MODELING NUCLEOSYNTHESIS: WEB-BASED TOOLS

http://www.ces.clemson.edu/physics/nucleo/srobbins/index.html

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ABSTRACT

We have constructed a web site that allows members of the internet and scientific communities to seed and execute their own customized nucleosynthesis calculations utilizing the Clemson Nuclear Network Code. Through the provided HTML and Java interfaces, users are guided through the setup process and, after they have run the code, they can display and save results in several different ways. The Java code allows cross-platform and cross-browser compatibility as well as a standard GUI across the site to increase usability.

I. INTRODUCTION

Nuclear-reaction network codes allow researchers to follow element synthesis in stars and supernovae. These codes are complex, however, and require considerable experience and resources to run and to explore the output.

To overcome this limitation, we developed tools that allow internet users to access the Clemson Nuclear Network Code (Meyer 2002) via the world-wide web, customize their own nucleosynthesis calculations, run the calculation on a server professionally maintained by the College of

Engineering and Science (CES) at Clemson University in Clemson, SC, and visualize and save the results.

Previous access to the code required users to request the necessary FORTRAN files from the Clemson astrophysics group, compile the code on their own computers, navigate the sometimes complicated input files, and develop plotting routines to interpret the output.

With this project, any internet user may now run the code and plot or download results in a simple and straightforward manner without needing to directly access the various input nor output files. The web port for this is through IONJava - a flavor of Java that includes unique classes to communicate with a server that is running IDL and JavaScript. The interface is standardized across the site, allowing for easier and more widespread use and for high-quality output graphics.

Easy and reliable access to flexible nucleosynthesis networks is already becoming important. Numerous radioactive ion beam facilities currently operating in the world permit nuclear experimentalists to measure reaction cross sections important for nucleosynthesis. These researchers require an easy way of measuring the effect of their results. Our web site gives them the means to do this. Moreover, the currently proposed Rare Isotope Accelerator (RIA), if built, would produce isotopes at the limit of nuclear existence. This will allow researchers to measure the properties of these nuclei, which, to date, have only been extrapolated from nuclear models. As these properties of these nuclei are measured, astrophysicists will be able to use our web site to understand how this new knowledge affects the r-process of nucleosynthesis. Finally, this web site will also be a useful tool for students seeking to understand the science of nucleosynthesis.

II. WEB SITE LAYOUT

A structural diagram of the web site is shown as Figure 1. The user is guided through each page via explanatory text headers and side help bars. The plotting applets also include help buttons that the user can press to retrieve information on running the applet.
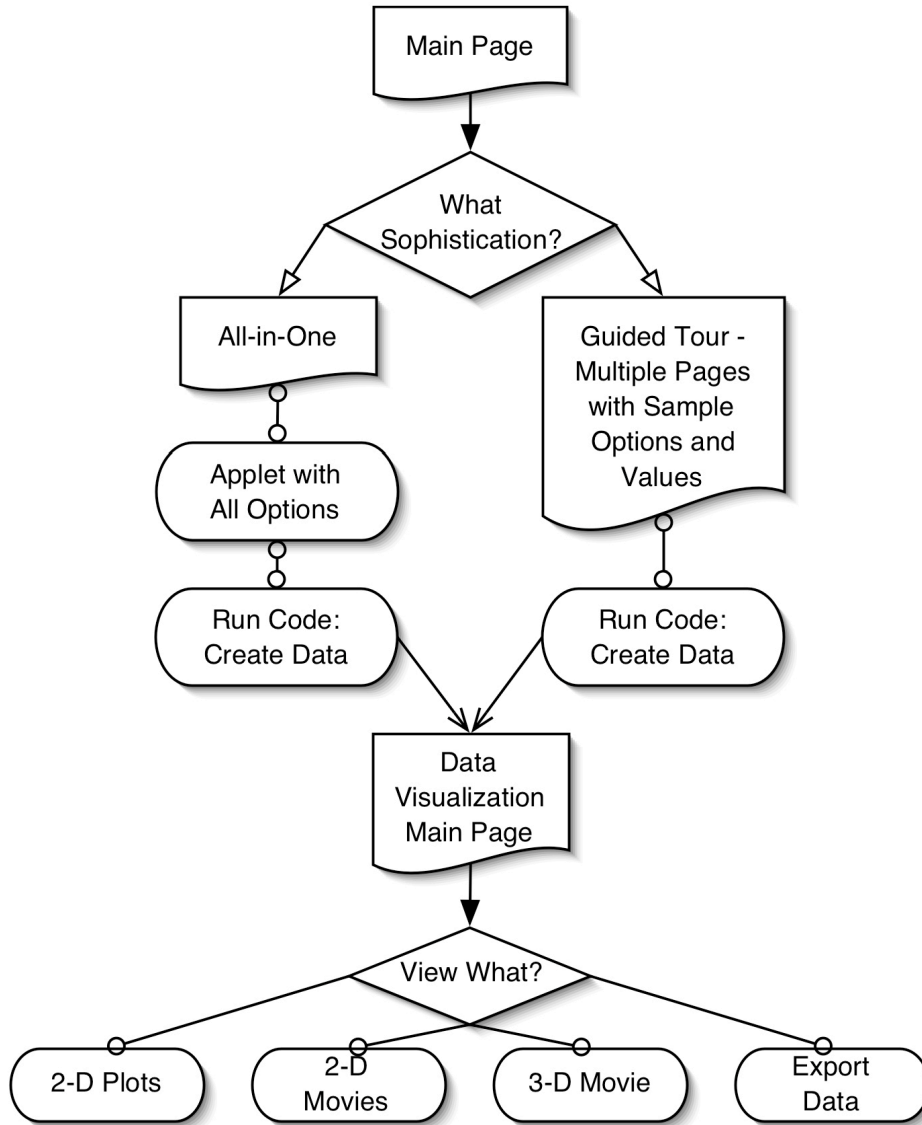

FIGURE 1: This is a structural diagram of the way the web site is organized. In this diagram, rectangles with curved bottoms represent one or multiple HTML pages, diamonds represent user choices, and rounded rectangles an applet. The "Multiple Pages …" method that allows customization of the input is in prep; see Jordan, Robbins, and Meyer (2004) for a final version and more complete discussion of this.

III. DATA GENERATION

The method for customizing one's nuclear network is a series of steps where the user is asked to enter specific information that is later used to run the network code. Figure 2 shows a screen shot of the "All in One" path's steps, format, and layout.
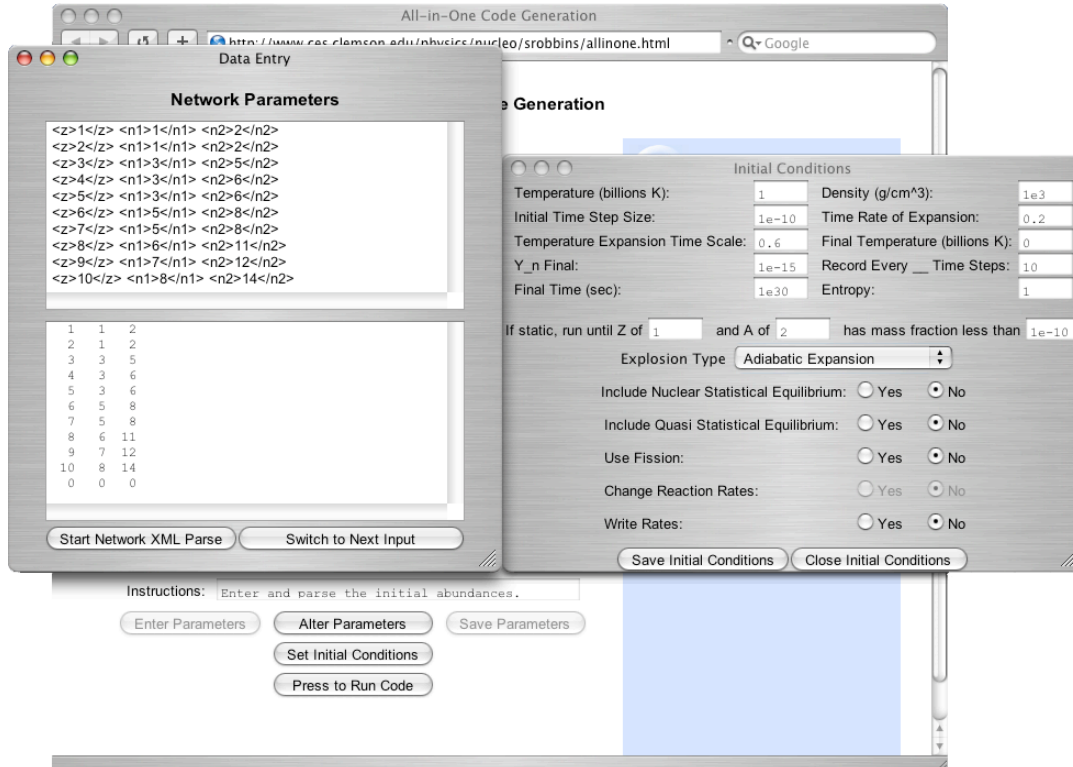

FIGURE 2: The applet embedded in the page contains an instructions bar that tells the user what the next step in customization is. The first is to enter network, initial abundance, and thermodynamics, which is done in the pop-up window seen to the left. Once the user has entered these, the applet saves them to temporary data files; after this is completed, the user is prompted to enter the initial conditions which is accomplished through the interface in the pop-up window to the right. Once these are saved, the user can run the code; when the code is finished executing, the user is automatically brought to the Data Visualization page.

For this project, the "All in One" generation is the only method for network customization and data generation. The "Guided Tour" will become the sole method in the extension of this project which will be laid out in Jordan, Robbins, and Meyer (2004).

The customization creates several temporary files on the CES server. Once the user has completed all the customization steps, the nuclear network

code will be executed, running the simulation on the CES server. The final results of the calculation are stored in a temporary output file. The final data file name is passed through a query string in the browser's Location bar at the end of the URL (see figure 3). Subsequent pages in the site have JavaScript functions that read this query string and input it as a parameter in the applets within that page.
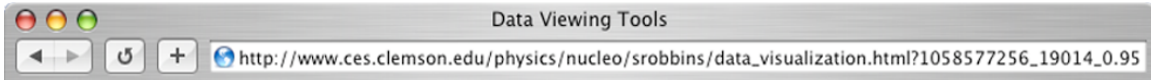

FIGURE 3: The query string of a URL is what follows a "?." Here is displayed a sample of the method in which the name of the temporary data files are passed between separate HTML pages. This is needed because Java applets cannot inherently retrieve on-the-fly information from one another.

IV. DATA VISUALIZATION & SAVING

Once the nuclear network code writes the final output file, users are taken to a data visualization landing page where they are presented with options to save the generated data in an ASCII text file or to view 2-D plots or 2- or 3-D movies. With each of these options, users are presented with a side help bar in HTML as well as help buttons within each of the applets to explain the specific functionality of the visualization applet.

The data output option (figure 4) allows the user to view and save any and all of the data that was generated in the simulation. The plots are all created on the server-side in IDL and passed to the applet for the user to view, manipulate, and save.

Due to the user interface that Java can create and the computational power provided by IDL, the user is able to manipulate any of the graphs in almost real time -- specific time results depending on connection speed, server load, network traffic, and the rendering power of the end user's interface.
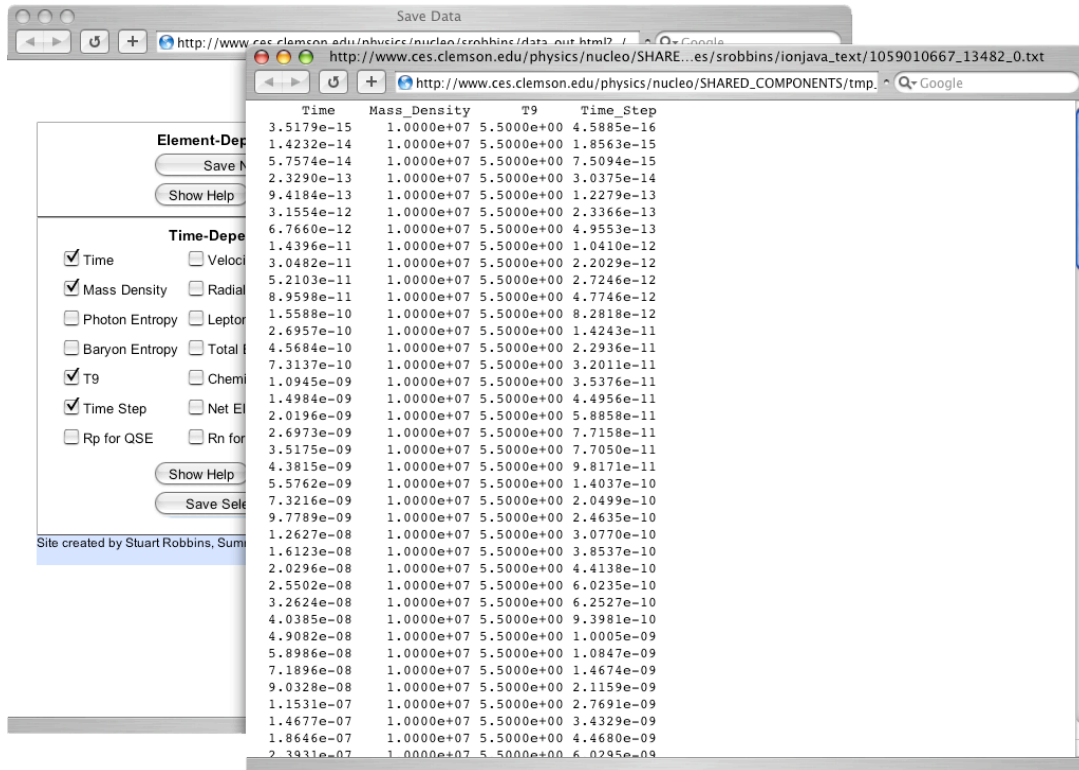
FIGURE 4: This shows the interface and the browser output from the data output applet. In the background browser window there are two applets - one from which the user can save the output network, and the other from which the user can select various data to save. The foreground window is the result: Once a user has decided what to save and has pressed the "Save …" button, a temporary text file is created on the CES server and is displayed to the user in a new browser window. The output is ASCII and in columns that are readable by most graphing programs.

V. PLOT CONTROLS

All of the plot interfaces are designed so that all the controls for the applets are as similar as possible. They are also designed so that users have the fullest possible control over all aspects of their plots. Figures 5-8 detail the various interfaces.
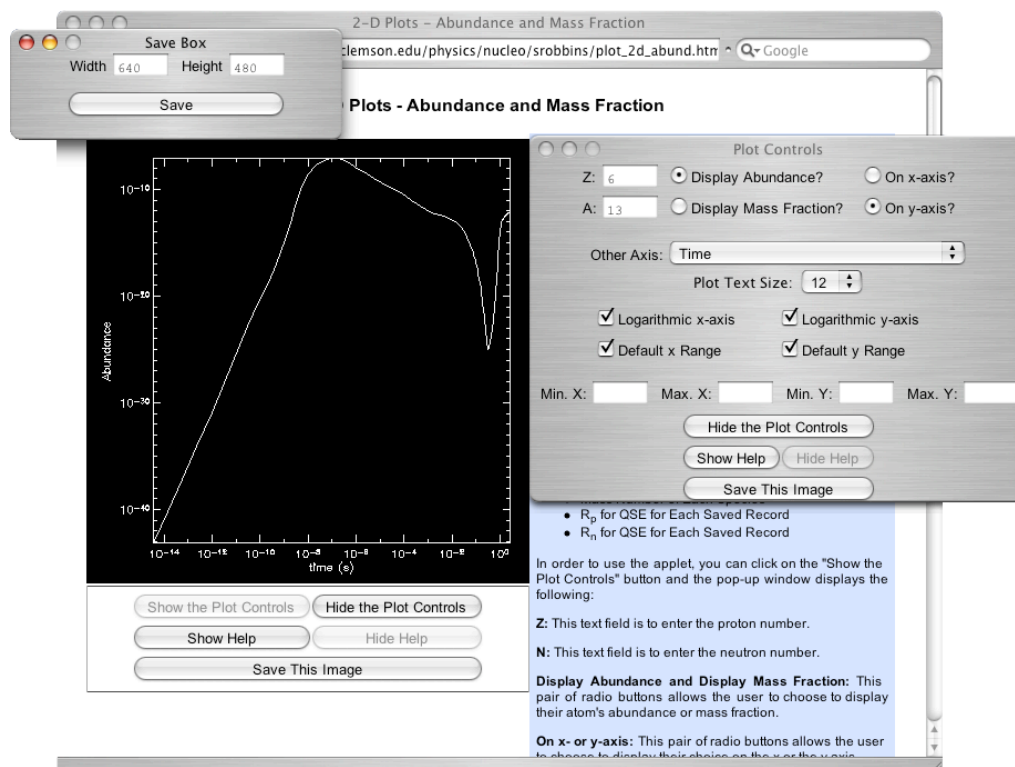
FIGURE 5: This is a screen shot of the entire control system for the 2-D Abundance / Mass Fraction plotter. The background window is the main browser window and contains the applet with the graph area and macro control buttons; the top left window is a save dialog box that opens when the user wishes to save the image; the top right window is the plot window that will open when the user chooses the "Show the Plot Controls" button on the main applet. The control panel for the 2-D Abundance / Mass Fraction plot is the most complex of the plot controls on the site. Users can enter the nuclide, graph it against another data axis of their choosing, and have full control over all aspects of the axes. Once the user is satisfied with the way the plot looks, they have the option to save the image. A new frame will open, seen in the upper left of this figure, and the user can specify the width and height in pixels of the final image; pressing the save button will open a new browser window with the image, which the user can then save to their local hard drive.

FIGURE 6: This is the control panel for the simple 2-D image plotter. Users can choose to view the various data on either axis, and they have control over log scales, axis range, and the text size. They can also view help information from this panel as well as save the image once they are satisfied with the way it looks in the main browser window.
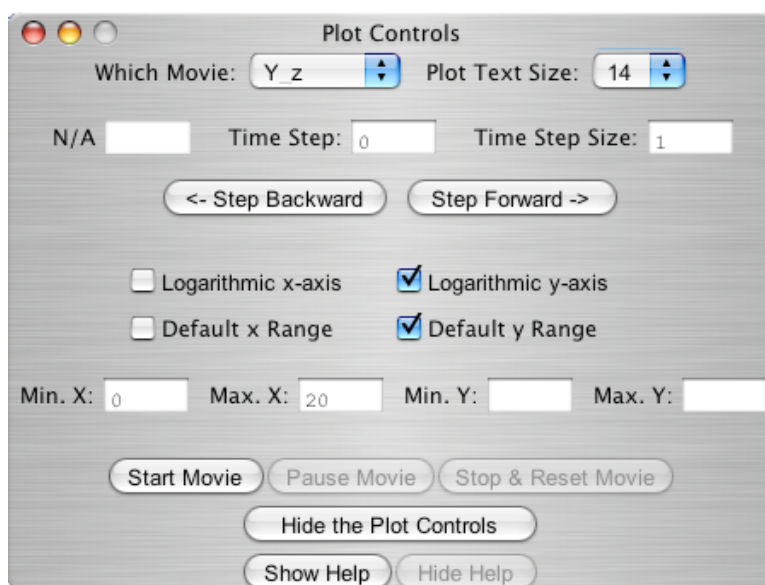

FIGURE 7: This is the control panel for the 2-D movie plotter. The user can choose from various movies from their data; if the movie requires extra input, the "N/A" text box will change, instructing the user to enter whatever information is necessary. The user, as with the simpler plots, has control over axis range, logarithmic scale, and text size. Extra controls for the movie are presented that allow the user to customize the way it is shown. For example, the users can go to any time step in the movie, select what the step size for the movie is while it is playing, and, when stopped or paused, can step forward or backward through the movie.
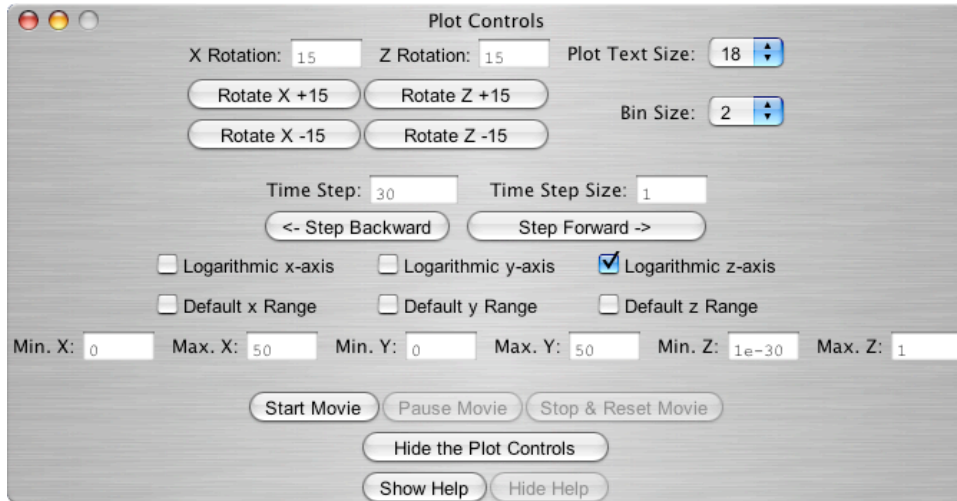
FIGURE 8: Here is the control panel for the 3-D movie plotter. The controls are identical to those for the 2-D (figure 7) except for the application of 3-D components. The movie that is displayed is neutron vs. proton number on the *x-y* plane and abundance on the *z* axis. The user has control over the view through the rotate buttons. The data can also be binned into a 3-D histogram with the bins being squares in the *x-y* plane.

VI. CONCLUSION

This web site provides a user-friendly, flexible environment for running nuclear-reaction network calculations and exploring the results. It should prove useful to students and researchers seeking to explore nucleosynthesis from the world-wide web.

The web site can be accessed at the following address:

http://www.ces.clemson.edu/physics/nucleo/srobbins/index.html

ACKNOWLEDGEMENTS

REFERENCES

Jordan, George C., IV; Robbins, Stuart J.; and Meyer, Bradley S. 2004, in preparation for Physical Review C.

Meyer Bradley S. 2002, Physical Review Letters, 89, pp. 231101.