Technical note 1: EPICS2017 (EPDL)

Zhuxin LI, Claire MICHELET, Sébastien INCERTI CENBG, Version October 17, 2017

Introduction

EPICS2017 [1] is the Electron Photon Interaction Cross Section library that provides the atomic data needed to perform Electron and Photon transport calculations. Atomic data are provided for elements Z = 1 to 100, over the energy range 10 eV to 100 GeV. EPICS2017 include four separate databases:

1) EEDL: the Evaluated Electron Data Library, describes the interaction of electrons with matter

2) EPDL [2]: the Evaluated Photon Data Library, describes the interaction of photons with matter

3) EADL: the Evaluated Atomic Data Library, describes the emission of electrons and photons following an ionizing event, caused by either electron or photon interaction on atoms

These data files are prepared by Dr Dermott E. Cullen, National Nuclear Data Center, BNL, alumnus, Nuclear Data Section, IAEA, Vienna, alumnus, University of California, LLNL, retired, 1466 Hudson Way, Livermore, CA 94550.

In this technical note, we explain explicitly the format of EPDL2017.

1. Original data files of EPICS2017

We can download the databases on the web site of IAEA as indicated in Fig. 1:

https://www-nds.iaea.org/epics/

Whole Libraries (ALL Elements: Z=1 to 100, in one file)				
ENDF Format	ENDL Format (ALL updated July 2018)			
EADL (updated Apr. 2018)	EADL			
EEDL	EEDL			
EPDL	<u>EPDL</u>			
Individual Elements (EAC	H Element: Z=1 to 100, in a separate file)			
Individual Elements (EAC	H Element: Z=1 to 100, in a separate file) ENDL Format (ALL updated July 2018)			
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Individual Elements (EAC) ENDF Format EADL (updated Apr. 2018) EEDL EPDL	H Element: Z=1 to 100, in a separate file) ENDL Format (ALL updated July 2018) EADL EEDL EPDL			

Fig. 1. Download page of IAEA website.

2. Description of EPDL2017.ALL

2.1. Physical quantities

The data file **EPDL2017.ALL** (Evaluated Photon Data Library) [3] contains complete information for particle transport for Z = 1-100 and specific data as follows:

1) Coherent scattering

a) integrated cross section,

b) form factor,

c) real and imaginary anomalous scattering factors,

d) average energy of the scattered photon,

2) Incoherent scattering

a) integrated cross section,

b) scattering function,

c) average energy of the scattered photon and recoil electron.

3a) Total photoelectric reaction

a) integrated cross section,

b) average energy to the residual atom, i.e., local deposition,

c) average energy of the secondary photons and electrons.

3b) Photoelectric reaction, by subshell

a) integrated cross section,

b) average energy to the residual atom, i.e., local deposition,

c) average energy of the secondary photons and electrons.

4) Pair production reaction

a) integrated cross section,

b) average energy of the secondary electron and positron.

5) Triplet production reaction

a) integrated cross section,

b) average energy of the secondary electron and positron.

2.2. Units

Energy is in MeV.

Cross section is in **barns**.

2.3. Format

EPDL2017.ALL contains a series of tables in **ASCII format**. Each table starts with **two header lines** that contain the parameters related to the data that follow (Fig. 2). The two header lines are followed by a series of two-column **physical data lines**, one data point per line. Each table is terminated by an end of table line which is blank except for a 1 placed in column 72 (column 72 is blank on all other lines in the table). Fig. 2 presents an example of two complete tables contained in **EPDL2017.ALL**.

	2808	9.388700000E+04 8.239800000E-15				
	2809	1.00000000E+05 7.736000000E-15				
	2810			1		
first header line —	2811	1000 7 0 1.00797 1807172 2 0.0 0.0	0.0	first table		
second header line	2812	73 11 91 0.0 1. 0.0 0.0	0.0			
	2813	1.36000000E-05 1.36000000E-05				
	2814	1.00000000E+05 1.36000000E-05				
end of table —	2815			1		
	2816	1000 7 9 1.00797 1807172 2 0.0 0.0	0.0	second table		
	2817	73 10 91 0.0 1. 0.0 0.0	0.0			
	2818	1.36000000E-05 0.00000000E+00				
	2819	1.00000000E+05 1.00000000E+05				
	2820			1		



2.3.1. Information in the first header line

As an example, some detailed explanations are given in Fig. 3 for the first header line extracted from the first table presented in Fig. 2. Only the information pertinent to EPDL2017 is considered.



Fig. 3. Information in the first header line of table

Additional information:

- for mass number, in all cases A = 0 (for elemental data)
- for **incident** particle (**i index**),
 - Yi = 0, no incident particle
 - Yi = 7, photon
 - Yi = 8, positron
 - Yi = 9, electron
- for secondary/outgoing particle (o index)
 - Yo = 0, no secondary/outgoing particle
 - Yo = 7, photon
 - Yo = 8, positron
 - Yo = 9, electron
- for date: YYMMDD
- for interpolation flag

Iflag = 0, or 2, linear in x and y Iflag = 3, logarithmic in x, linear in y Iflag = 4, linear in x, logarithmic in y Iflag = 5, logarithmic in x and y

2.3.2. Information in the second header line

Fig. 4 illustrates the information contained in the second header line. As an example, we extracted the second header line from the first table presented in Fig. 2.





Additional information:

- for reaction descriptor (it is equivalent to the notion "physical process" used in Geant4)
 - C = 71, coherent scattering
 - C = 72, incoherent scattering
 - C = 73, photoelectric effect
 - C = 74, pair production
 - C = 75, triplet production
 - C = 93, whole atom parameters
- for reaction property
 - I = 0, the table contains data about the integrated cross section
 - I = 10, the table contains data about the average energy of secondary/outgoing particle, Yo
 - I = 11, table contains data about the average energy to the residual atom
 - I = 941, table contains data about the form factor
 - I = 942, table contains data about the scattering function
 - I = 943, table contains data about the imaginary anomalous scattering factor
 - I = 944, table contains data about the real anomalous scattering factor
- for reaction modifier
 - S = 0, no X1 field data required
 - S = 91, X1 field data required
- for X1, value depends upon the value of S

S = 91, X1 = subshell designator

2.3.3. Physical data lines

After the two header lines, are given the two-column physical data lines, **with 10 significant digits**. The physical quantities tabulated in these data lines depend on the value of the reaction property number I, which is indicated in the second header line (Fig. 4).

For example, in Fig. 4, I = 0. That means the physical data is about the integrated cross section. Therefore, the first column is the energy (**MeV**) of incident gamma, and the second is the corresponding cross section (**barn**).

References

[1] Cullen DE. EPICS2017: April 2019 Status Report. NA; 2019.

[2] Cullen DE. A survey of photon cross section data for use in EPICS2017. IAEA-NDS-225, rev. 1; 2018.

[3] Perkins S, Cullen D. ENDL type formats for the LLNL evaluated atomic data library, EADL, for the evaluated electron data library, EEDL, and for the evaluated photon data library, EPDL. International Atomic Energy Agency; 1994.