

QUICK GUIDE

PlasmAbel
Abel Transformation for Optical Measurements
release 1.0

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If you have any comments or suggestions for improvements, you are welcome to contact us.

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Chapter 1

Introduction

1.1 WHAT IS PLASMAABEL

The emission spectrum contains a wealth of information about the measured object. The spectral intensity distribution is closely related to the plasma internal temperature, particle density and composition. However, the spectral intensity obtained by various methods is mostly the spatial integral value along the optical path, and the point value cannot be directly obtained. The Abel inverse transform is an important means to obtain the point value from the integral value.

The existing Abel transformation/inverse transformation methods often have low accuracy (see the last chapter validation) and singularity problems, and the calculations are complicated and repetitive. PlasmAabel is a fast Abel/Inverse Abel transform substitute developed for this problem.

PlasmAabel is a plasma optical radiation experiment/calculation data processing software developed based on Python. The software can generate Abel and inverse Abel transforms for one-dimensional/two-dimensional experimental/calculated data.

It should be noted that the measurement unit of the emission spectrum experiment is usually a.u., so PlasmAabel software is not sensitive to the absolute value of the data, and the measurement calculation results are normalized during the calculation process.

1.2 MANUAL STRUCTURE

This manual briefly introduces PlasmAabel operation methods.

Chapter 2 introduces the basic operating steps of the software, readers will be able to quickly grasp how to prepare data, input data, perform calculations and export data.

Chapter 3 introduces the detailed suggestions for the format and processing of the input and output data of the software.

Section 4 introduces software verification.

Chapter 2

How to use

A quick guide to make use of the software.

2.1 ONE-DIMENSIONAL DATA TRANSFORMATION

After the software is loaded, it contains two display boxes, the "Load data" button and the "About" button on the left, and the "Dimension", "Direction" and "Transformation" in the middle. Method” option box and the “Run”, “Export” and “Exit” buttons on the right, as shown in figure 2.1.

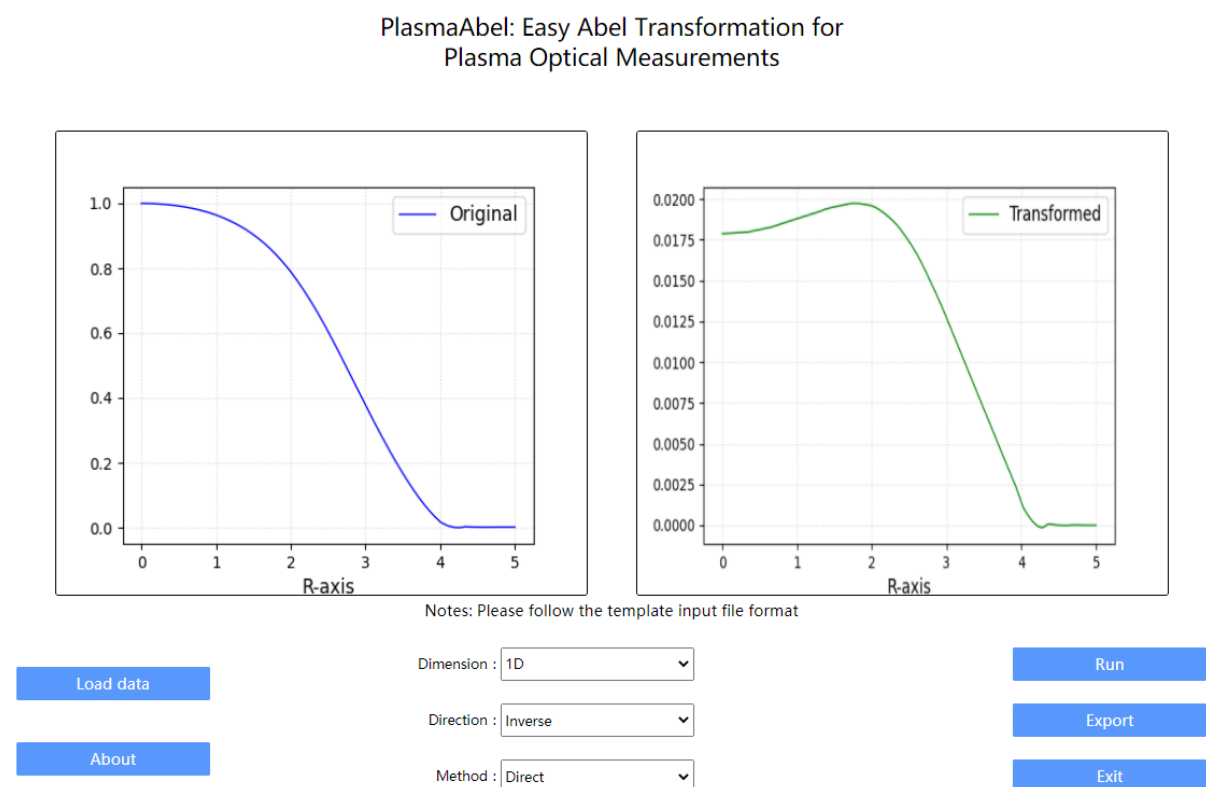


Figure 2.1: One-dimensional Abel transformation page settings and transformation results (fast ionizing wave optical radiation experimental value and inverse transformation value)

- If you want to perform Abel transformation on one-dimensional data, follow these steps:
- (1) Prepare data (one-dimensional data in two columns in a dat file, no title is needed);
 - (2) Click the "Load data" button and select the data file;
 - (3) Set the dimension (1D) in the three-column option list in the middle, select the transformation direction and transformation method and click the "Run" button on the right, the calculation result will be displayed in the display box;
 - (4) After the calculation result is confirmed to be correct, you can click the "Export" button to output the data in the display column.

Note that two-dimensional data changes: The loaded data will be automatically normalized.

2.2 TWO-DIMENSIONAL DATA TRANSFORMATION

If you want to perform Abel transformation on two-dimensional data, follow the steps below:

- (1) Prepare data (picture format);
- (2) Click the "Load data" button and select a picture;
- (3) Set the dimension (2D) in the three-column option list in the middle, select the transformation direction and transformation method and click the "Run" button on the right, the calculation result will be displayed in the display box;
- (4) After the calculation result is confirmed to be correct, you can click the "Export" button to output the data in the display column (matrix format).

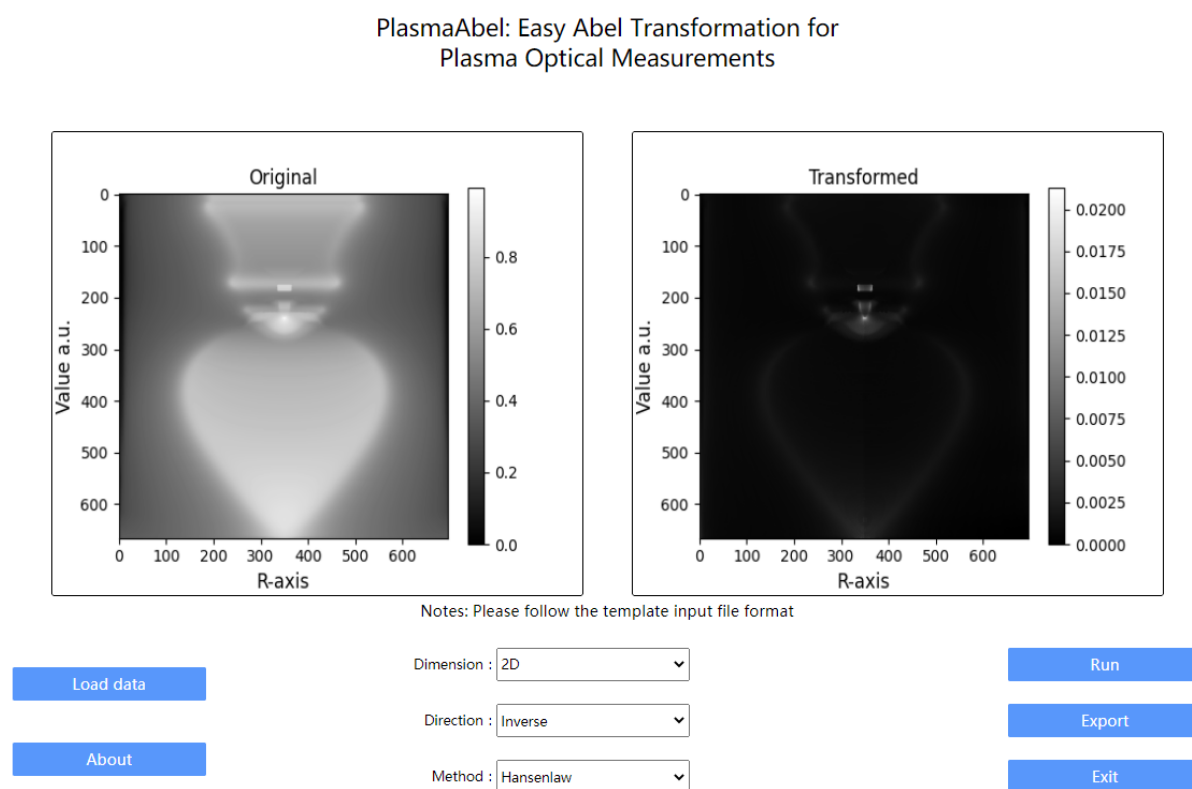


Figure 2.2: 二维Abel变换页面设置与计算结果.

The two-dimensional data changes need to pay attention to:

- (1) Input as picture format;
- (2) Choose the third method (Hansenlaw) as much as possible for the transformation method. The first method (Direct) involves global numerical integration, which is time-consuming and has little difference in calculation accuracy;
- (3) The output format is matrix data dat instead of pictures. Users can redraw and view in Origin and other software.

Chapter 3

Input/output format requirements and templates

This chapter records software input format file requirements/templates and output file formats.

3.1 ONE-DIMENSIONAL DATA FORMAT

The one-dimensional input file has two columns of data, the first column is the x-axis coordinate value, and the second column is the data. After the data is loaded, it will be automatically normalized. Please load a positive result.

The input file template is as follows, **Note: Do not add any header information in the first line!**

```

0.00000 99.0009
0.03704 98.9970
0.07407 98.9851
0.11111 98.9643
0.14815 98.9346
0.18519 98.8960
0.22222 98.8485
    
```

The format of the output file is similar to the input, but it has three columns of data. The first column is still the x-axis coordinate value, the second column is the input data, and the third column is the transformed output data. Contains the header. The format is as follows:

```

          X original transformed
0.000000000000000000 0.9092704562150362 50.7402458709814
0.00740740740740740 0.9096197088317178 50.7462139634628
0.01481481481481481 0.9099689614483994 50.7468023973068
0.02222222222222222 0.9103182140650812 50.7412166350419
0.02962962962962963 0.9106674666817625 50.7300780708903
0.03703703703703704 0.9110240640389634 50.7137843646662
0.04444444444444444 0.9115153766232508 50.6926375076886
0.05185185185185186 0.9121639071486997 50.6667165844638
0.05925925925925926 0.9129383684628406 50.6359998322099
    
```

3.2 TWO-DIMENSIONAL DATA FORMAT

The two-dimensional input file is a picture format, **please try to improve the accuracy of the picture and ensure the axis symmetry of the picture.**

The two-dimensional output data is a matrix file, which contains the drawing data of the image on the right side of the drawing frame. Users can directly use Origin software to perform post-processing drawing.

Chapter 4

Benchmark

This chapter shows the calculation results of using PlasmAbel to transform/inverse the analytic function. It is verified that the algorithm kernel used for the one-dimensional data is exactly the same as that of the two-dimensional transformation, so I will not repeat it.

To verify the unimodal function:

$$y(x) = 1000(1 - x^2) \tag{4.1}$$

The exact solution of the Abel inverse transformation corresponding to this function is:

$$Y(x) = \frac{2000}{\pi} \sqrt{1 - r^2} \tag{4.2}$$

Load the calculation result of the unimodal function as input to PlasmAbel, and the calculation result is shown in the figure below:

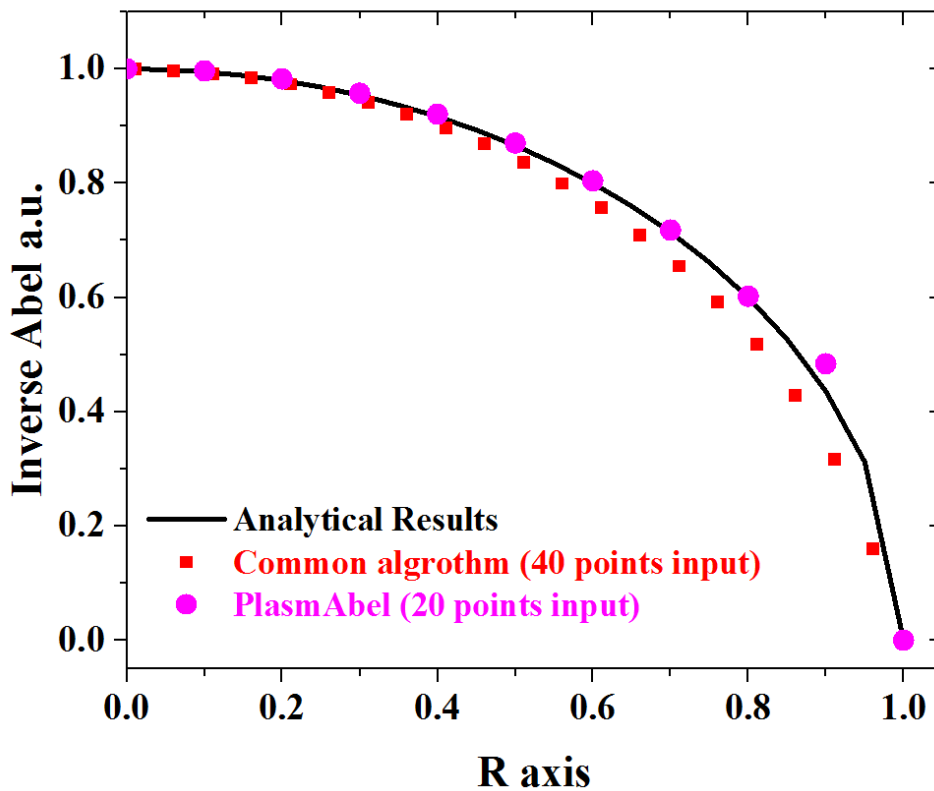


Figure 4.1: Verification of Abel pseudo-transformation results: the pink points are the calculation results of PlasmAbel (20 points are input), the black solid lines are the analytical solutions, and the red points are the calculation results of matlab (40 points) interpolation method

It can be seen from the figure that the results obtained by PlasmAbel calculation are in good agreement with the analytical solution, the calculation accuracy exceeds the ordinary algorithm, and there will be no singularity problem at the 0 coordinate position.

It should be noted that the measurement unit of the emission spectrum experiment is usually a.u., so the PlasmAbel software is not sensitive to the absolute value of the data, and

the calculation result will be normalized during the calculation process. Therefore, when performing comparison verification, users also need to normalize the analytical solutions for comparison.