

A Graphical User Interface for User Generated Opacity Files

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1. Abstract

A Graphical User Interface (GUI), *Vermillion* was created that graphs opacity data produced by the *APLMIX* code for mixtures of elements. The GUI produces graphs that display the opacity on the vertical axis and the user's choice of density, temperature, or frequency on the horizontal axis. This provides the user with a convenient way to assess the adequacy of the density, temperature, and frequency grids chosen for use with *APLMIX*. Features of the GUI include linear or logarithmic horizontal axis, drag-and-click zooming, dynamic panning, and various customizations. If the user wants to resolve structure in the opacity as a function of frequency by adding multiple points to the frequency grid, he/she can rapidly display the spectrum at different (temperature, density) points and identify where more frequency points are required.

2. Introduction

Hydrodynamic simulations are a significant part of research for the University of Rochester's OMEGA laser - these simulations are vital for ignition experiments. The hydrodynamic targets used in these simulations require subsets of opacity data. Opacity is the measure of the ability of an object to obstruct the penetration of x rays. Opacity is measured in units of cm^{-1} , which is equivalent to the distance that a photon will travel before being absorbed by an electron in a material. The higher the value of opacity, the more obstructed x rays are when passing through a material. LLE uses a large database of opacities for 30 elements from hydrogen to zinc, obtained from Los Alamos.¹ Opacity is stored for every possible density, temperature, and frequency combination. The opacity database consists of 14,900 frequency data points per temperature – density point. There are roughly 20 density points and 50 temperature points in a typical opacity file. Hydrodynamic simulations conducted at LLE need to work with subsets of opacity data and need to be able to mix elements as well. Mixed opacity data files are created using a FORTRAN

program, *APLMIX*.² A Java program, *Opacity Viewer*,³ allows the user to view the complete Los Alamos opacity data for individual elements. However, prior to this work, there was no simple user-accessible way to view the mixed opacity data files. The GUI (Vermillion) described in this report was designed to address this issue.

3. Vermillion

APLMIX compiles specified data from the opacity database and produces opacity data for the desired material. The User must identify the material, temperatures, densities, and boundaries for frequencies. *APLMIX* then calculates the average opacity for each of the frequency ranges, and inserts this data in FORTRAN output files known as FORT.20.

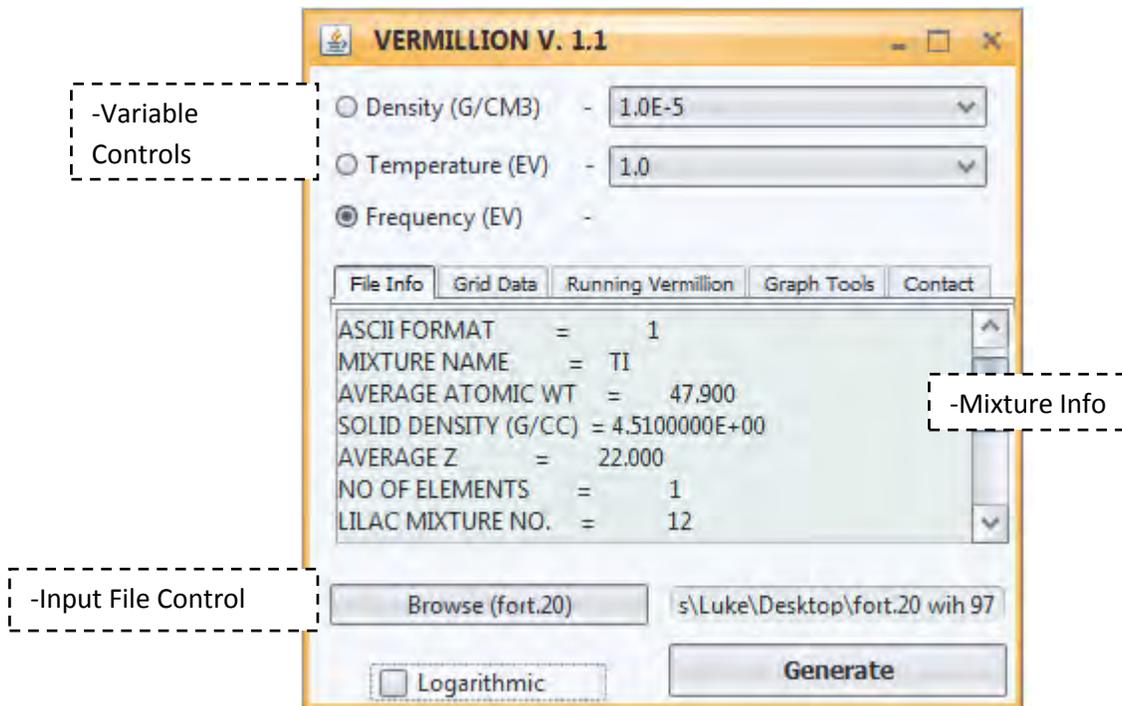


Figure 1 – Vermillion Menu 1.1 with configured graph controls and mixture information.

Figure 1 shows *Vermillion*'s three sections: the variable selection, the FORT.20 browser, and the file information. Before the graph of opacity can be created by *Vermillion*, the User must specify the directory of the FORT.20 file created by *APLMIX*. This is simply done by navigating the browse menu located at the bottom left corner of the GUI.

Vermillion will extract mixture information from the FORT.20 file such as the name of the mixture, the solid density, the atomic weight, etc. This information is displayed under the "File Info" tab of figure 1.

Vermillion will also extract the opacity data for every available density-temperature point. After this information is processed, the user has to select the two constant variables and the independent variable that will be used for the graph. In the example shown in figure 1, the density and temperature are selected as constants and frequency is chosen as the independent variable. This is the most common usage. The graph will then be generated. *Vermillion* displays opacity values logarithmically ($\log_{10}[\text{Opacity}] \text{ cm}^{-1}$) as given by *APLMIX*.

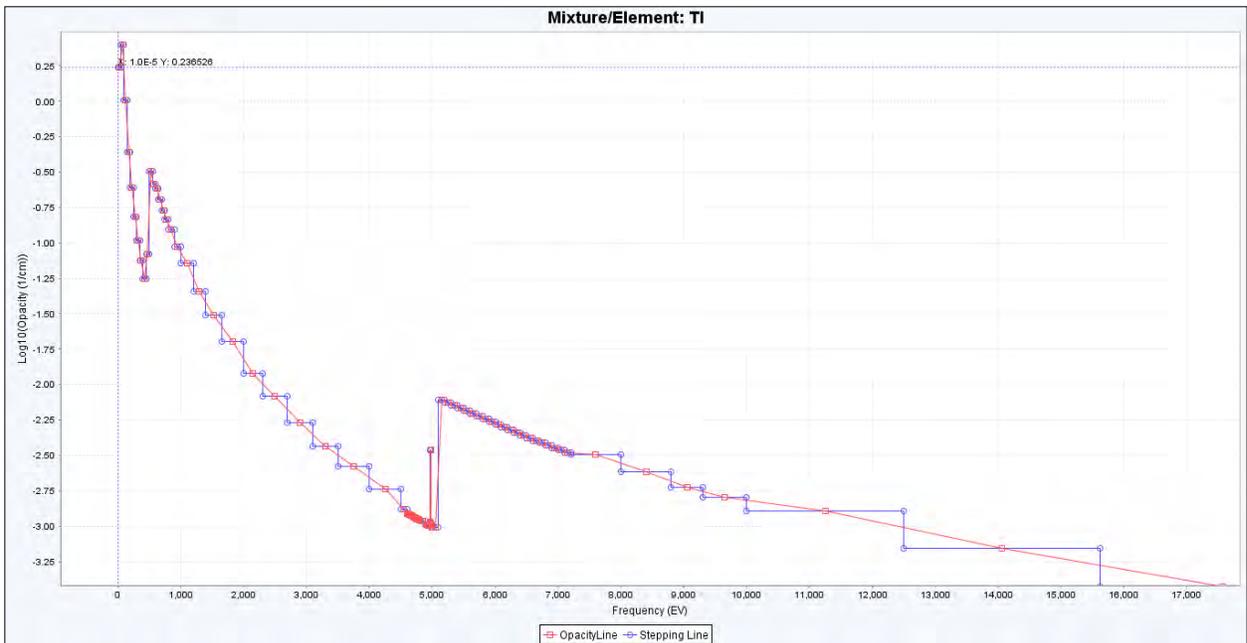


Figure 2 - Opacity as a function of frequency for Titanium, at a density of 1E-5 g/cc, and a temperature of 1.0 eV

A typical opacity graph is shown in figure 2. The range axis is always represented by logarithmic opacity, given in inverse centimeters. The domain is represented by the independent variable selected on the *Vermillion* menu. As figure 2 shows, two distinctly colored lines are given that connect two differently colored sets of points. Blue points represent the frequency grid boundaries selected by the user while red points represent the average opacity between boundaries. *Vermillion* has a number of graphing tools for ease of use. Dynamic zooming is implemented for simple one-click zooming. Dynamic panning allows the user to manipulate the window range of the graph. Other features include .PNG exporting, XY coordinate display, and direct printing.

4 Frequency Grid Adjustment

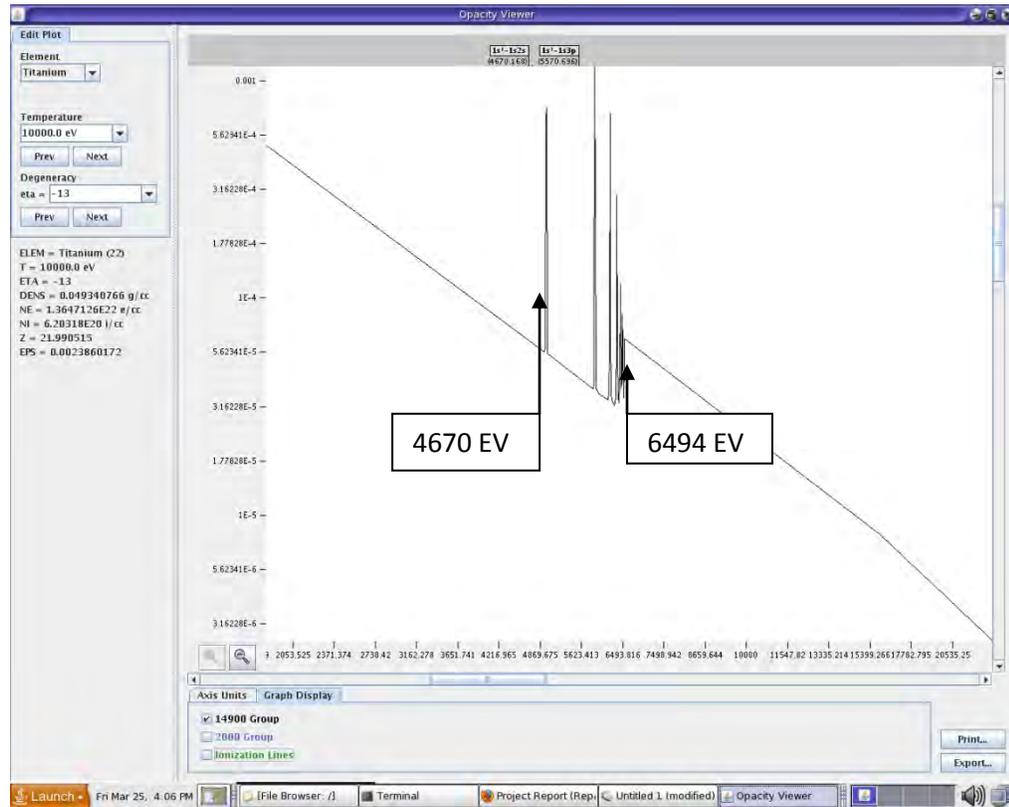


Figure 3 – Opacity vs Frequency as shown by Opacity Viewer for Ti at a density of 0.0315 g/cc and a temperature of 10000 eV

For many elements the opacity data is highly structured in the frequency domain. An example for titanium is shown in figure 3, produced by Opacity Viewer. The graph plots all 14,900 frequency points for the selected density and temperature. The result is a highly detailed graph of titanium opacity. A “standard” opacity file used in many hydrodynamic simulations uses just 48 frequency points, 18 density points, and 17 temperature points. This resolution, seen in figure 4, fails to resolve the structure of opacity for most elements and pales in comparison to its 14,900-point counterpart.

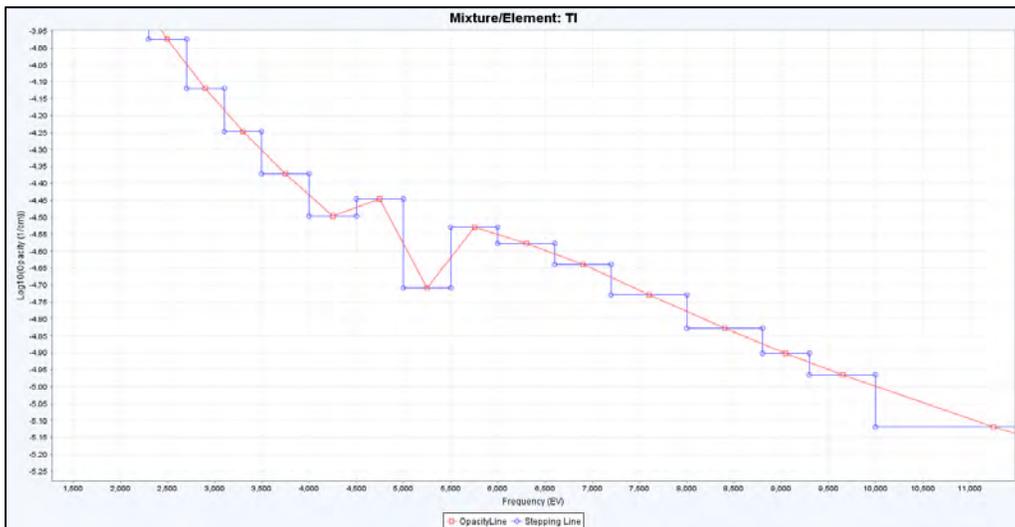


Figure 4 – Opacity of Ti as a function of frequency at a density of 0.0316 g/cc and a temperature of 10000 eV, for the “standard” 48 frequency groups.

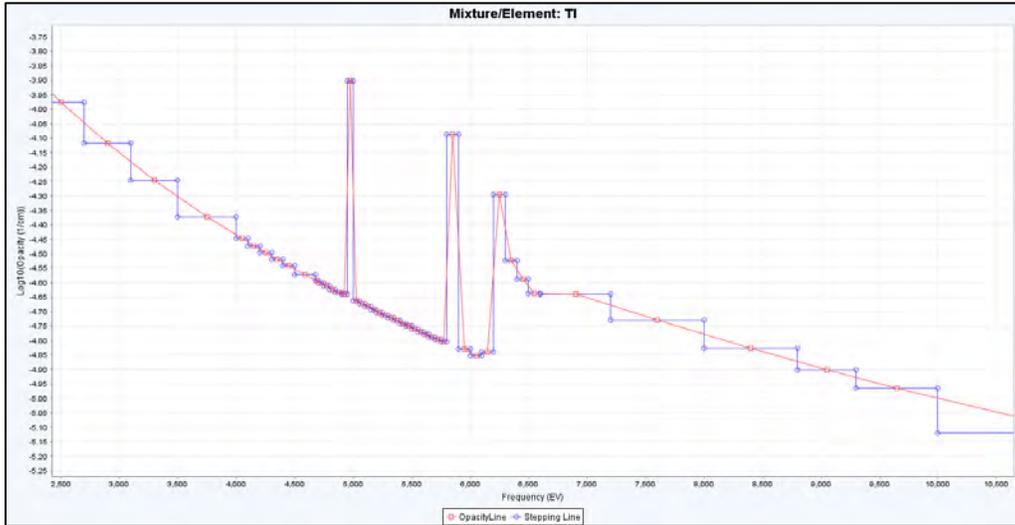


Figure 5 – Opacity of Ti as a function of frequency at a density of 0.0316 g/cc and a temperature of 10000 eV, for 80 frequency groups.

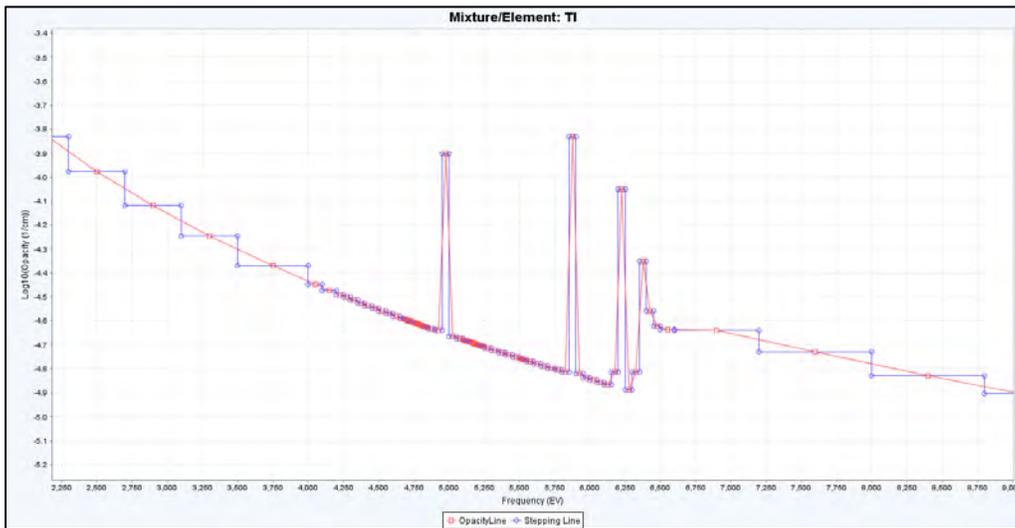


Figure 6 – Opacity of Ti as a function of frequency at a density of 0.0316 g/cc and a temperature of 10000 eV, for 120 frequency groups.

5 Conclusion

A Graphical User Interface, *Vermillion*, has been programmed for the easy viewing of opacity files for mixtures of elements. Scientists will use *Vermillion* to view opacity data under various conditions. The resulting information garnered from this data will help scientists perform more accurate hydrodynamic simulations.

6 Acknowledgements

I would like to thank Dr RS Craxton for helping me understand the science of opacity, as well as the numbers behind the opacity data itself. I would also like to thank Robert Raumbaut for his help and consultation with the programming and design of *Vermillion*.

7 References

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