reaction to ~11.4 MeV. For all these measurements the activation method has been applied using the ^{27}Al(n, α), ^{197}Au(n,2n) and ^{93}Nb(n,2n) as reference reactions and two HPGe detectors of 55% and 80% efficiency for the measurement of the induced activity after neutron irradiation. The flux variation of the neutron beam is monitored by using a BF_3 detector with paraffin moderator, whose spectra are stored at regular time intervals during the irradiation. In all these measurements computer codes (MCNP, GEANT) were used to correct self absorption and coincidence summing effects of cascading gamma rays and counting geometry.

The main features of the cross-section measurements of the ^{237}Np(n,2n) reaction of interest to MANREAD were also presented. These measurements are to be carried out from 8 to 11.4 MeV in the next two years, provided that a massive and pure ^{237}Np sample is available.

N. COLONNA – Istituto Nazionale Fisica Nucleare, Sezione di Bari, Italy

Fission cross-section measurements on ^{241}Am, ^{243}Am, ^{245}Cm: Report on n_TOF results and discussions of experimental apparatus, technique and analysis of related uncertainties

The current status of the fission cross-sections of ^{241}Am, ^{243}Am and ^{245}Cm was presented. Several measurements for ^{241}Am at low energy (from thermal to fission threshold) and important discrepancies up to 15% were observed between different data sets. At higher energies differences still remain between different data sets and evaluated cross-sections. A similar situation exists for ^{243}Am: while at high energy, data and evaluated cross-sections show reasonable accuracy, at low energy and around threshold there are very few data sets covering only the low energy range and with poor energy resolution. For ^{245}Cm, few measurements have also been reported, covering different energy regions and with some discrepancies between the different data sets, experimental data and evaluated cross-sections at all energies.

At present, fission cross-section data of the three isotopes (^{241}Am, ^{243}Am and ^{245}Cm) indicate the importance of accurate new data. This was also confirmed in a recent sensitivity analysis made for accelerator-driven systems and new generation reactors, as contained in the WPEC-SG26 report. In most cases, it is necessary to improve the current accuracy between 20 and 40% down to only a few percent, both below and around threshold.

The n_TOF Collaboration has recently performed measurements on a series of isotopes, among which are ^{241}Am, ^{243}Am and ^{245}Cm with the aim of improving the current situation of the fission cross-section data on minor actinides for transmutation and new generation reactors. The measurements have benefited from the innovative features of the n_TOF neutron beam, in particular the high instantaneous neutron flux, which has allowed minimization of the background related to the natural radioactivity of the sample, the wide energy range which helps minimize the systematic uncertainty of the cross-section normalization, and the high resolution which permits the extraction of more accurate resonance parameters.

The fission measurements at n_TOF have been performed with two detection systems: Fast Induction Chamber (FIC) and Parallel Plate Avalanche Counters (PPAC). The high performance of the detectors was complemented by the innovative Data Acquisition Systems, based entirely on Fast Flash ADC. The analysis of the fission cross-sections measured at n_TOF is in progress and in some cases close to completion. Preliminary results were shown for the Am and Cm isotopes, as well as for other reactions measured at n_TOF. The data exhibit the expected features of high resolution - low background and wide energy range, which should lead to an improvement of the accuracy for the fission cross-sections of minor actinides. Final results are expected to be available in a few months.

J. ULLMANN – Los Alamos National Laboratory, NM, USA

Research on minor actinides at the Los Alamos National Laboratory

Presented by Rene Reifarth (GSI, Darmstadt)

An experimental programme to perform precise fission cross-section measurements has been developed at Los Alamos Neutron Science Center (LANSCE), aimed at providing fission cross-sections required for next generation nuclear energy technology. Two different experimental stations with a common data acquisition are used to span 10 decades in neutron energy. One station in the Lujan Center views a water-moderated spallation neutron spectrum and the other in the Weapons Neutron Research (WNR) facility views an unmoderated spallation neutron spectrum. The time-of-flight method is used to determine the incident neutron energy, and the usable part of the two neutron spectra overlap in the 100 - 200 keV range. The measurements are performed with ionization chambers relative to ^{235}U(n,f). The first minor actinide under investigation was ^{237}Np, and these data were published this year. Data have also been obtained for ^{238,240,241,242}Pu and the analysis is in progress. Plans exist for ^{233}U and other Pu isotopes.

The experimental possibilities provided by the Lujan Center are also used to measure neutron capture cross-section and capture to fission ratios. A 4π BaF_2 detector (DANCE) is used to detect the γ -rays following the capture and a PPAC is used inside the beam pipe to detect fission events.

Successful measurements have been performed on $^{234,236}U$, ^{237}Np, $^{240,242}Pu$, $^{241,243}Am$ and measurements are planned or currently ongoing for ^{238}Pu, ^{242m}Am.

The prompt fission neutron spectrum as well as the prompt fission neutron multiplicity of ^{237}Np have been measured with the FIGARO setup in the WNR facility in the MeV range.

Activation measurements of $^{241}Am(n,2n)$ have been performed at the Triangle Universities Nuclear Lab (TUNL) between 7 and 15 MeV incident neutron energy.

The Lead Slowing Down Spectrometer located in the Blue Room at LANSCE allows measurements of differential fission cross-sections on extremely small samples in the keV regime. Successful proof-principle-experiments have been performed with only 10 ng of ^{239}Pu. Plans exist to measure $^{235m}U(n,f)$ and $^{240}Am(n,f)$.

V. MASLOV – National Academy of Sciences, Minsk, Belarus

Minor vs Major actinides

Improvements in nuclear reaction modelling and nuclear parameter systematics, and developments in neutron data descriptions of major actinides ^{232}Th, ^{233}U, ^{235}U, ^{238}U and ^{239}Pu, were shown to provide a sound basis for the critical assessment of the fission, capture, inelastic scattering and (n,xn) reaction cross-sections of minor actinides. The main reasons for improvements were justified by:

(a) refined treatment of collective states spectra at equilibrium and saddle deformations;
(b) consistent description of (n,F) as a superposition of (n,f) and (n,xnf) reactions, (n,xn) reaction cross-sections and prompt fission neutron spectra of ^{235}U, ^{238}U and ^{232}Th;
(c) refined treatment of the collective and intrinsic excitations influence on the level densities at equilibrium and saddle deformations;
(d) calculation of the exclusive neutron spectra of (n,xn) and (n,xnf) reactions.

Conclusive evidence of the reliability of the approach employed comes from the confirmation of the predicted $^{237}U(n,F)$ reaction cross-section (Maslov, 2005) by the surrogate measurements of the ratio of $^{238}U/^{236}U$ fission probabilities (Burke *et al.*, 2006).

The methods proven in case of $^{232}Th(n,\gamma)$ and $^{238}U(n, \gamma)$ data analysis were used for neutron capture reactions on even-even U, Pu and Cm nuclei in unresolved resonance and fast neutron energy ranges. Calculated $^{240}Pu(n,\gamma)$ reaction cross-section shape is quite similar to those observed for the $^{238}U(n,\gamma)$ and $^{232}Th(n,\gamma)$ reaction cross-sections. Differences are due to fission and neutron emission.

Competition depends on the (Z,N)-composition of the compound nucleus. The first Wigner cusp was observed around the first rotation level excitation threshold; another two cusps are due to further increases in neutron and fission competition. Decreasing trends in Weston and Todd (1977) data need to be further checked experimentally. Similar cross-section shape is reproduced in JENDL-3.3 evaluations where absolute differences are due to inherent approximations of evaluation procedures of JENDL-3.3.

^{239}Pu, ^{233}U and ^{235}U capture cross-sections demonstrate most vividly the influence of target spin differences, fission transition states spectroscopy and fission/gamma-emission competition on capture cross-section shape and absolute values. Capture cross-sections were obtained via consistent description of fission and elastic/inelastic scattering, with the $(n,\gamma f)$ reaction also being included. In the case of $^{239}Pu(n,\gamma)$, the structure at E_n below 5 keV is defined by fission via 1^+ sub-threshold transition states. At E_n around 100 keV, there are systematic differences in measured

$^{239}Pu(n,\gamma)$ data trends. For $^{235}U(n,\gamma)$ reasonable values of average resonance parameters support the high values of capture cross-section around 10 keV, and the measured data inconsistencies need to be addressed. In the case of $^{233}U(n,\gamma)$, reasonable values of average resonance parameters provide a consistent description of capture data in keV- and MeV-energy ranges. Evaluations of ENDF/B-VII.0 for $^{233}U(n, \gamma)$ and $^{235}U(n, \gamma)$ relative to measured data by Weston *et al*. (1970) and Muradyan *et al*. (1977), respectively, need to be undertaken to explain the data biases.

The predicition of the fission cross-section of $^{242}Cm(n,F)$ is based on the sub-threshold neutron and surrogate data at higher excitation energies. Fission cross-section of $^{238}Pu(n,F)$ was based on the neutron data in the non-emissive fission domain and surrogate data for $^{237}Pu(n,f)$ at excitation energies higher than emissive fission threshold. The latest $^{238}Pu(n,F)$ data by Fursov *et al*. (1997) discards the previous extremely high fission cross-section estimates at E_n = 6-20 MeV range. The same problem of inconsistency appeared for Cm targets, where the (n,F) reaction data are higher than the modern estimates of the neutron absorption cross-section.

Fission cross-section fits serve as a constraint for the (n,xn) reaction prediction. $^{241}Am(n,2n)$ measurement reported at ND2007 by Vieira *et al*. nicely confirmed the older evaluation of Maslov *et al*. (1997), and the evaluated data file was accepted afterwards for JENDL-3.3. Regarding $^{243}Am(n,2n)$ reaction feeding $^{242m}Am(J = 5)$ (141 y) and $^{242g}Am(J = 1)$ (16 h), there is a measurement by Gangarz referred by Chadwick *et al*. (2007). The quoted Gancarz data point gives the yield of $^{242g}Am(J = 1)$ (16 h) at 15 MeV as 0.2 barn – this value is compatible with an estimate of $^{243}Am(n,2n)^{242(m+g)}Am$ of 0.3 barn, granted that branching ratio of m/g or (long-lived-to-short/lived) is similar to that in $^{237}Np(n,2n)$ reaction. The uncertainty of the $^{243}Am(n,2n)$ cross-section could be claimed to be 30% or equal to that of $^{241}Am(n,2n)$, otherwise this parameter should be increased to 100%.

F. KÄPPELER – Forschungszentrum Karlsruhe, Karlsruhe, Germany

Neutron capture on ^{241}Am: Status of branching ratio, and future plans

The branching ratio (BR) of ^{241}Am, defined by the ratio of the partial neutron capture cross-section to the ground state divided by the total (n,γ) cross-section, determines the production of the Cm isotopes. Experimental data for BR are scarce and have been derived mostly via integral experiments. The only exception was an activation measurement using the detection of the electrons from the decay of the short-lived ground state of ^{242}Am. While the BR values obtained with the two methods agree well at thermal neutron energies, the direct method produced a more accurate, but significantly lower value at 30 keV than the integral experiments. The experimental technique of the direct measurement excludes the possibility to explain this discrepancy by systematic effects. On the other hand, the low 30 keV value is very difficult to reproduce by standard Hauser-Feshbach calculations.

In view of this situation, new attempts were made in the EFNUDAT project as well as at LANL to test the BR value at 30 keV. The dim was to irradiate an ^{241}Am sample in the high neutron flux at the Van de Graaff accelerator of Forschungszentrum Karlsruhe (FZK) and to identify the induced activity by chemical separation of the ^{242}Cm decay product. The separation should be undertaken in two steps: soon after the irradiation, the ^{242}Cm represents the branch to the short-lived ground state and after a waiting time of about 100 days a second separation yields the ^{242}Cm produced via the isomer.

While the EFNUDAT measurement had been suspended because of unforeseen difficulties with the radiochemistry, the group at LANL expects a separation factor of 109, sufficient for identifying the ^{242}Cm produced in the remaining ^{241}Am background. Further improvements may be achieved at the Frankfurt neutron source FRANZ, which will provide 500 times higher neutron flux than is presently available from the Van de Graaff accelerator in Karlsruhe. This facility is presently under development and is expected to start full operation in 2010.

Y. NAGAI – JAEA, Tokai, Japan

Experiments and data evaluations on MA in Japan

Current experimental activities on the cross-section measurements of the (n,γ) reaction on minor actinide are carried out by JAEA, TIT, KURRI and Nagoya groups (using neutrons from reactors at JRR3 and JRR4 and pulsed neutrons from the 30 MV Linac at KURRI, as well as the Pelletron at TIT). New data of the (n,γ) reaction cross-sections on ^{237}Np, ^{241}Am and ^{243}Am have been obtained at $1 < E_n < 100$ eV with a 4π Ge spectrometer. The data were analyzed and a new result for the cross-section of ^{241}Am$(n,\gamma)^{242g}$Am at thermal energy (activation method) is in press –a Gd filter with a cut-off energy of 0.1 eV had been used to correct for a resonance at E_n = 0.3 eV. Progress with the new beam line at the J-PARC 3 GeV spallation neutron source and the installation of new measurement system for the (n,γ) reaction cross-section at the 4 MV Pelletron at JAEA were described. Beam commissioning at the J-PARC beam line will start in 2008, and the performance of the measurement system at the Pelletron was fully assessed. Work on the JENDL Actinide file (JENDL/AC) was outlined, and the file will be released in 2008. All data in JENDL-3.3 from Ac to Fm over a neutron energy from 10^{-5} eV to 20 MeV have been reviewed by means of a new nuclear reaction model code (CCONE). Consequently, almost all of the data in JENDL-3.3 were revised, based on available experimental data, new theoretical calculations, resonance parameters and cross-sections. Secondary spectra for all nuclides were calculated with the CCONE code, and the least-squares method (GMA code) was used for the evaluation of fission cross-sections.

A. PLOMPEN - EC-JRC Institute for Reference Materials and Measurements, Geel, Belgium

Minor actinide activities at JRC Geel

Geel interest in minor actinide neutron data is related to studies concerning the minimization of high level nuclear waste. Historically, emphasis was placed on accelerator driven systems configured as minor actinide burners. At present, this effort has shifted to advanced nuclear energy systems, such as those considered by the Generation IV and GNEP initiatives.

Recent measurements on minor actinides concern transmission factors for total cross-sections and capture yields for the capture cross-sections of ^{237}Np, capture yields of ^{236}U, fission cross-sections of ^{234,236}U and transmission factors for ^{240,242}Pu. The data for ^{237}Np and ^{236}U(n,γ) have been delivered to CEA for analysis and interpretation. The fission data for ^{234,236}U have been analysed by C. Wagemans and collaborators at the University of Gent. By studying the n+^{234}U reaction, S. Oberstedt has discovered an unknown isomer in ^{235}U, and several discrete gammarays were found that establish a link with the ground state well of ^{235}U. The isomer is proposed to be a fission isomer, but the direct link with the fission process remains to be established.

Ongoing work concerns the total cross-section and (n,2n) cross-section of ^{241}Am. Samples were obtained from JRC-Karlsruhe, and were prepared by techniques that have been applied to the fabrication of pellets irradiated in the Phénix experimental fast reactor. Three transmission factors were determined for the total cross-section at a 50 Hz repetition rate on the 26 m flight path of GELINA – these data sets involve different background filters and are useful up to about 20 eV. Two data points for the (n,2n) reaction were taken below E_n=10 MeV and three between 18 and 21 MeV. Additional work is planned to improve our understanding of Doppler broadening with improved transmission data, to elaborate on the excitation curve for the (n,2n) reaction and to study the feasibility of capture measurements.

The transmission factors for the first few resonances of $^{240,242}Pu$ revealed serious problems as a result of sample inhomogeneities at a microscopic level. Nominally, thin samples were prepared but the data may only be understood by assuming that effectively only a single particle is in the line of sight of a neutron. Strong thickness inhomogeneity does not allow the improvements to the resonance parameters (Kopecky *et al*. ND2007, Nice). The sample prepared for ^{241}Am does not appear to have this problem, so we are investigating the possibility of improved measurements on $^{240,242}Pu$ using this sample preparation technique. Finally, plans were made to study the fission cross-section of ^{245}Cm in collaboration with University of Gent, and the capture cross-section in the keV region of ^{231}Pa in collaboration with FZK and CEA. A ^{245}Cm sample is being purchased and ^{231}Pa sample was shipped from IRMM to FZK.

A. WALLNER – Vienna Environmental Research Accelerator (VERA), University of Vienna, Vienna, Austria

Neutron-capture cross-section measurements by activation and subsequent detection using AMS

The technique of accelerator mass spectrometry (AMS) was described in detail as based on a 3 MV tandem accelerator at the Vienna Environmental Research Accelerator (VERA). AMS is used over a wide range of different applications, whereby an accelerator ois used and molecular isobaric interferences are almost completely ruled out. The potential of this technique was exemplified for measurements in the actinide mass range that are actually underway at the VERA laboratory. Measurements are available for the various Pu isotopes in environmental samples, the search for minute quantities of possible extraterrestrial Pu or Cm in terrestrial archives, and cross-section measurements in the mass range above that where one faces isobaric interferences, i.e. for masses larger than 209.

As a proof-of-principle experiment the $^{235}U(n,\gamma)^{236}U$ neutron-capture reaction is being measured on the VERA facility in cooperation with FZ Karlsruhe. Neutrons with energies around 25 keV and 500 keV are produced to activate natural U samples, and the resulting U will be measured by AMS. Limitations in AMS occur as consequence of background signals or the overall efficiency in the measurement. Isotope ratios for U are measured with expected background ratios of $^{236}U/^{238}U$ in the range of a few 10^{-12}; typical overall efficiencies are around 10^{-5} to 10^{-4} which defines the counting statistics. One of the main issues in mass spectrometric methods is the sample material consumed during the measurement. Precautions have to be taken to avoid contamination of the facility by such samples and to exclude memory effects which might influence future experiments. Therefore, elaborate and efficient sample chemistry is required prior to a potential AMS measurement. The latter can also be applied to other mass spectrometric techniques, which sputter the sample material during the measurement process. In addition, the amount of radionuclides of interest in the sample prior to irradiation has to be determined and, if possible, separated from the bulk material. Several reactions in the MA region were shown which are possibly accessible for AMS measurements.

3. DISCUSSIONS

Planning of measurements: are we covering a significant fraction of MA data of interest?

- quote final report of WPEC SG-26 as source of information
- the complete chain of Cm isotopes taken into consideration reflects the fact that we should provide reliable fundamental data.

New and advanced measurement techniques

New DAQ, simulation tools and computer power greatly enhanced the capabilities of performing precision measurements. Neutron sources with high luminosity based on spallation reactions have made previously inaccessible measurements of cross-section data available. New applications of Lead Slowing Down Spectrometers (LSDS) and other detection techniques have improved in sensitivity and efficiency. An additional example is the suppression of the alpha- and spontaneous-fission in measurements with pulsed neutron fields and very short flight-paths. As a consequence, accurate measurements of cross-sections are feasible, even on unstable and small samples. In addition, fission and capture cross-sections can now be measured simultaneously using gamma-ray calorimeters.

Concerning new methods to derive cross-section data, mention should be made of techniques such as Accelerator Mass Spectrometry (AMS), Thermal Ionization Mass Spectrometry (TIMS) and Inductively Coupled Plasmas Mass Spectroscopy (ICPMS). Finally, indirect methods using surrogate reactions have recently produced a significant amount of data. All these techniques will be reviewed and considered in assessing the capabilities of obtaining cross-section data for MA in MANREAD.

Procurement of sample material for short-lived/exotic isotopes

Sample procurement is certainly a crucial point for any type of new measurement on MA. The demand for samples has been partially reduced with the possibility of using small samples and intense neutron sources. Nevertheless, the lack of material with necessary purity often represents a major obstacle for new measurements.

This situation could be improved by establishing (or re-establishing) capabilities for the production of isotopically pure materials (radiochemistry and mass separation) and the preparation of samples. This information on and access to present inventories is considered crucial for making future measurements in the field of MA. Resources are required to obtain samples from research laboratories, and satisfying this need should be considered as a higher priority for future experiments.

Links to EC, USA, RF and Japanese initiatives on MA data

A number of related activities presently underway in Europe, the USA and Japan have been identified which could be linked to MANREAD. These are listed here for possible further reference:

- EFNUDAT (EC)
- NUDAME (EC) to continue as EUFRAT
- EUROTRANS/NUDATRA (EC)
- GNEP (International) – Check if there is any specific initiative on Nuclear Data within USA. (Action: John Ullmann/Rene Reifarth)
- WPEC (International) and subgroups
- ISTC (RF + International)

Modeling/theory: any progress?

A huge amount of work has been done to validate model parameters and their derivation from basic principles. Nuclear reaction models are able to describe cross-sections for various reaction channels to assist greatly in data evaluations. Considerable improvements can be achieved by proper application of standard reaction models with enhanced capabilities. In this respect, the RIPL initiative, coordinated by the IAEA, has contributed considerably to establish a database of relevant model parameters which can be readily used for MA cross-section calculations.

From experimental data to application libraries: can we reduce the time-lag?

New evaluations for selected isotopes based on new experimental data will be produced and released at the end of the CRP activities. Results for the full set of MA will also be promoted to ensure that they are included in evaluated nuclear applications data files.

Ongoing measurement activities (see Appendix 3)

Present experimental activities performed in various laboratories worldwide cover the full list of MA which has been considered in MANREAD. We can state that the expected accuracy of the measurements underway or just completed is substantially improved with respect to the present situation. The planned measurements cover a large fraction of all reaction channels in the energy range considered (thermal to 20 MeV). This work will allow a consistent description of the reaction processes on the basis of available models. In turn, reliable estimates of yet unmeasured quantities will be provided.

Note to the Agenda

On the last day of the meeting participants visited the Vienna Environmental Research Accelerator (VERA) facility at the University of Vienna, lead by A. Wallner.

4. TASK ASSIGNMENTS

After a detailed discussion on the main objectives of the CRP, the following tasks were assigned:

1. Available experimental data of the reaction cross-sections of MA will be assessed according to Appendix 3. General criteria on how the assessment will be performed were agreed. The principal actions required to perform the assessment are as follows:

- retrieve experimental data from the EXFOR data library and from other sources when possible (literature search through CINDA, journals, etc.)
- identify missing data, provide plots of measured data and compare with evaluated files, and following a common template
- comment on the quality, accuracy and completeness of available data

The final goal of this assessment is to provide the basic working material on which the Technical Report (final Report of the CRP) will be based.

2. An assessment of the present and reachable accuracy of reaction data for MA will be given for each isotope considered (see Appendix 3). In addition, we will identify the cases in which improvements can be achieved with existing experimental tools.

3. For selected cases for which new experimental information has been obtained, new evaluations will be provided and evaluated data files will be produced and made available by IAEA/NDS.

4. Measurements planned within the CRP will be performed, and results will be reported at the 2nd RCM.

5. CRP activities will be reported at international meetings and conferences. An active website will be maintained and will provide the community with all relevant information related to the CRP.

5. RECOMMENDATIONS

The participants of the 1st RCM have agreed that a side meeting should be arranged in conjunction with the CGS13 Conference, to be held on 25-29 August 2008 in Cologne, Germany, in order to verify the status of the activities and to prepare for the 2nd RCM.

Close contacts will be maintained with WPEC to avoid duplication of efforts on data needs for Advanced Reactor Systems.

6. ACTION LIST

- Check if there is any specific initiative on Nuclear Data within the USA. (John Ullmann/Rene Reifarth).
- Submit an abstract on MANREAD activities to the CGS13 Conference (Mengoni *et al.*)
- Produce a template for the assessment work (Mengoni, Käppeler, all)
- Review status of the assessment forms after 12 months (all)

7. CLOSE

The meeting was closed after F. Käppeler had thanked the participants for their cooperation and contributions, the IAEA for hospitality, and A. Mengoni for organization.

1st Research Co-ordination Meeting on

Minor Actinide Neutron Reaction Data (MANREAD)

IAEA Headquarters, Vienna, Austria

19-23 November 2007

Room A0478

AGENDA

Monday, 19 November

08:30 - 09:30 Registration (IAEA Registration desk, Gate 1)

09:30 - 10:30 Opening Session

- Welcoming address – N. Ramamoorthy
- Introductory remarks – A. Mengoni

10:30 – 11:30 Administrative Matters

Coffee break

11:30 – 12:15 Start presentations
1x30 + 15 min

12:15 - 14:00 Lunch break

14:00 - 17:30 Presentations (cont.)
4x30 + 15 min
(Coffee break as appropriate)

Tuesday, 20 November

9:30 - 12:30 Presentations (cont.)
4x30 + 15 min
(Coffee break as appropriate)

12:30 - 14:00 Lunch break

14:00 - 17:30 Presentations (cont.), start discussion
(Coffee break as appropriate)

19:30- Social event: dinner at Melker Stiftskeller (typical Viennese "Stadt heuriger")

Wednesday, 21 November

9:30 - 12:30 Discussions (cont.); task assignement
(Coffee break as appropriate)

12:30 - 14:00 Lunch break

14:00 - 17:30 Discussion on agreed MANREAD topics
(Coffee break as appropriate)

<u>**Thursday, 22 November**</u>

9:30 - 12.30 **Discussion on agreed MANREAD topics (cont.)**
(Coffee break as appropriate)

12:30 - 14:00 **Lunch break**

14:00 - 17:30 **Layout 1st RCM report**
(Coffee break as appropriate)

<u>**Friday, 23 November**</u>

9:30 - 12:30 **Draft 1st RCM report**
(Coffee break as appropriate)

12:30 - 14:00 **Lunch break**

14:00 - 16:00 **Finalize 1st RCM report**
Close

1st Research Co-ordination Meeting on

Minor Actinide Neutron Reaction Data (MANREAD)

IAEA Headquarters, Vienna, Austria

19-23 November 2007

Room A0478

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TASK ASSIGNMENTS

ISOTOPE	n,tot	n,γ	n,f; pfns;	n,2n	n,inel	others
U-234	Gunsing	Gunsing	Colonna Vlastou	Wallner	Plompen	Plompen
U-236	Gunsing	Gunsing	Colonna Vlastou	Wallner	Plompen	Plompen
Np-237	Reifarth Gunsing	Reifarth Gunsing	Reifarth	Vlastou	Reifarth	Reifarth
Pu-238	Gunsing	Wallner Belgya Szentmiklosi	Colonna	Wallner	Belgya Szentmiklosi	Plompen
Pu-240	Gunsing	Wallner Belgya Szentmiklosi	Colonna	Wallner	Belgya Szentmiklosi	Plompen
Pu-241	Gunsing	Wallner Belgya Szentmiklosi	Colonna	Wallner	Belgya Szentmiklosi	Plompen
Pu-242	Gunsing	Wallner Belgya Szentmiklosi	Colonna	Wallner	Belgya Szentmiklosi	Plompen
Am-241	Plompen	Käppeler Nagai Plompen	Fursov Colonna	Vlastou Plompen	Plompen	Plompen
Am-242	Plompen	Käppeler Nagai	Fursov	Vlastou	Plompen	Plompen
Am-242m	Plompen	Käppeler Nagai	Fursov	Vlastou	Plompen	Plompen
Am-243	Plompen	Käppeler Nagai Plompen	Fursov Colonna	Vlastou Plompen	Plompen	Plompen
Cm-242	Maslov	Nagai Käppeler	Fursov	Maslov	Maslov	Maslov
Cm-243	Maslov	Nagai Käppeler	Fursov	Maslov	Maslov	Maslov
Cm-244	Maslov	Nagai Käppeler	Fursov Colonna	Maslov	Maslov	Maslov
Cm-245	Maslov	Nagai Käppeler	Fursov Colonna	Maslov	Maslov	Maslov
Cm-246	Maslov	Nagai Käppeler	Fursov	Maslov	Maslov	Maslov
Cm-247	Maslov	Nagai Käppeler	Fursov	Maslov	Maslov	Maslov
Cm-248	Maslov	Nagai Käppeler	Fursov	Maslov	Maslov	Maslov

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