A. Nouri, P. Nagel*

JANIS: new software for nuclear data services

Basic nuclear data are fundamental to all applications involving radioactive materials and nuclear fuels. These data cover both the properties of radioactive nuclei and the elementary laws of nuclear interactions. Two important aspects are to be taken into account when providing nuclear data services:

- The volume of data is large (several hundreds of megabytes for a comprehensive library).
- There is a wide variety of applications and of end users of these data.

The first requirement calls for the utilisation of efficient means to store and to retrieve the data, and for the definition of standardised formats to allow their exchange among users and their treatment with specialised computer codes. The Evaluated Nuclear Data File (ENDF) format, for instance, provides a comprehensive way of representing nuclear data. However, these formats become too complex for a non-specialised user. Furthermore, cross-platform compatibility requires the formats to be based on textual representation of the data. It becomes difficult even for specialised users to check and handle the data contained in large files. Both experienced and non-specialised users would thus benefit from easy and efficient access to nuclear data that does not require prior knowledge of the storage format.

Background

The OECD Nuclear Energy Agency Data Bank is part of an international network of data centres in charge of the compilation and dissemination of basic nuclear data. The NEA and the other centres provide an essential link between nuclear data producers and users.

* *Dr. Ali Nouri (ali.nouri@oecd.org) and Dr. Pierre Nagel (nagel@nea.fr) are members of the NEA Data Bank.*

The NEA has accumulated experience in the development of user-friendly means for accessing and manipulating data. Two axes of developments were conducted.

Nuclear data display software installed on desktop computers offers flexibility in terms of the users' interface. However, the user does not have access to the latest version of the data. JEF-PC is an example of such software. It was developed by the NEA in the early nineties in collaboration with the University of Birmingham, UK, the *Centre de Spectrométrie Nucléaire et Spectrométrie de Masse*, Orsay, France and the UK nuclear industry. Versions 1.0 and 2.0 were released in 1994 and 1998, and were acquired by more than 500 users. JEF-PC features include the display of evaluated and experimental cross-sections, radioactive decay data and fission yields.

The other option concerns Internet access. The NEA has been using relational databases since 1993 to provide a centralised repository of data and has used web technology to allow interactive retrieval of the data. The NEA website (www.nea.fr) offers interfaces to the main nuclear databases: EVA for evaluated data, CINDA for bibliographical information and EXFOR for experimental data. The latter also includes on-line plotting capabilities. By accessing centralised information, web users benefit from up-to-date data. The drawbacks are that the graphical interface is less sophisticated and the user may be limited by the amount of data he or she can transfer.

Important feedback was received from the users of these two kinds of services. Suggestions for further developments of the JEF-PC program in order to add new features (such as possibilities for plotting angular and energy distributions) faced the problem of software architecture. JEF-PC was developed using Borland C++, which implies limitations in terms of compatibility on different

operating systems and flexibility of the users' interface. The solution therefore resided in a combination of software development and web-based services.

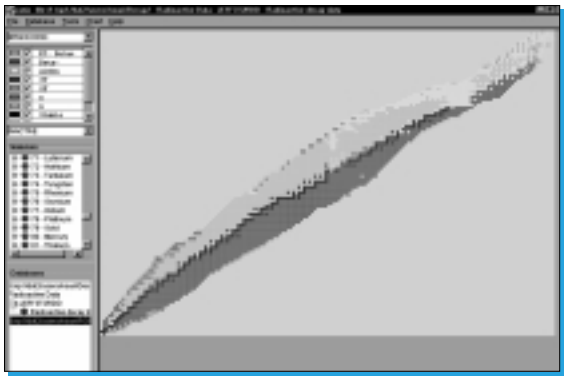
Investigations of different programming languages were carried out in 1998 and 1999 taking into account criteria such as cross-platform portability, performances in terms of execution time and the possibility of having dual usage as explained above (i.e. software and web-based). Java technology offered the optimum choice and a project was launched by the NEA to design a new software called JANIS (Java Nuclear Information System) which would supersede JEF-PC in terms of features and portability while maintaining comparable performances in terms of execution time. This new software would also offer all the necessary connectivity to web services and centralised databases.

JANIS features

JANIS can access data contained in comprehensive databases (typically all materials contained in an evaluation library) or in a single file (typically data for one nuclide either retrieved from centralised databases or obtained from data processing codes). The formats supported are: ENDF-6 (along with the linearised, pointwise option PENDF and the group-wise option GENDF) and the computerised format derived from EXFOR. Data originating from the major evaluation files ENDF/B, JEF(F), JENDL, BROND... can be displayed and compared.

Various navigation tools are available for helping the user identify the nucleus of interest. Figure 1 shows the "Chart of Nuclides" and "Nuclide Explorer". The properties of the selected nuclide are then displayed using textual, graphical or tabular formats. Search capabilities are also included, enabling the user to query the databases and to identify nuclides that have specific characteristics.

Figure 1: Chart of nuclides and nuclide explorer



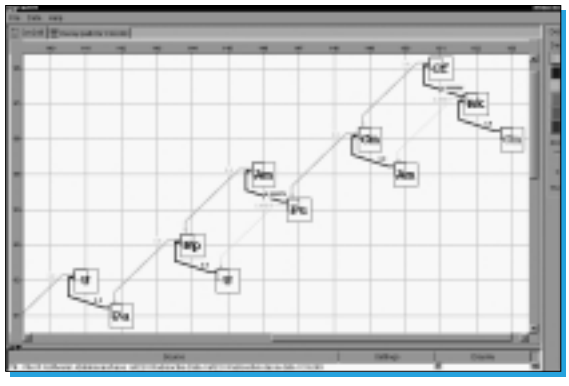
Radioactive decay data

JANIS provides a summary of important properties of radioactive nuclides. This includes the mass of the nuclide, its excitation energy, the spin and parity, the half-life, the mean decay energies and decay modes. For each decay mode, the corresponding Q value, branching ratio and nuclide produced are given.

The decay path followed by a particular nuclide towards stability (also called the decay chain) can be displayed (see Figure 2). This chain is constructed from the information available in the library (half-life, decay modes, branching ratios). The decay path is produced in tabular and graphical formats.

Discrete and continuous spectra of emitted particles (gamma and X rays, alpha particles, beta+ and beta-) are represented in JANIS using tabular and graphical formats. The information displayed includes: the energy of the emitted particle and the corresponding uncertainty, relative and absolute line intensity and the associated errors.

Figure 2: Radioactive decay path

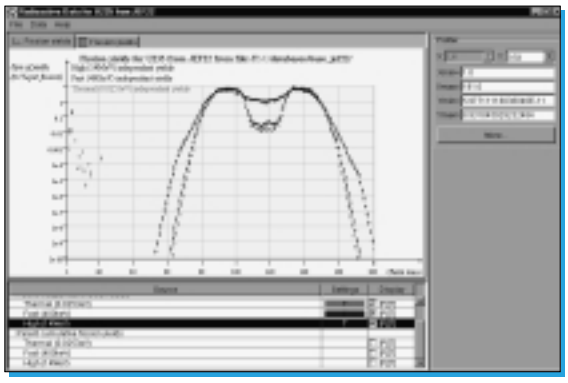


Fission yield data

Fission yields give the proportion of nuclides produced by fission. Data exist as independent yields (yield directly produced by fission prior to delayed neutron, beta decay, etc.) and cumulative yields (which account for all decay branches after fission). JANIS displays these yields using tabular and graphical formats. The tabular format gives the yield for all products (isotope, excitation energy state) while the graphical representation gives the fission yield as a function of the chain mass (sum of yields for a given mass number A).

Fission yields depend on the energy of the neutron causing fission. Independent and cumulative yields are thus given for typical neutron spectra (thermal neutron-induced, fast neutron-induced and high-energy neutron-induced fission). Spontaneous fission yields are given as well. An example of an independent fission yield graph is given in Figure 3.

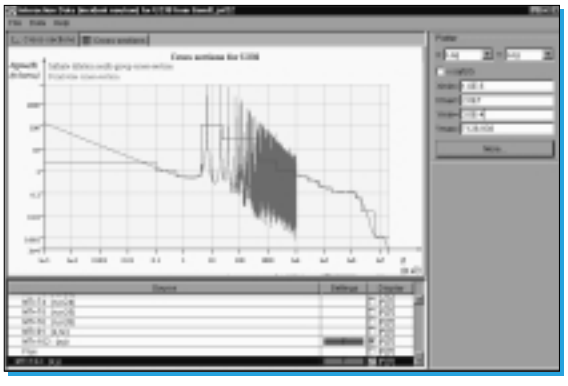
Figure 3: Fission yield data



Interaction data

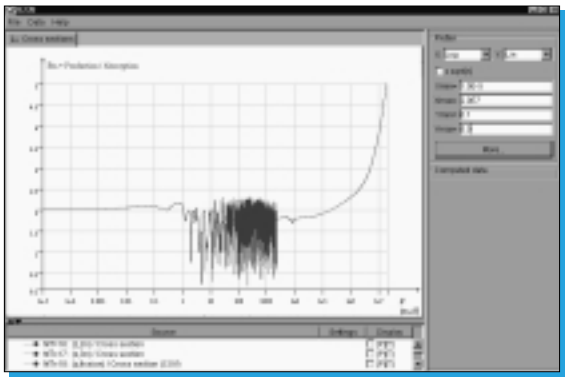
Data displayed in this category include cross-sections (pointwise and mutigroup forms, as shown in Figure 4) and associated uncertainties, resonance parameters, energy distributions, angular distributions and correlated energy-angle distributions. JANIS was specially designed to offer flexibility for the comparison of different data sets.

Figure 4: Comparison of pointwise and multigroup cross-sections



Various tools enabling data manipulation are provided including simple operations with cross-sections (linear combination, product, and ratio) and flux weighting. Figure 5 shows a graphical display of $\eta = (\nu \sigma_f/\sigma_a)$ obtained from individual components in the ENDF file. Experimental data can be plotted as well with advanced search options combining reaction identifiers, projectile energy range, laboratory and date of the experiments.

Figure 5: Example of cross-section manipulation $\eta = (\nu \sigma_f/\sigma_a)$



Future developments

The current version of JANIS can access data from local or network drives and via the Internet. Developments are ongoing in order to fully link JANIS with the relational databases available on the NEA web server using distributed computing technology. The same technology can be extended to provide the user with a package of services in integrated client/server architecture. For instance, the server side can be used for data retrieval and processing at the desired temperature and accuracy using the latest version of well-established tools. The user can then choose the information to be transferred onto his or her local computer. Various options are under study aiming at optimising the amount and format of data to be transferred through the Internet. The client side will be used for the display and manipulation of data sets.

Conclusions

JANIS is meant to provide both specialised and non-specialised users with easy and efficient access to nuclear data. The software is free and can be downloaded directly from the NEA website (www.nea.fr/janis). Feedback can be posted on the web and updates downloaded automatically through the live-update feature.

The software runs on almost all operating systems and will enable users to access the latest versions of the data and associated tools through its integrated client/server architecture. Prior to its official release, JANIS was tested by more than 100 users in over 20 different countries who provided valuable feedback. ■