A brief status report on selected Indian nuclear data physics activities submitted to the NRDC Meeting-2009

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IAEA Technical Committee Meeting of International Network of Nuclear Reaction Data Centres

(NRDC, 25-26 May 2009, IAEA Headquarters, Vienna, Austria, Europe.

Director, BARC formed a committee in 2007 to find ways and means of forming a national nuclear data centre

In India, we are including all the national laboratories and university teams using the DAE-BRNS mechanisms in order to evolve a streamlined and coherent activity of nuclear data in India that will be sustainable.

NUCLEAR DATA ACTIVITIES IN INDIA

- *Basic nuclear data physics measurements.*
- *EXFOR compilations.*
- *Nuclear model based calculations.*
- *Processing of evaluated nuclear data files to produce plug-in libraries for discrete ordinates and Monte Carlo codes.*
- *Efforts to digest the status of covariance error methodology in nuclear data and its applications*
- *Preparation of integral Indian experimental criticality benchmarks for integral nuclear data validation studies.*

BARC is in the process of formally announcing the formation of a strong and sustainable Indian Nuclear Data Centre.

This announcement is expected to be made formally soon.

BARC is in the process of formally announcing the formation of a strong and sustainable Indian Nuclear

In 2008, India attended as observer the IAEA Technical Committee Meeting of International Network of Nuclear Reaction Data Centres (NRDC), 22-25 September 2008 at the Institute of Physics and Power Engineering in Obninsk, Russian Federation.

India is a member of the NRDC since September 2008

At the time of NRDC-2009 Meeting the official count for the IAEA accepted EXFOR entries are as follows:

- 10 new entries in 2006,
- 33 in 2007, 9 in 2008
- 1 in 2009.

- **India considers the activity of EXFOR compilation as an important activity of the Classical nuclear data physics in the Indian Nuclear Data Centre**

Since NRDC-2008 (September 2008), this year, 6 new Indian EXFOR entries (Reference: EXFOR entry with no: D6064, D6067, 33020, 33021, 33022 and 33023. (Paresh Prajapati (Ph. D., Student, MS University, Vadodara, Reactor Physics Design Division, Dr. H. Naik, Dr. S. Singh (Radio Chemistry Division)) collaborated in this effort.

Workshops in India on EXFOR Compilation

- **India will be hosting the 2009 EXFOR training Workshop in Mumbai during November 9-13, 2009**

The 2009 EXFOR training Workshop will be conducted under the auspices of the proposed India Nuclear Data Centre.

Previous history:

- **September 4-8, 2006, Mumbai (IAEA Faculty: Dr. Otto Schwerer)**

- **October 29-November 2, 2007, Mumbai (IAEA Faculty: Dr. Ms. Svetlana DUNAEVA)**

Experimental generation of nuclear data in India

- 14 MeV neutron generator in Pune and IPR
- BARC-TIFR Pelletron
- Photon induced reactions (Electron accelerator based bremstrahlung)

EXCITING SURROGATE TECHNIQUE

RAPID COMMUNICATIONS

PHYSICAL REVIEW C 78, 061602(R) (2008)

Determination of the ^{233}Pa(n, f) reaction cross section from 11.5 to 16.5 MeV neutron energy by the hybrid surrogate ratio approach

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(Received 5 August 2008; published 12 December 2008)

A new hybrid surrogate ratio approach has been employed to determine neutron-induced fission cross sections of ^{233}Pa in the energy range of 11.5 to 16.5 MeV for the first time. The fission probability of ^{234}Pa and ^{236}U compound nuclei produced in ^{232}Th(^{6}Li, α)^{234}Pa and ^{232}Th(^{6}Li, d)^{236}U transfer reaction channels has been measured at $E_{lab} = 38.0$ MeV in the excitation energy range of 17.0 to 22.0 MeV within the framework of the absolute surrogate method. The ^{233}Pa(n, f) cross sections are then deduced from the measured fission decay probability ratios of ^{234}Pa and ^{236}U compound nuclei using the surrogate ratio method. The ^{233}Pa(n, f) cross section data from the present experiment along with the data from the literature, covering the neutron energy range of 1.0 to 16.5 MeV have been compared with the predictions of statistical model code EMPIRE-2.19. While the present data are consistent with the model predictions, there is a discrepancy between the earlier experimental data and EMPIRE-2.19 predictions in the neutron energy range of 7.0 to 10.0 MeV.

DOI: 10.1103/PhysRevC.78.061602 PACS number(s): 24.50.+g, 24.75.+i, 25.85.Ec, 28.20.−v

Determination of the neutron-induced fission cross sections of short-lived actinide nuclei is a major challenge for nuclear physics and nuclear astrophysics. Often indirect methods

27 day half-life of the ^{233}Pa isotope. As this isotope is produced in an intermediate step during the formation of the fissile ^{233}U nucleus, reactions competing with its natural decay affect the

In Progress: BARC (B. K. Nayak et al.,) working on using Li-7+^{232}Th to measure ^{234}Pa(n,f) reaction data.

Available online at www.sciencedirect.com
ScienceDirect
Nuclear Physics A 802 (2008) 1–11
NUCLEAR PHYSICS A
ELSEVIER
www.elsevier.com/locate/nuclphysa

Cross-sections for formation of $^{89}Zr^{m}$ through $^{90}Zr(n, 2n)^{89}Zr^{m}$ reaction over neutron energy range 13.73 MeV to 14.77 MeV

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Received 5 November 2007; received in revised form 31 December 2007; accepted 4 January 2008

Available online 18 January 2008

Abstract

The cross-sections for formation of metastable state of ^{89}Zr ($^{89}Zr^{m}$, 0.588 MeV, 4.16 m) through $^{90}Zr(n, 2n)^{89}Zr^{m}$ reaction induced by 13.73 MeV to 14.77 MeV neutrons were measured for the first time and also theoretically estimated using Empire-II and Talys programs. At 13.73 MeV neutron energy, the ^{89}Zr nuclei can be excited to metastable state, $^{89}Zr^{m}$, when the first and the second emitted neutrons have energies lower than the most probable energy ~ 0.64 MeV. The probability of exciting ^{89}Zr nuclei to energy levels higher than 0.588 MeV and therefore of populating the metastable state through decay process increases with increasing neutron energy. The measured cross-sections vary from 41 ± 3 mb to 221 ± 15 mb over neutron energies 13.73 MeV to 14.77 MeV, and are in agreement with the cross-sections estimated using Empire-II code. The formation of $^{89}Zr^{m}$ is favoured when the first and the second reaction neutrons are emitted with the most probable energies rather than lower energy, except for 13.73 MeV neutrons.

ScienceDirect
ELSEVIER
Nuclear Physics A 821 (2009) 23–35
NUCLEAR PHYSICS A
www.elsevier.com/locate/nuclphysa

Double differential cross-sections of (n, α) reactions in aluminium and nickel at 14.77 MeV neutrons

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Received 14 November 2008; received in revised form 10 February 2009; accepted 10 February 2009

Available online 20 February 2009

Abstract

The double differential cross-sections (DDX) for the emission of alpha particles from ^{27}Al$(n, \alpha)^{24}$Na and Ni(n, α) reactions induced by 14.77 MeV neutrons were estimated from the alpha particle spectra recorded at 30°, 50°, 90°, 110° angles for aluminium, and at 20°, 45°, 90°, 110° for natural nickel. The results indicate that the alpha particles below and around the most probable energies (~6.3 MeV from aluminium and ~8 MeV from natural nickel) are emitted predominantly through the compound nucleus formation process, and the higher energy alpha particles are emitted through the pre-equilibrium or the direct reaction. In general, the measured double-differential cross-sections are in agreement with the theoretical cross-sections estimated using Talys-1.0 and Preco2007 computer programs. The present value of the level density parameter for ^{24}Na is close to the literature value and, therefore, these results reveal consistency in the alpha particle spectra recorded with a single silicon surface barrier detector at different scattering angles.

Measurement of ^{67}Zn(n, p)^{67}Cu, ^{92}Mo(n, p)^{92m}Nb and ^{98}Mo(n, γ)^{99}Mo reaction cross sections at incident neutron energies of E_n = 1.6 and 3.7 MeV

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Manuscript accepted (10 March 2008) for publication in Nuclear Science and Engineering. Journal of American Nuclear Society after a critical peer-review process.

- *Nuclear model based calculations. EVALUATION OF NUCLEAR DATA IS EXPECTED TO BE TAKEN UP SOON*

- *Processing of evaluated nuclear data files to produce plug-in libraries for discrete ordinates and Monte Carlo codes. Updating ORIGEN data for fast reactors, PHWRs, AHWRs and CHTRs.*

- *Efforts to digest the status of covariance error methodology in nuclear data and its applications*

An example of calculations and study of systematics by the Pune team is shown in the next slide.

NUCLEAR MODEL CODES:

EMPIRE AND TALYS ARE BECOMING MORE POPULAR

Annals of Nuclear Energy xxx (2009) xxx–xxx

Contents lists available at ScienceDirect

Annals of Nuclear Energy

journal homepage: www.elsevier.com/locate/anucene

Excitation functions and isotopic effects in (n,p) reactions for stable nickel isotopes from reaction threshold to 20 MeV

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ARTICLE INFO

Article history:
Received 27 September 2008
Received in revised form 27 November 2008
Accepted 28 November 2008
Available online xxxx

ABSTRACT

The excitation function for (n,p) reactions from reaction threshold to 20 MeV on five nickel isotopes viz: ^{58}Ni, ^{60}Ni, ^{61}Ni, ^{62}Ni and ^{64}Ni were calculated using Talys-1.0 nuclear model code involving the fixed set of global parameters. A good agreement between the calculated and measured data is obtained with minimum effort on parameter fitting and only one free parameter called 'Shell damping factor'. This is of importance to the validation of nuclear model approaches with increased predictive power. The systematic decrease in (n,p) cross-sections with increasing neutron number in reactions induced by neutrons on isotopes of nickel is explained in terms of the proton separation energy and the pre-equilibrium model. The compound nucleus and pre-equilibrium reaction mechanism as well as the isotopic effects were also studied.

CERN n_TOF international collaboration-Phase-2

- **In September 2008, a formal MOU between BARC (Director, BARC) and CERN was signed.**
- **The annual O & M fee has also been paid by BARC in May 2009.**

India -Korea collaboration on nuclear data

Dr. H. Naik, Radiochemistry Division, BARC visited Pohang as a visiting scientist for 3 months during the last quarter of 2008 and continued generation experimental data of photo-fission yields and photon induced neutron emission cross sections. (Pohang electron LINAC machines)

ENSDF Evaluation Activities

The ENSDF evaluation activities and research work are being actively continued by Ashok Jain (IIT Rourkee), M. Gupta (Manipal), Gopal Mukherjee (VECC, Kolkata) and others.

The Indian Nuclear Data Centre under formation will factor into account the continuation of these important nuclear data physics activities.

The online nuclear data services

http://www-nds.indcentre.org.in/)

mirror the nuclear data website of the Nuclear Data Section of the International Atomic Energy Agency (IAEA), Vienna

http://www-nds.iaea.org.

The MOU between DAE/BARC and the IAEA is expected to be continued beyond 2010.

Promoting the online nuclear data services in India is an ongoing task and in the coming years.

India is a participant in the ITER programme.

The nuclear data needs for fusion system applications is receiving increased focus and attention in India.

Measurement of n, p and D induced activation cross sections in the MeV energy region.

Calculations using TALYS and EMPIRE codes

FENDL library of the IAEA: Use and QA studies

Fusion integral benchmark analayis.

Use of EASY-2007 package by Robin Forrest et al.

INTEGRAL NUCLEAR DATA VALIDATION STUDIES

Indian experimental nuclear criticality benchmarks

2009: Work started on PURNIMA-I (PUO_2 fast system)

History of previous benchmarking tasks:
For details, please visit the URL: http://icsbep.inl.gov/

2005: India contributed the KAMINI experimental benchmark
(ICSBEP Reference: U233-MET-THERM-001)

2008: India contributed the PURNIMA-II experimental benchmark
(ICSBEP Reference: U233-SOL-THERM-007)

THANK YOU