NADS: A WEB APPLET FOR MANIPULATION AND GRAPHICAL VIEWING OF NUCLEAR DATA

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ABSTRACT

We have developed a program called NADS (Nuclear and Atomic Data System) which provides a web-based, user-friendly interface for viewing nuclear data. NADS uses a client/server model. The client is a Java applet that runs in a web browser. The server is a Python code that delivers pointwise data to the applet per user request and then plots the data. The data is also stored in tables for viewing and modifying. NADS can display 2-D, 3-D and 4-D (time sliced) data in a powerful, user-friendly environment. Currently, evaluated nuclear data are available from ENDF/B-V, ENDF/B-VI, JENDL, JEF and Lawrence Livermore National Laboratory's ENDL databases. LLNL's ENDL database has data for neutron, gamma and charged particles as projectiles. In addition to displaying and saving data, NADS has the capability to perform computations with the data. NADS is accessible over the Internet at http://nuclear.llnl.gov/.

Key Words: NADS, graphical, plot, ENDF, ENDL

1 INTRODUCTION

1.1 Overview of Databases

Fundamental to nuclear applications are the nuclear data which are fed into them. The evaluated nuclear data are derived from the experimental data, which are stored in the EXFOR [1] database. Each evaluator creates a nuclear data set based on certain principles, assumptions and analysis. Currently, there are 6 major evaluations. They are: ENDF/B [2] from Brookhaven National Lab., ENDL [3] from Lawrence Livermore National Lab., JEFF [4] from Europe, JENDL [5] from Japan, BROND [6] from Russia and CENDL [7] from China. All the databases except ENDL store their data using the ENDF/B format. This format is a combination of pointwise and parametric data. ENDL only uses a pointwise data format.

Since nuclear data are important, visualization tools have been created to view the data. Brookhaven National Laboratory [8] and Los Alamos National Laboratory [9] offer web forms to visualize some of the data. JANIS [10] represents a user-friendly graphical approach to view the experimental and evaluated nuclear data. Lawrence Livermore National Laboratory has developed its own nuclear data viewer called NADS: Nuclear and Atomic Data System.

1.2 Features of NADS

NADS is available through the Internet by pointing a Java 1.4+ enabled browser to http://nuclear.llnl.gov/. It presents a user-friendly graphical interface for viewing nuclear data such as neutral and charged particle cross sections, outgoing spectrum distributions and outgoing energy. The data are shown in tables as well as in interactive 2-D, 3-D and 4-D plots. The data

and plots may be copied and pasted into other documents. NADS also presents a powerful computational ability for manipulating data. An online help menu is available to explain each feature.

1.3 Benefits to Users

One of the main uses for NADS is to look at cross section data to see if they make sense in light of an experiment or calculation. Comparing evaluations is another use for NADS. Some users may wish to check evaluated data versus experimental data with uncertainties. Plotting cross sections for a presentation or exporting the data to a spreadsheet is yet another benefit. Finally, some may use NADS for computations such as determining macroscopic cross sections or looking at attenuation in a slab as a function of energy.

Figure 1. Screen capture of NADS's data tree viewer. In this example the evaluated data branch is opened. Under this, the user has opened LLNL's endl94 database which shows a list of available projectiles. The user has opened deuteron as a projectile which shows a list of available targets (only hydrogen is visible). The hydrogen target has been opened and a list of reactions shown. The H-1(d, n p)H-1 reactions has been opened and its cross section is highlighted.

As mentioned in the Introduction, LLNL uses the ENDL format. ENDL is a pointwise format. LLNL database has data for neutron, gamma and charged particles as projectiles. In addition, spectrum and outgoing energy data are available.

Since most of the world uses ENDF/B format, a translation program was developed called Fête [11] that converts ENDF/B-VI formatted data into ENDL formatted data. Currently, translated versions of ENDF/B-V, ENDF/B-VI, JEFF and JENDL are available via NADS. In addition, LLNL's processed deterministic data (ndf) and cross-section data from EXFOR are also available.

A user chooses data in NADS by opening the data directory viewer as shown in Figure 1. In this figure, the tree has been expanded to show the evaluated databases. Under "endl94" the projectile deuteron was opened. The hydrogen-1 target has been chosen followed by the reaction in which the incident deuteron breaks up into a neutron and proton. The next level shows the data itself in a color coded format. The dimensionality of the data is represented with colors where red, pink and blue mean 2-D, 3-D and 4-D, respectively. The green "Target Option" leaf may be double clicked to enter target options such as the temperature of the target for heating of cross section data.

Double clicking on a data leaf downloads the data from the server, plots the data and stores it in a table. The data may also be sent to the "Computation" window described below. Selecting multiple sets of data allows for all the data to be plotted all at once. In the case of a computation, the data are sent to the computation window as a merged data.

3 CLIENT / SERVER MODEL

NADS works under a client/server model as demonstrated in Figure 2. The client is a Java applet while the server is a Python program that connects to various routines to serve up the data. Java was picked as the client because it runs on many platforms, is found in most common Internet browsers, has high security, and has strong features for networking and graphing. NADS is designed to be an applet as opposed to an application so it can be upgraded with no redistribution of the executable.

Figure 2. Clients send requests to the server which uses access routines to gather the data and return them to the clients.

The client and server communicate across the Internet using an XML-formatted protocol. This simple breakup in handling communication decouples the client and server development except for message passing. The NADS server communicates with access routines to read in the data and perform any needed manipulations such as heating or weighting.

4 PLOTTING

4.1 2-D Plotting

An example of a 2-D plot is shown in Figure 3. This figure shows a plot of the total cross section of oxygen-16. The red data is experimental data from EXFOR with the uncertainties shown. The cyan line is the ENDL94 data. The plot is zoomed in to show how well the evaluated data matches this experimental data.

The plot is made up of components such as the graph, legend, title and axis labels. A component can be moved by clicking on it and dragging it. Clicking and dragging in one of the border grow boxes allows for the component to stretch or shrink.

Right-clicking on a component allows for one to position it in front or behind other components. The user may select the properties option as shown in Figure 4. Many options may be selected such as autoscaling, linear/log axis, label names, fonts and marker/line styles.

Dragging in the graph creates a rectangle that allows for zooming in or out. One can zoom into the whole rectangle or just the horizontal or vertical axes can zoom. For zooming out, the larger the rectangle, the further out the plot will expand.

Figure 3. Comparison of EXFOR data to Endl94 for the total cross section for a neutron hitting oxygen-16 from 3 MeV to 7.3 MeV.

Figure 4. Properties for the 2-D plot. Other options may be chosen by selecting the tabs at the top.

4.2 3-D and 4-D Plotting

NADS can display 3-D and 4-D data in user-controlled plots as well. A 4-D plot is a series of 3-D plots where the 4th dimension is treated like "time." An example of a 4-D plot is given in Figure 5. A user may adjust the different axes with the controls on the right. Rotation may be accomplished with the controls or by clicking and dragging in the plot window. The "time" axis may be selected or animated with the controls in the bottom right. There are also options to fully scale the current "time" to fill the current plot window. The 3-D plot is just like this plot except the "time" axis controls are not present.

Chart options are available under the "Chart" menu. The option dialog allows for linear/log to be set for the three major axes. It allows for different line coloring as well as selecting the symbol. Other options such as allowing for cross hatching of the lines as well as changing plot size may be set as well.

Figure 5. 4-D plot example for the outgoing angle and energy distribution of a neutron for the Be-9 + n → 2n + 2He reaction.

5 TABLES

All data plotted are stored in a table where each row represents a point. Data may be copied and pasted to and from other applications such as text processors or spreadsheets. Using the controls on the right side of a table as shown in Figure 6, one can add or delete highlighted rows. Data may be entered by hand and plotted, or sent to the computation window for further manipulation.

The "Table" menu offers options to rename column headers, change table title or change the number of columns. The names "Positive dx", "Negative dx", "Positive dy" and "Negative dy" are reserved names showing relative uncertainty on the x and y axes.

Tables may also be saved and loaded from the "File" menu. All cut/paste and file operations involve extending security policies to the NADS applet so it has permission to access these functions. Check out the "Frequently Asked Questions" on the main page for directions on how to set up policy permissions.

E (MeV)	cross-section (barns)	Positive dy	Negative dy
1.447	3.468	0.07532	0.07532
1.448	3.363	0.06726	0.06726
1.45	3.424	0.07018	0.07018
1.451	3.354	0.06635	0.06635
1.452	3.455	0.0735	0.0735
1.453	3.632	0.1034	0.1034
1.455	3.462	0.08351	0.08351
1.456	3.449	0.08387	0.08387
1.457	3.486	0.08567	0.08567
1.458	3.511	0.08962	0.08962
1.459	3.423	0.08084	0.08084
1.461	3.484	0.08385	0.08385
1.462	3.443	0.08249	0.08249
1.463	3.442	0.08214	0.08214
1.464	3.414	0.07804	0.07804
1.465	3.385	0.07309	0.07309
1.467	3.45	0.08215	0.08215
1.468	3.469	0.08281	0.08281
1.469	3.474	0.0835	0.0835
1.47	3.485	0.08494	0.08494
1.472	3.338	0.07001	0.07001
1.473	3.423	0.0789	0.0789
1.474	3.437	0.08116	0.08116
1.475	3.468	0.08421	0.08421
1.477	3.441	0.07955	0.07955

Source: NADS Server

New Plot ▼   Plot Selected

Send to Computation

Add Row   Delete Row

rack, H. T. Heaton | exfor: 10005003
1H(n,Total)
(1969) R. B. Schwartz, R.

Figure 6. Table example of the total cross section from neutron hitting hydrogen-1 from the EXFOR database. Uncertainties in the y axis are shown in the two right columns..

6 COMPUTATIONS

One of the most powerful tools available in NADS is the ability to do computations on the data. Computations are performed in the computation window as shown in Figure 7. To send data to the computation window, selected the desired data from the data directory window as shown in Figure 1. Then, click on the "Compute with Selected" button to send the data to the computation window. In the computation window, the data are accessed through variables (under the symbol heading). In the example in Figure 7, the symbols "a" and "c" are the total cross sections for a neutron hitting carbon and hydrogen, respectively. "b" and "d" are the corresponding capture cross sections. The equation "a + 2 * c" is set to the variable "e" by

typing the equation and pressing the "Store" button. The final equation shown, "(1 – exp(-2 * e)) * f / e", is then plotted by clicking on the "Process" button. Many functions beside the exponent function are available and are described under the "Help" menu. The computation session may be saved to a text file under the "File" menu.

Figure 7. Computation window example showing the capture fraction as a function of energy for CH$_2$.

If several sets of data are selected in the database directory window and sent to the computation window, they are stored as a merged entity. For 2-D evaluated data, this is equivalent to the data being added together. However, the EXFOR data are not lines, but points. So a merge of this type of data just combines all the points. Computations for 3-D and 4-D are not supported at this time.

User defined data may be entered into a new blank table and sent to the computation window. This allows for many advanced computations to take place such as flux weighting or modifying cross sections.

7 FUTURE WORK

NADS development is an ongoing project with many features planned for the future. Some of the upcoming enhancements are

1. A relational database search capability.

2. Plotting ACE formatted files.

3. Plotting of EXFOR distribution data

4. Faster 2-D plotting of very large data sets.

5. To allow for text and arrows to be placed on 2-D plots.

6. To package the 2-D plotter as freeware for others to use.

Feature requests to NADS may be submitted by email to the authors or by using the "Feedback" dialog under the "File" menu.

8 ACKNOWLEDGMENTS

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