Nuclear Data Project McMaster University

Status Report: Oct. 1, 2008-Sept. 30, 2009

USNDP: November 4-6, 2009

Part 1: Nuclear Structure and Decay Data Evaluation

Prepared by: B. Singh

ENSDF Work

- **Permanent Responsibility**:

  A=1 (2005);
  31 (2008,s), **32** (1998,s),
  33 (1998,w), **34** (1998,s,*),
  35(1998,w), **36-37**(1998,w,*),
  38 (2007), **39** (2006), **40** (2004),
  41 (2001), **42** (2000),
  43 (2001), **44** (1999).
  64 (2006), **89** (1998,s),
  98 (2003), **100** (2007),
  149 (2004), **151** (2008),
  164 (2001), **188** (2002),
  190 (2003), **194** (2006)

- Note: The number in parentheses gives the year of last revision in ENSDF database
- w: work in progress
- s: revision submitted
- *: collaboration with Ninel Nica
- During FY-2009, work was done on other A-chains and nuclides also, which are outside McMaster's A-chain responsibility

Mass-chain Evaluations Published or Submitted Since October 1, 2008

- **A=151**: B. Singh NDS 110, 1-264 (2009)
- **A=78**: A.R. Farhan and B. Singh NDS 110, 1917-2080 (2009)
- **A=84**: Bucharest ENSDF-09 workshop NDS 110, 2815-2944 (2009).
  (submitted in July 2009; coordinated this effort)
- **A=32**: C. Ouellet and B. Singh (submitted Sept 2009) (previous: Endt 1998)
- **A=34**: N. Nica and B. Singh (submitted Sept 2009; pre-review) (previous: Endt: 1998)
- **A=50**: Z. Elekes, J. Timar and B. Singh (submitted Sept 2009) (previous: 1995)
- **A=71**: K. Abusaleem and B. Singh (submitted Sept 2009) (previous: 1993)
- **A=77**: B. Singh and N. Nica (submitted Aug 2009; pre-review) (previous: 1997)

(A=32, 50, 71, 84: as part of mentoring and training effort)

Nuclide updates

37 nuclides were updated for ENSDF: (by Singh)

Most are (far-off the stability line) New Nuclides and/or nuclides for which excited state and/or gamma-ray data became available for the first time

11 nuclides in ENSDF were removed; literature checked and found no experimental data or identification.

- Review work: A=102 for ENSDF / NDS (by Singh)

XUNDL work

Compilation of Data from Current Literature

- Between October 1, 2008 and October 8, 2009, 393 compiled (checked for internal level-scheme and data consistency) datasets prepared by McMaster group have been included in XUNDL.
- 19 datasets were shared with other contributors
- 76 compiled at other centers were checked.
- **35** datasets in XUNDL were updated to incorporate newer related papers from the same groups.
- Represent about 2550 primary publications in experimental nuclear structure.
- Frequent scanning of web pages of primary nuclear physics journals:
  (PR-C, PRL, NP-A, PL-B, EPJ-A, JP-G, IJMP-E, Chinese Phys Lett, ArXiv-preprints, others)
- About 40 current papers are being compiled.
- At McMaster, participation in this effort by undergraduate students: Scott Geraedts
  (Mar 2007 – April 2009); Allison MacDonald (Oct 2008 – Dec 2009); Babak Karamy (since April 2009)
- Students' work is checked and edited by B. Singh, before submission to NNDC for inclusion in XUNDL
- Communication with authors actively continue to resolve data-related inconsistencies and/or to request additional data details; about 50 communications this year.
- With pre-arrangement, data for 3 PRC/PRL papers published in 2008-2009 exist only in XUNDL.

NSR compilation work (key-wording of PR-C) (Oct 1, 2008 – Sept 30, 2009)

Undergraduate student participation in preparing draft versions of keywords for about 1000 articles in PR-C.

Scott Geraedts: PRC: Sept - Nov 2008
Allison MacDonald: PRC: Nov 2008 – Aug 2009
Babak Karamy : PRC: Apr 2009 – Aug 2009

B. Singh provided local training for the key-wording process. Students' work checked and edited for technical content, wording and running through NSR-PREP code to resolve formatting errors.

Work in Progress
(as of October 1, 2009)

A=58, 182 (post-review stage); expected completion by the end of 2009
A=85, 89 (pre-review stage); expected completion by July 2010.

A=33, 35. Complete all ENSDF style datasets for all reactions and adopted properties.
A=33 expected to be submitted by July 2010; A=35 by the end of 2010

A=36, 37: in collaboration with Dr. N. Nica at Texas A&M, expected completion by Sept 2010

A=61: in collaboration with Dr. K. Zuber of IFJ-PAN, Poland.

A=75: in collaboration with Dr. A. Negret of IFIN-HH, Bucharest.

A=76: in collaboration with Dr. A. Farhan of Kuwait U.; expected submission by the end of 2010.

A=129: in collaboration with Drs Z. Elekes and J. Timar, ATOMKI, Hungary.

A=139: in collaboration with Dr. P. Joshi, TIFR, India and Dr. J. Tuli at NNDC.

XUNDL and mass compilation work will continue during 2009-2010.

Mentoring and Training
of New Data Evaluators through Collaborative work

- **A=31, 32:** Dr. Christian Ouellet, McMaster / BNL. Both A chains have been submitted, A=31 is near completion.
- **A=33, 35:** Dr. Jun Chen, McMaster
- **A=61**: Dr. K. Zuber, IFJ-PAN, Krakow, Poland. He attended Bucharest workshop.
- **A=50, 129**: Drs. Zoltan Elekes and Janos Timar, ATOMKI, Hungary. Both visited McMaster for about two weeks each in 2009. A=50 is submitted; A=129 is in progress.
- **A=71**: Dr. Khalifeh Abusaleem, University of Jordan. Visited McMaster twice for two weeks each time in 2009. A=71 is now submitted.
- **A=75**: Dr. A. Negret, IFIN-HH, Bucharest. He attended Bucharest workshop.
- **A=84**: B. Singh participated in Bucharest ENSDF-09 workshop in April 2009; coordinated work on A=84. This work is now published.
- **A=139**: Dr. Paresh Joshi, TIFR, India. Dr. Joshi is expected to visit McMaster for about 2 weeks in summer 2010.

Other collaborations and visitors

- A=78, 76: Dr. Ameenah Farhan, Kuwait U., Nov 2008, 10 days
- A=34, 77: Dr. Ninel Nica: Texas A&M: June 2009: 10 days

Other Related Activities

- **Review of M1 transition probabilities in ENSDF:**
  (Final presentation at NSDD-09, about revised RUL for M1 transitions).

- **Atomic mass compilations since AME-2003**.
  2008-2009: 27 primary papers compiled
  Scott Geraedts, Allison MacDonald, B. Singh

  Aug 2008 – Feb 2009 and Mar 2009 – Oct 2009 compilations available on www.nuclearmasses.org webpage.

- **Compilation of directly measured nuclear spins**: work in summer 2009, draft completed.
  Allison MacDonald, Babak Karamy, B. Singh

- **NDS band software**: For some mass chains, final NDS print versions with new band drawings and their inclusion in the main tables with re-pagination were prepared at McMaster.

Division of effort

- 2 FTE + 1 volunteer
- ENSDF: 1.5 FTE + 1 volunteer (John Cameron)
- Nuclear Astrophysics (evaluation+experiment): 0.2 FTE
- XUNDL, Mass compilation: 0.2 FTE
- NSR comp, training of students, etc.: 0.1 FTE

Personnel and Funding

- A. Chen: Assoc. Professor, Principal Investigator of Data Project.
- J. C. Waddington: Emeritus-Professor, Co-PI of Data Project.
- J. A. Cameron: Emeritus-Professor: Volunteer work since 1999 on ENSDF evaluation of A=31-44 region
- B. Singh: Research Scientist/Nuclear Data Evaluator.
- C. Ouellet: Post-doctoral Fellow: Sept 2007 – Feb 2009
- J. Chen: Post-doctoral Fellow: since July 2009
- S. Geraedts: Undergraduate Student: Mar 2007 – Apr 2009
- A. MacDonald: Undergraduate Student: Oct 2008 – Dec 2009
- B. Karamy: Undergraduate Student: since Apr 2009

- Financial support from Office of Nuclear Physics, Office of Science, DOE, USA and from NSERC, Canada.

Part 2: Astrophysics Data

Prepared by: J. Chen and A. Chen

Astrophysics Data Evaluation

- Astrophysical reaction rate evaluated for two reactions:
  $^{25}Al(p,\gamma)^{26}Si$ and $^{29}P(p,\gamma)^{30}S$
- Both reactions are among thesis projects in Alan Chen's group
  - $^{25}Al(p,\gamma)^{26}Si$, by Jun Chen
    - study ^{26}Si levels of astrophysical interest via $(p,d\gamma)$ and (p,p) both in inverse kinematics with radio-isotope beams
    - finished and analysis results under finalization
  - $^{29}P(p,\gamma)^{30}S$, by Kiana Setoodehnia
    - study ^{30}S levels of astrophysical interest via (p,t) and $(^3He,n\gamma)$ btoh in normal kinematics
    - analysis and new experiments ongoing
- Rates submitted using the Computational Infrastructure for Nuclear Astrophysics at www.nucastrodata.org at ORNL
- Further update expected from the results of our group's research

$^{25}Al(p,\gamma)^{26}Si$ Rate Evaluation

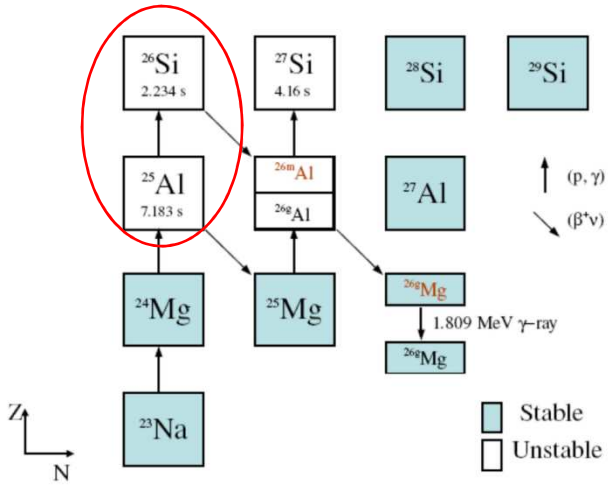
- The galactic ^{26}Al is an important probe for Inter-Stellar Medium (ISM) since its γ-emissions have been detected by the satellite and it has been observed in the meteoritic abundance study.

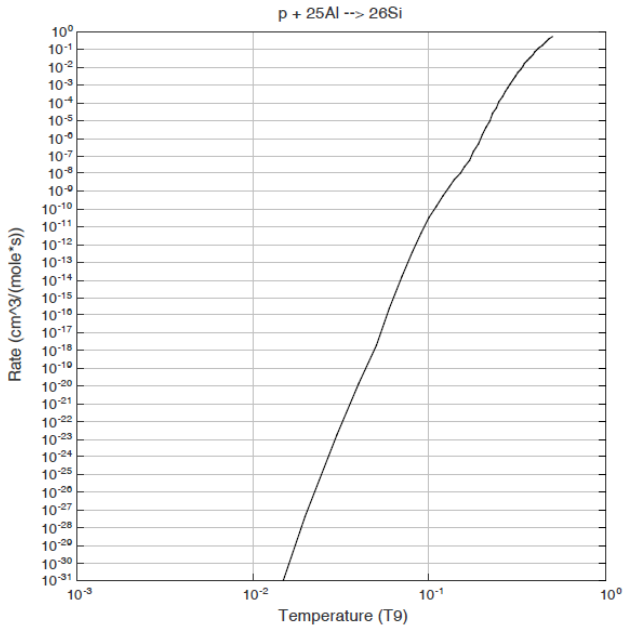
- The $^{25}Al(p,\gamma)^{26}Si$ reaction is a key reaction for the ^{26}Al production at nova temperatures via $^{25}Al(p,\gamma)^{26}Si(\beta^+)^{26m}Al(\beta^+)$ but its rate is uncertain because of poor understanding of resonances above proton threshold in ^{26}Si.

- Various indirect measurements have been used to study ^{26}Si levels of astrophysical interest for deducing the resonance energies, spin-parities and resonance strengths.

- Even a few keV difference in energies of dominant resonances can result in orders of magnitudes difference in the reaction rate.

- Rate is dominated at Nova temperatures (0.1-0.4 GK) by three resonances of which large uncertainties exist in resonance energies and spin-parity assignments.





$^{29}P(p,\gamma)^{30}Si$ Rate Evaluation

- The ^{29}Si and ^{30}Si abundances are important to understand the nucleosynthesis occurring in nova explosions.

- The $^{29}P(p,\gamma)^{30}Si$ reaction is the key reaction that affects the production and destruction of ^{29}Si and ^{30}Si in nova outbursts.

- It increases the ^{30}Si abundance through the $^{29}P(p,\gamma)^{30}S(\beta^+)^{30}P(\beta^+)^{30}Si$ reaction path and increases the ^{29}Si abundance through the $^{29}P(\beta^+)^{29}Si$ reaction path.

- The rate is uncertain because the level structure above the proton threshold is poorly understood.

- Variation in $^{29}P(p,\gamma)^{30}S$ rate within its current limits changes the abundances of ^{29}Si and ^{30}Si by a factor of 3.

- Rate is dominated at Nova temperatures (0.1-0.4 GK) by two resonances at E_x=4733 and 4888 keV whose properties are predicted by the shell model.