Centre for Photonuclear Experiments Data (CDFE)
Skobeltsyn Institute of Nuclear Physics (SINP)
Lomonosov Moscow State University (MSU)
Report for 2023-2024

CDFE photonuclear data processing and evaluation activity, 2023/2024

V.V.Varlamov, A.I.Davydov, I.A.Mostakov, V.N.Orlin

Progress report on the CDFE photonuclear data processing and evaluation activity, 2023/2024

for the Technical Meeting of the International Network of Nuclear Reaction Data Centres (14 – 17 May 2024)

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Report shortly describes the main photonuclear data activity results obtained in the CDFE for the period of time from the previous Meeting (the IAEA’s Headquarters, Vienna, Austria, 9 - 12 June 2023).

The CDFE total permanent stuff:
4 professional, 2 general service officer, 1 – 2 student(s) of the MSU Physics Faculty.

The main CDFE fields of activity were the following:

- compilation of new photonuclear reaction data;
- correction of old data in accordance with the comments of the NRDC experts;
- photoneutron reaction cross-section evaluation;
- nuclear database service.

CDFE EXFOR Compilation

7 new CDFE EXFOR m123 – m129 TRANSes and 2 prelim.m130 and prelim.m131 ones have been produced and transmitted to the IAEA NDS.

All TRANSes contain both 10 new ENTRYs and *71 old ENTRYs* corrected in accordance with the new EXFOR format rules and comments and recommendations of the NRDC experts, first of all, Naohiko Otsuka, Daniela Foligno, and Svetlana Dunaeva.

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

TRANS	*Old*	New	Total (SUBENTs)
m123	*7*	1	8 (80)
m124	-	-	4 (12)
m125	*10*	2	12 (41)
m126	*1*	4	5 (52)
m127	*9*	1	10 (67)
m128	*8*	2	10 (41)
m129	*9*	-	9 (79)
prelim.m130	*11*	-	*11 (68)*
prelim.m131	*12*	-	*12 (64)*
Common	*71*	10	81 (504)

The main CDFE scientific activity is analysis of reliability of cross sections obtained in various experiments

and

evaluation of photoneutron reaction cross sections satisfied objective physical criteria of data reliability

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2 objective physical absolutely hard data reliability criteria:

1) F_i – definitely positive values (cross-section – dimension of area (barn, cm^2));

2)

$$F_1 = \frac{\sigma(\gamma, 1n)}{\sigma(\gamma, 1n) + 2\sigma(\gamma, 2n) + 3\sigma(\gamma, 3n) + \ldots} < 1.00$$

$$F_2 = \frac{\sigma(\gamma, 2n)}{\sigma(\gamma, 1n) + 2\sigma(\gamma, 2n) + 3\sigma(\gamma, 3n) + \ldots} < 0.50$$

$$F_3 = \frac{\sigma(\gamma, 3n)}{\sigma(\gamma, 1n) + 2\sigma(\gamma, 2n) + 3\sigma(\gamma, 3n) + \ldots} < 0.33$$

$F_4 < 0.250$, $F_5 < 0.200$, $F_6 < 0.166$, $F_7 < 0.143$, $F_8 < 0.125$, …

3) 3-rd not hard (soft) criterion - F_i^{exp} and F_i^{theor} agreement (closeness).

Cross-section evaluation:

$$\sigma^{eval}(\gamma, in) = F_i^{theor}(\gamma, in) \bullet \sigma^{exp}(\gamma, Sn),$$

where $\sigma^{exp}(\gamma, Sn) = (\gamma, 1n) + 2(\gamma, 2n) + 3(\gamma, 3n) + \ldots$ are experimental data,
and $F_i^{theor} = \sigma^{theor}(\gamma, in)/\sigma^{theor}(\gamma, Sn)$ are calculated in the combined model of photonuclear reactions

Newly evaluated photoneutron reaction cross sections

It was found that for about 50 nuclei from ^{51}V to ^{209}Bi experimental cross sections more-less are not reliable because of significant systematic uncertainties of the experimental method for photoneutron multiplicity sorting.

The program of evaluation of reliable partial photoneutron reaction cross sections using the experimental-theoretical method based on objective physical criteria was continued for data obtained using quite different method in experiments with bremsstrahlung.

New evaluations were carried out using the relevant experimental data obtained for ^{51}V, ^{52}Cr, and ^{90}Zr in addition to $^{58,60}Ni$. In detail comparison of evaluated data with data obtained for those relatively light nuclei and medium-heavy $^{112,114,119}Sn$, ^{127}I, ^{165}Ho, and ^{181}Ta ones it was found out that in many cases partial reaction cross sections $\sigma(\gamma, 1n)$ and $\sigma(\gamma, 2n)$ obtained using statistical theory corrections to the neutron yield cross sections $\sigma(\gamma, Sn) = \sigma(\gamma, 1n)+2\sigma(\gamma, 2n)$ are not reliable also because of some shortcomings of such procedure.

The main reason – presence of two-nucleon neutron-proton reaction $\sigma(\gamma, 1n1p)$ which in cases of relatively light nuclei compete not with reaction $\sigma(\gamma, 1n)$ with the same multiplicity (1), but with reaction $\sigma(\gamma, 2n)$ with multiplicity 2.

New Experimental Methods

It was found out before that photoneutron cross sections obtained using alternative methods of direct photoneutron multiplicity determination, for example, activation method and the suitable method realized on the beam of laser Compton scattering photons, give to one possibility to obtain reliable data.

Because of that the relevant experiments using activation method were carried out for Se, Nb and Mo and the discussions of new laser Compton scattering photons facility project were started.

2023/2024 Main Publications
(Eur. Phys. J., Phys. Atom. Nucl., Bull. Rus. Acad. Sci., MSU Phys. Bull.)

1. V.V.Varlamov, A.I.Davydov. Reliability of ^{159}Tb partial photoneutron reaction cross sections obtained in various experiments. Phys. Atom. Nucl., 85, N6 (2023) 361–371.
2. V.V.Varlamov, A.I.Davydov, I.A.Mostakov, V.N.Orlin. Cross sections of partial photoneutron reactions on ^{59}Co in experiments with bremsstrahlung. Phys. Atom. Nucl., 86, N5 (2023) 600–612.
3. P.D.Remizov, M.V.Zheltonozhskaya, A.P.Chernyaev, V.V.Varlamov. Measurements of flux-weighted yields for (γ, α*Xn*) reactions on molybdenum and niobium. Eur. Phys. J. A, 59 (2023) 141.
4. V.V.Varlamov, A.I.Davydov, V.N.Orlin. Similarities and differences in processes of ^{58,60}Ni photodisintegration. Bull. Rus. Acad. Sci. Phys., 87, №8 (2023), 1179–1187.
5. V.V.Varlamov, A.I.Davydov, V.N.Orlin. Cross sections of partial photoneutron reactions in experiments on beams of bremsstrahlung γ-radiation. Bull. Rus. Acad. Sci. Phys., 87, № 8 (2023) 1188–1195.
6. S.S.Belyshev, V.V.Varlamov, L.Z.Dzhilavyan, A.A.Kuznetsov, A.M.Lapik, A.L.Polonski, A.V.Rusakov, V.I.Shvedunov. On monitoring on the under-development source based on backward Compton scattering for photonuclear research at $E\gamma \leq 40$ MeV. Mos. Univ. Phys. Bull., 78, N 3 (2023) 278–283.
7. S.S.Belyshev, V.V.Varlamov, L.Z.Dzhilavyan, A.A.Kuznetsov, A.M.Lapik, A.L.Polonski, A.V.Rusakov, V.I.Shvedunov. On the program of photonuclear research using the backward Compton quasi-monochromatic γ quanta with tunable energy $E\gamma \leq 40$ MeV. Mos. Univ. Phys. Bull., 78, N 3 (2023) 284–290.
8. A.I.Davydov, V.V.Varlamov, V.N.Orlin. Cross sections of partial photoneutron reactions: problems of reliability and new data. Moscow University Physics Bulletin. 78, N. 3 (2023) 291–302.
9. V.V.Varlamov, A.I.Davydov, V.N. Orlin. Status of experimental photonuclear results. Mos. Univ. Phys. Bull., 78, N. 3 (2023) 303–315.
10. V.V.Varlamov, A.I.Davydov, I.A.Mostakov. Reliability of ^{51}V photoneutron reaction cross sections obtained using bremsstrahlung. Eur. Phys. J. A., 60 (2024) 44.

2023/2024 publications (in print)

11. V.V.Varlamov, A.I.Davydov. Photonuclear experiments: from the bremsstrahlung to the Compton backward scattering photons. Mos. Univ. Phys. Bull., V. 79, N. 2 (2024), in print.
12. V.V.Varlamov, A.I.Davydov, I.A.Mostakov, V.N.Orlin. Photoneutron reaction cross sections for ^{90}Zr in different experiments. Phys. Atom. Nucl. 87, N5 (2024), in print.
13. V.V.Varlamov, A.I.Davydov, I.A.Mostakov, V.N.Orlin. Photoneutron reaction cross sections for light and medium-heavy nuclei in experiments on the beams of bremsstrahlung. Bull. Rus. Acad. Sci. Phys. (2024), in print.
14. V.V.Varlamov, A.I.Davydov, I.A.Mostakov. Reliability of cross sections of photoneutron reactions on ^{51}V and ^{59}Co in experiments with bremsstrahlung. Bull. Rus. Acad. Sci. Phys. (2024), in print.

Short-term (2024/2025) CDFE Program

The main items of CDFE (2024/2025) program, main priorities and most important tasks are traditional and the following:

- continuation of new photonuclear data compilation using EXFOR format, production of new TRANSes (M132, M133, etc.);

- correction of old ENTRYs in accordance with new EXFOR coding rules and the NRDC Network experts'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, carried out using different sources of photons (quasimonoenergetic annihilation photons, bremsstrahlung photons, laser Compton backscattering photons);

- continuation of development of methods for direct photoneutron multiplicity determination.

THANKS A LOT FOR ATTENTION !