International Nuclear Data Evaluation Network on Light Elements (INDEN-LE)

Introduction

Vivian Dimitriou NAPC-Nuclear Data Section International Atomic Energy Agency

CM INDEN-LE 2024



R-matrix Codes + INDEN-LE: goals





Exchange of know how

Compatibility of R-matrix codes



Interchangeable and usable resonance parameters



Shared curated database



Joint evaluation

> Thompson et al., Eur. Phys. Journal A (2017) 72:56

Neutrons 2021-2024

- Independent evaluations
- New experimental data (n+14N; alpha+13C; alpha+11B)
- 170 discussed feedback from integral measurements

n+9Be

Gerry Hale, Mark Paris Helmut Leeb, Thomas Srdinko Zhenpeng Chen

n+160

Gerry Hale, Mark Paris Zhenpeng Chen James deBoer (13C(alpha,n)) Marco Pigni **n+23Na** Pierre Tamagno

n+15N

Satoshi Kunieda

n+14N

Gerry Hale James deBoer Ian Thompson

Charged particles 2021-2024

Independent evaluations:

- 3He+4He (Thompson ENDF/B-VIII.1)
- > 7Be: Chen, Hale-Paris

Test 2 + Test 3: lead by Ian Thompson

In progress

7Be: p+6Li; 3He+4He

Group effort Test 2: fitting statistical methods Test 3: evaluation

13C(alpha,n) (170)

Gerry Hale, Mark Paris Zhenpeng Chen James deBoer (13C(alpha,n)) Marco Pigni

19F(alpha,n) Dimitriou deBoer

IAEA OneDrive: Light_Elements

Experimental data from EXFOR and deBoer

Evaluations from Chen, Thompson, deBoer MARIAN, Ludmila > External_Projects > Light_Elements > INDEN-LE & ß Name ~ Modified \downarrow \checkmark Modified By ~ File size ~ Sharing ~ CM-INDEN-LE-2019 June 13, 2019 MARIAN, Ludmila 7 items 응 Shared 😬 • Experimental Data June 7, 2019 MARIAN, Ludmila 2 items 응 Shared ... 🖻 🟠 Evaluations 0 00 June 7, 2019 MARIAN, Ludmila 8 items 응 Shared Name Modified ↓ ~ ß Name ~ Modified ↓ 🔒 Ne21 June 7, 2019 Notre Dame data June 24, 2022 8 017 June 7, 2019 🔐 Ne22 June 7, 2019 ... 62 EXFOR June 7, 2019 Ê 😽 Na24 June 7, 2019 **M** Name ~ Modified ↓ ~ 8 N15 June 7, 2019 8 N16 June 7, 2019 😬 11B+a ... 🖻 🟠 March 19, 2021 \bigcirc 😬 Be10 June 7, 2019 13C_an 8 March 19, 2021 😽 Be7 June 7, 2019

R-matrix Analysis of Charged Particle Reactions (RMACPR)

- Ian Thompson's Github repository
- Experimental data from EXFOR, deBoer, Paris
- Evaluations from Thompson

Github: https://github.com/RMACPR

opular repositories		⊙ View as: Public ◄
Be7_Rmatrix_Analysis Public R-matrix analyses of the Be7 system TeX ¹ ²	INDEN_LE-data Experimental data used for INDEN-LE evaluations Python 🟠 2	Public You are viewing the README and pinne as a public user. You can create a README file visible to People
] Repositories		@\$@ !\${
Q Find a repository	Type - Language - Sort -	Rew Top languages
Be7_Rmatrix_Analysis Public R-matrix analyses of the Be7 system		● Python ● TeX
INDEN_LE-data (Public) Experimental data used for INDEN-LE evaluations		
● Python 🏠 2 😲 0 ⊙ 0 🛟 0 Updated on Feb 14, 2023		

Ferdinand code

- By Ian Thompson
- Translating resonance parameters from different bases and different R-matrix codes
- GitHub:

https://github.com/LLNL/ferdinand

lan Thompson and Ian Thompson Adding add		Translate Rematrix Evaluations				
	_excitations_Ryaml.py 🚥 78125bd · 5 months ago	3 26 Commits				
f90nml	Reviewed and released version 0.40 for publishing on github	2 years ago				
gitignore	Fix boundaryConditionValue in read_eda.py	6 months ago 화고 Apache-2.0 license				
BarkerTransformation-v1.py	Ferdinand 0.41: minor changes	2 years ago Code of conduct				
BarkerTransformation.py	Ferdinand 0.50 using Fudge 6.	last year E Custom properties				
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CODE_OF_CONDUCT.md	Reviewed and released version 0.40 for publishing on github	2 years ago 9 0 forks	 ◆ 4 watching ♀ 0 forks 			
CONTRIBUTING.md	Reviewed and released version 0.40 for publishing on github	2 years ago Report repository				
CoulCF.py	Reviewed and released version 0.40 for publishing on github	2 years ago				
LICENSE	Reviewed and released version 0.40 for publishing on github	2 years ago				
NOTICE	Ferdinand 0.50 using Fudge 6.	last year				
README.md	Ferdinand 0.50 using Fudge 6.	Packages	Packages			
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Test 2: comparison of minimization techniques

Test case: 7Be; Experimental database selected by Hale and deBoer; 1 data set per channel (alpha,el), (p, el), (alpha,p), (p,alpha)

To compare: minima (chi2) and covariance matrices of cross sections and resonance parameters

- The covariance matrix should also contain the normalisations. However, cross correlations between normalization and resonance parameters cannot be treated in ENDF-6 format. A format must be agreed on.
- The bound channels are fixed following Hale's prescription, i.e. using boundary condition for bound state B = S(E_{bound}) and for all others B = -L. The matching radii were the same as in Test 1.
- Degrees of freedom: number of experimental points number of R-matrix parameters number of unconstrained normalization (unconstrained = no measurement of normalization error)
- Total chi2-value: sum of chi2 for each data set +chi2 for normalization for each data set
- Number of iterations: those with analytical derivatives should estimate their iterations by also taking into account the number of free parameters
- Uncertainties of initial parameters should be specified (without correlations)
- Apart from normalizations, only statistical experimental uncertainties are assumed in Test 2

Test 2 cont'd

Status: as of 21 March 2024

Ian will prepare a YAML file with detailed instructions on how to build the parameter covariance matrices:

- R-matrix parameters in certain order, normalization in certain order and covariance matrix with same order of R-matrix and normalization parameters.
- Define order of experiments.
- Agree if E is in Lab or CM. Whether to provide reduced widths or not.

Code developers will then submit their results, chi2 and covariances accompanied with their YAML file detailing how to read their covariance matrices.

The results of the comparison will be discussed at the next INDEN-LE meeting. Dates to be confirmed.

Ian will also discuss with GNDS team possible ways of accommodating cross-correlations between scaling and resonance parameters in a new format.

Test 3: evaluation of 7Be

All conditions and experimental database detailed in 1 Sept. 2022 document

Status: as of 21 March 2024

Ian submitted 3He+4He channel evaluation to ENDF/B-VIII.1

James to improve his evaluation

Helmut and Thomas will also perform an evaluation although their priority is n+9Be system

Marco strongly urges to publish

Experimental data

Previous Experiment Data for the Be7 system

Use *.dat files from de Boer to make 'Test3' calculation

Still need to specify properties of these files:

projectile	ejectile	residual	file	sys-error	stat-error	norm	group	splitnorms	lab	abserr	scale	filedir	eshift	ecalib	splitshifts
h	h	0	Barnard_aa.dat	5	3	1	E	FALSE	TRUE	TRUE	b	Expt5/	0	0	FALSE
р	h	0	Elwyn_pa.dat	9	-1	1	Α	FALSE	TRUE	TRUE	b	Expt5/	0	0	FALSE
р	р	0	Fasoli_pp.dat	-1	1.5	1	E	TRUE	TRUE	TRUE	b	Expt5/	0	0	FALSE
р	р	0	Harrison_pp0.dat	-1	2	2.2	Α	FALSE	TRUE	TRUE	b	Expt5/	0	0	FALSE
р	р	1	Harrison_pp1.dat	-1	-1	0.2	Α	FALSE	TRUE	TRUE	b	Expt5/	0	0	FALSE
р	h	0	Lin_pa.dat	10	-1	1	Α	TRUE	TRUE	TRUE	b	Expt5/	0	0	FALSE
р	р	0	McCray_pp.dat	5	-1	1	E	TRUE	TRUE	TRUE	b	Expt5/	0	0	FALSE
h	h	0	Mohr_aa.dat	-1	5	1	Α	TRUE	TRUE	TRUE	b	Expt5/	0	0	FALSE
h	h	0	Spiger-A1094004-lab_aa.dat	1.5	-1	1	Е	TRUE	TRUE	TRUE	b	Expt5/	0	0.02	TRUE
h	р	0	Spiger-cm_ap0.dat	1.5	-1	1	Α	TRUE	FALSE	TRUE	mb	Expt5/	0	0	FALSE
h	h	0	Tombrello_aa.dat	5	-1	1	E	FALSE	TRUE	TRUE	b	Expt5/	0	0.02	TRUE
а	h	15	LIMIT	4.001506	3.01550116										
р	Li6	2.79	LIMIT	1.008665	6.01347726										

Correct some data:

- 1. The 9.106 MeV point at 36.999 deg in the Spiger_aa data is not extracted from the plots properly.
- 2. The Tombrello_aa data (not A1039 but A1295) should have a constant discretization error of 0.5 mb/sr added in quadrature to the per-cent errors for the A1295002 data.
- 3. The points in Elwyn_pa at Ep = 2.277, 2.377, and 2.476 MeV were not plotted correctly, if checked by Legendre data.

Have we sorted all the experimental data?

Do we have a final experimental database for the evaluation?





Developments - Discussions





Ian Thompson retired

Redefine goals

Review exercises Test 2 and Test 3 New RMACPR Git repo?

Ferdinand?

New members

New goals? New format?



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Title Here



ENDF/B-VIII.1

• **n+**¹⁹**F**:

Cross Section (bams)

- n,TOT and n,G from JENDL-5;
- (n,INL): Morgan et al 1976





