International Atomic Energy Agency
Nuclear Data Services
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Technical Meeting of the International Network of Nuclear Reaction Data Centres (NRDC)

Centre for Photonuclear Experiments Data (CDFE)
Skobeltsyn Institute of Nuclear Physics (SINP)
Lomonosov Moscow State University (MSU)

Progress report on the CDFE photonuclear data compilation and evaluation activity for 2019/2021.

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for the Technical Meeting of the International Network of Nuclear Reaction Data Centres , Vienna, Austria (4 - 7 May 2021, virtual).

The report contains the short review of the Centre for Photonuclear Experiments Data (Centr Dannykh Fotoyadernykh Eksperimentov - CDFE) of the Russia Lomonosov Moscow State University Skobeltsyn Institute of Nuclear Physics main results obtained for the period of time from the Technical Meeting of the International Network of Nuclear Reaction Data Centres at the IAEA's Headquarters in Vienna, Austria, from 9 to 12 April 2019. The new photonuclear data compilations and old data corrections, the results of analysis and evaluation of photonuclear data obtained in various experiments and nuclear data service in generally are presented.

The CDFE total permanent staff:
3 professional, 2 general service officers and 1 post graduate student of the MSU Physics Faculty.

The main CDFE fields of activity were the following:

- EXFOR compilation and/or correction in accordance with the contents of the NRDC Network Memo, first of all CP-D/465 ("FPY compilation") and the NDS database "Articles for compilation" (https://www-nds.iaea.org/nrdc/alloc/);
- photoneutron reaction cross section evaluation; participation the IAEA CRP;
- CDFE nuclear database service.

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CDFE EXFOR Compilation

11 new CDFE EXFOR m100 – m110 TRANSes and prelim.m111 have been produced and transmitted to the IAEA NDS.
All TRANSes contain both 48 new ENTRYs and 120 old ENTRYs corrected in accordance with the new EXFOR format rules and the NRDC experts, first of all, Naohiko Otsuka, Michael Fleming, and Daniela Foligno comments and recommendations.

Special thanks to Svetlana Dunaeva for kind help in corrections of old ENTRYs.

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On the whole new CDFE TRANSes have been produced in the reported period:

TRANS	*Old*	New	Total
m100	*37*	1	38
m101	*37*	-	37
m102	*20*	4	24
m103	*2*	22	24
m104	-	6	6
m105	-	4	4
M106	*9*	1	10
M107	*3*	-	3
M108	*8*	2	10
M109	-	3	3
m110	*1*	2	3
All	*117*	45	162
prelim.m111	*3*	*3*	*6*
Common	*120*	48	168

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The main CDFE scientific activity is evaluation of photoneutron reaction cross sections obtained in various experiments

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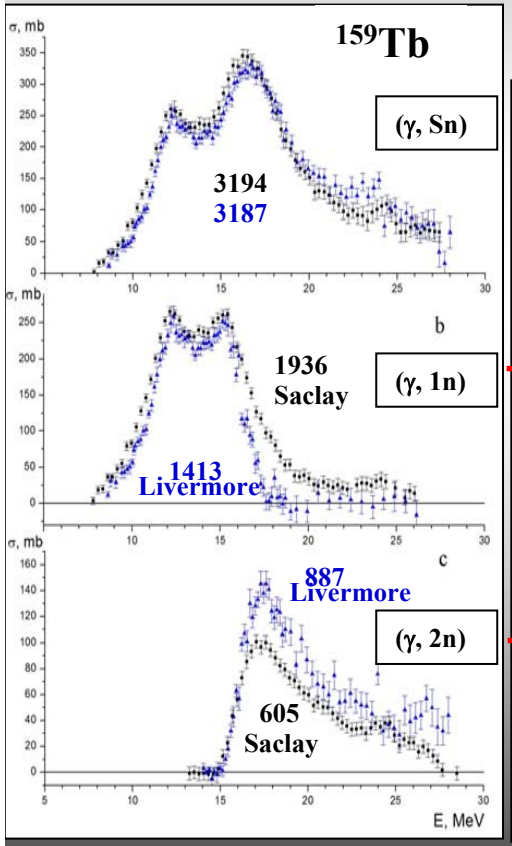
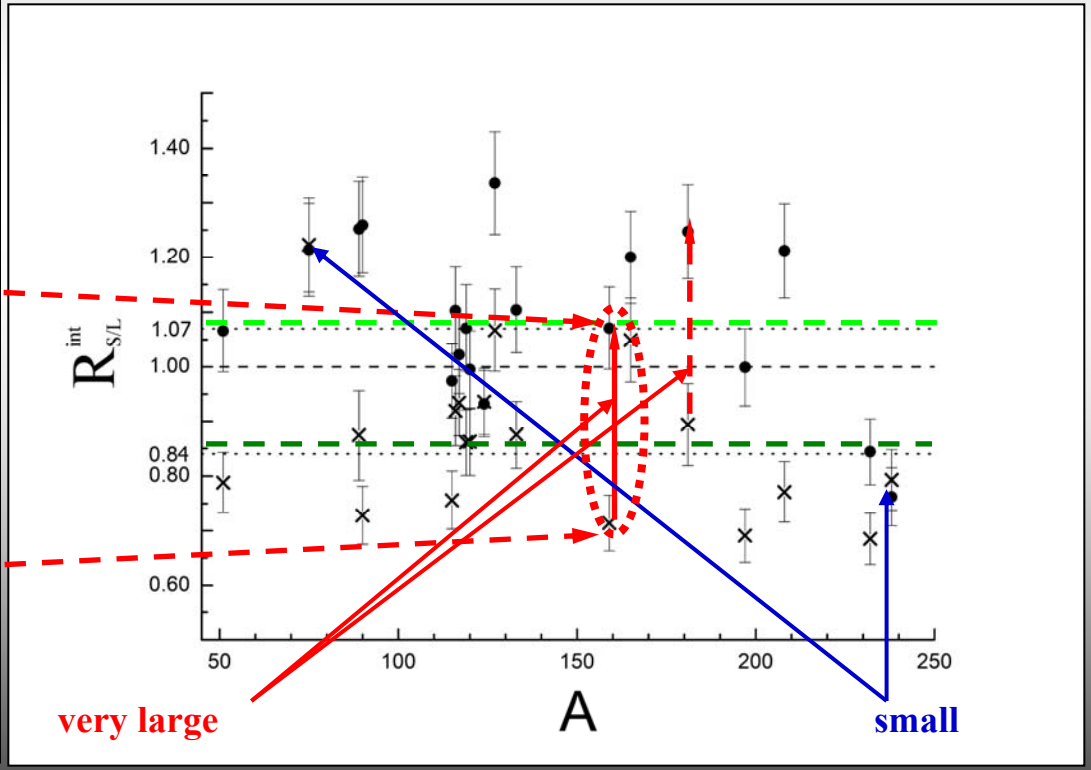
Main problem for 19 nuclei investigated in both Labs:

Cross sections for (γ, 1n) are larger at Saclay but for (γ, 2n) - at Livermore.

V.V.Varlamov, N.N.Peskov, D.S.Rudenko, M.E.Stepanov. Consistent Evaluation of Photoneutron Reaction Cross Sections Using Data Obtained in Experiments with Quasimonoenergetic Annihilation Photon Beams at Livermore (USA) and Saclay (France). INDC(CCP)-440, IAEA NDS, Vienna, Austria, 2004, p. 37.



Ratios of integrated cross sections $R^{int}_{S/L} = \sigma^{int}_S / \sigma^{int}_L$



Circles - ratios for (γ, 1n) reactions – are larger than 1.0:

<R> ~ 1.07.

Crosses - ratios for (γ, 2n) reactions – are smaller than 1.0:

<R> ~ 0.84.

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Objective physical criteria of data reliability not dependent on the methods of their obtaining were proposed.

The most interesting is F_2 – effective tool for investigation of competition between three partial photoneutron reactions under discussion - (γ, 1n), (γ, 2n) and (γ, 3n).

$$F_2 = \frac{\sigma(\gamma, 2n)}{\sigma(\gamma, 1n) + 2\sigma(\gamma, 2n) + 3\sigma(\gamma, 3n) + \ldots}$$

In accordance with definition:
$F_1 < 1.00$; $F_2 < 0.50$; $F_3 < 0.33$;
$F_4 < 0.25$, $F_5 < 0.20$ …;

Theoretically calculated in the combined model of photonuclear reactions transitional multiplicity functions
$F_i^{theor} = \sigma^{theor}(\gamma, in)/\sigma^{theor}(\gamma, Sn)$
are used for cross section evaluation by following way
$\sigma^{eval}(\gamma, in) = F_i^{theor}(\gamma, in) \bullet \sigma^{exp}(\gamma, Sn)$.

The evaluation method means that competition of partial reactions is described by the model and their correspondent sum $\sigma^{eval}(\gamma, Sn)$ is equal to the experimental $\sigma^{exp}(\gamma, Sn)$ reaction cross section.

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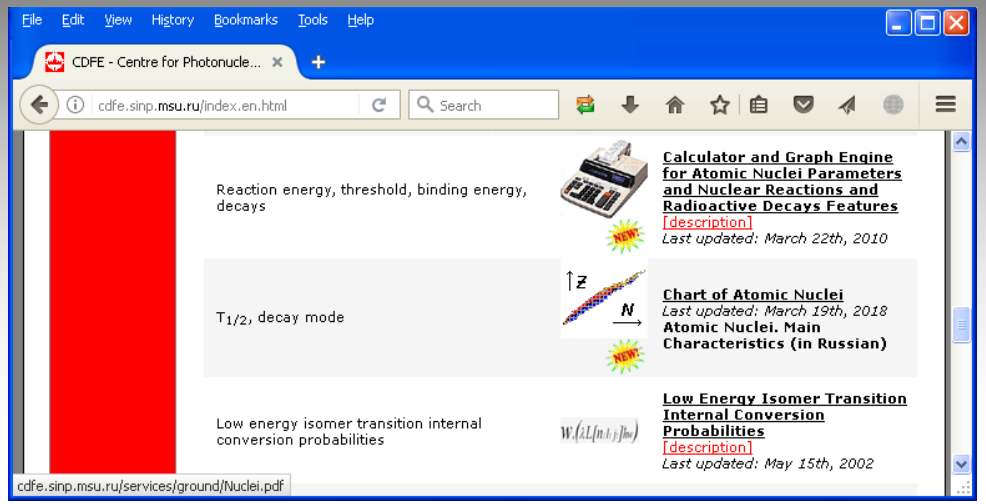
Newly evaluated photoneutron reaction cross sections

In the frame of the finished IAEA – MSU SINP Research Contract N 20501 "Evaluation of partial and total photoneutron reactions cross sections using new objective physical data reliability criteria" in the frame of the Coordinated Research Project N F41032 "Updating the photonuclear data library and generating a reference database for photon strength functions" new data for partial (γ, 1n), (γ, 2n), (γ, 3n) and total (γ, tot) = (γ, 1n)+(γ, 2n)+(γ, 3n) photoneutron reaction cross sections were evaluated using experimental-theoretical method and objective physical criteria of data reliability for many nuclei (^{51}V, ^{59}Co, ^{63,65}Cu, ^{75}As, ^{76,78,80,82}Se, ^{89}Y, ^{90,91,92,94}Zr, ^{98}Mo, ^{103}Rh, ^{115}In, ^{112,114,116,117,118,119,120,122,124}Sn, ^{127}I, ^{133}Cs, ^{138}Ba, ^{140,142}Ce, ^{141}Pr, ^{145,148}Nd, ^{153}Eu, ^{159}Tb, ^{165}Ho, ^{181}Ta, ^{186}W, ^{188,189,190,192}Os, ^{197}Au, ^{208}Pb, ^{209}Bi and some others).

New reliable evaluated data were published, included into the EXFOR database, and used for renewal and updating of the IAEA photonuclear data library.

CDFE Nuclear Database Service



The main CDFE nuclear database service activities are dissemination of modern international nuclear data for providing Lomonosov Moscow State University (Skobeltsyn Institute of Nuclear Physics, primarily) staff and students and also scientific and educational institutes and organizations of Russian Academy of Science with nuclear data for basic research, education and various applications.

EXFOR, ENSDF, and NSR databases are based on the international data sources (USA NNDC and NSDD) but have original Search Engines.

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2019/2020 Main Publications
(Nucl. Dat. Sheets, Phys. Rev., Phys.Atom.Nucl., EPJ Web of Conf., etc.).

1. T.Kawano,Y.S.Cho, P.Dimitriou, D.Filipescu, N.Iwamoto, V.Pluiko, X.Tao, H.Utsunomiya, V.Varlamov, R.Xu, R.Capote, I.Cheorghe, O.Gorbachenko, Y.I.Jin, T.Renstrom,M.Sin, K.Stopani, Y.Tian, G.M.Tveten, J.M.Wang, T.Belgya, R.Firestone, S.Goriely, J.Kopecky, M.Krticka, R. Schwenger, S.Siem, M.Wiedeking. IAEA Photonuclear Data Library 2019, Nuclear Data Sheets, 163 (2020) 109.

3. V.V.Varlamov. Evaluation of partial and total photoneutron reactions cross sections using new objective physical data reliability criteria. 3rd Research coordination meeting "Updating photonuclear data library and generating a reference database for photon strength functions", 17 – 21 December 2018, IAEA Headquarters, Vienna, INDC International Nuclear Data Committee Summary Report, INDC(NDS)-0777, IAEA NDS, Vienna, Austria, 2019, p. 10.

4. V.Varlamov, A.Davydov, V.Kaidarova, V.Orlin. Photoneutron reaction cross-section data for ^{75}As: Experiments and evaluation. Phys. Rev. C 99, N 2 (2019) 024608.

5. V.V.Varlamov, A.I.Davydov, B.S.Ishkhanov. New data on photoneutron reaction cross sections for ^{76,78,80,82}Se nuclei. Physics of Atomic Nuclei, 82, N1 (2019) 13.

6. V.V.Varlamov. Reliability of photonuclear data: various experiments and evaluations. Physics of Particles and Nuclei, 50, N5 (2019) 637.

7. V.V.Varlamov, A.I.Davydov, V.D.Kaidarova. Evaluation of reliable cross sections of photoneutron reactions on ^{103}Rh and ^{165}Ho. Physics of Atomic Nuclei, 82, N3 (2019) 196.

8. V.V.Varlamov, V.D.Kaidarova, V.N.Orlin. New reliable data on the photodisintegration of ^{160}Gd. Memoirs of the Faculty of Physics of the Lomonosov Moscow State University, N1, 2019, 1910202.

9. S.S.Belyshev, V.V.Varlamov, B.S.Ishkhanov, A.A.Kuznetsov, A.B.Priselkova, A.A.Prosnyakov, A.D.Fedorova, V.V.Khankin. Photodisintegration of ^{89}Y. Memoirs of the Faculty of Physics of the Lomonosov Moscow State University, № 2, 2019, 1920106.

10. A.I.Davydov, V.V.Varlamov, S.S.Belyshev, V.N.Orlin, B.S.Ishkhanov. New data on photodisintegration of nucleus ^{127}I: experiments and evaluation. Memoirs of the Faculty of Physics of the Lomonosov Moscow State University, № 3, 2019, 1930413.

11. S.Belyshev, A.Davydov, D.Filipescu, I.Georghe, B.Ishkhanov, V.Kaidarova, A.Kuznetsov, V.Orlin, K.Stopani, H.Utsunomiya, V.Varlamov. New reliable photoneutron reaction data for ^{159}Tb. International Conference on Nuclear Data for Science and Technology, May 19-24, 2019, Beijing, China. Conference Program & Abstract Book, China Nuclear Data Center, 2019, p. 58.

12. V.Varlamov, A.Davydov, B.Ishkhanov, V.Kaidarova, V.Orlin. Photoneutron reaction cross sections for ^{75}As and ^{181}Ta: Systematical uncertainties and data reliability. International Conference on Nuclear Data for Science and Technology, May 19-24, 2019, Beijing, China. Conerence Program & Abstract Book, China Nuclear Data Center, 2019, p. 144.

13. S.Belyshev, A.Davydov, D.Filipescu, I.Georghe, B.Ishkhanov, V.Kaidarova, A.Kuznetsov, V.Orlin, K.Stopani, H.Utsunomiya, V.Varlamov. New ^{209}Bi photodisintegration and physical criteria of data reliability. International Conference on Nuclear Data for Science and Technology, May 19-24, 2019, Beijing, China. Conference Program & Abstract Book, China Nuclear Data Center, 2019, p. 232.

14. Varlamov V.V., Davydov A.I., Ishkhanov B.S, Orlin V.N. New data on photodisintegration of ^{127}I: reliability of experimental reaction cross sections. LXIX International Conference «Nucleus-2019» on Nuclear Spectroscopy and Nuclear Structure "Fundamental Problems of Nuclear Physics, Nuclei at Borders of Nucleon Stability, High Technologies", Dubna, Russia, 1-5 July, 2019. Book of Abstracts. Joint Institute for Nuclear Researh, p. 48.

15. S.S.Belyshev, V.V.Varlamov, S.A.Gunin, A.I.Davydov, B.S.Ishkhanov, I.A.Pshenichnov, V.N.Orlin. Photoneutron reactions on ^{129}Xe nuclei and their electromagnetic dissociation in colliders. Physics of Atomic Nuclei, 83, N1 (2020) 2.

16. S.Belyshev, A.Davydov, D.Filipescu, I.Gheorghe, B.Ishkhanov, A.Kuznetsov, V.Orlin, K.Stopani, H.Utsunomiya, V.Varlamov. New ^{209}Bi photodisintegration data and physical criteria of data reliability. EPJ Web of Conferences, 239 (2020) 01031.

17. V.Varlamov, A.Davydov, B.Ishkhanov, V.Kaidarova, V.Orlin. Photoneutron reaction cross sections for ^{75}As and ^{181}Ta: Systematic uncertainties and data reliability. EPJ Web of Conferences, 239 (2020) 01035.

18. V.V.Varlamov, A.I.Davydov, V.N.Orlin. Photodisintegration of ^{127}I: Systematic Uncertainties of Experiments and Data Evaluated Using Physical Criteria. American Journal of Physics and Applications, 8 (2020) 64.

19. Varlamov V.V., Davydov A.I., Orlin V.N. Photoneutron reactions on ^{51}V: systematic uncertainties of experiments and new evaluated data. Yadernaya Fizika, 84, N3 (2021) 1.

Short-term (2021/2022) CDFE Program

The main items of CDFE (2021/2022) program, main priorities and most important tasks are traditional and the following:

- continuation of new photonuclear data compilation using EXFOR format, new TRANSes (M112, M113, etc.) production;

- correction of old ENTRYs in accordance with new EXFOR coding rule changes and the NRDC Network expert's comments and recommendations;

- continuation of analysis and evaluation using objective physical criteria of total and partial photonuclear reaction cross sections obtained in various experiments;

- renewal and upgrading of all databases put upon the CDFE Web-site (http://cdfe.sinp.msu.ru).

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THANKS A LOT

FOR ATTENTION!