

Manual for the HSFA reduction-analysis software package

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Chapter 1

Introduction

This manual is meant to help users of 0_flat_100.pro, 1_data_100.pro, 2_anal_102.pro. Originally, they are all written for Linux, but with small adjustments they can work in Windows as well. The first one generates master dark and master flat, by combining all dark frames or all flat fields given. The second one is used for calibrating the data while taking master dark and master flat which were already obtained. 2_anal_102.pro is used for analyzing the calibrated data.

Conditions that must be fulfilled before starting the software:

- All images must be in the same folder and named in the following form: 20070609.063949.700_ha_D.0.fit where 'D' stands for dark frame (or, 'F' for flat field and 'N' for the raw image of the object), 'ha' for the H_α camera or any other camera (SJ, CA, D3, H8 or IR), the date and time of the observation are in the beginning of the name. The '0' at the end should be exposition time but for older images, such information is not given in the name, therefore is written '0'.
- The IDL library must contain ASTRON, MACROS, HOOK, UTILITIES, OBSOLETE and MPFIT (sometimes MPFIT needs to be compiled separately).
- Files liege.txt and lines.txt contain information about spectral lines. They must be put in the location which is defined in the code. The line in the code where this address is written should be around 2726.
- Make folders named 'resources' and 'reduced_data' in your image folder.
- Files made by 2_anal_102.pro will be put in the same place where the 'IDL WORKSPACE' folder is.

Chapter 2

Calculating master dark and master flat

1. Open IDL workspace and if there is any running program in IDL, close it. Open 0_flat_100.pro, click **compile**, and then, click **start execution**.
2. A list of cameras will be displayed and you should pick all wanted cameras (it is necessary that the images of the chosen cameras are in the same folder), and then click OK. Next step is to pick the address where the images are.
3. You can choose whether you want to calculate master dark (click on CALCULATE MASTER DARK), or import it from some other place (click on READ MASTER DARK FILES). If you want to import it, this program expects them to be in **.fit** form, and in 'resources' folder. If this is the case, go to point **8**.
4. The program will now inform you about the number of dark frames that have been found and click YES to continue.
5. Now, you can see the table with two options, FIND BAD PIXELS and READ BAD PIXEL FILE. If you want to calculate bad pixels click on the first button. If you have chosen 'read bad pixel file' the program is expecting the file to be in folder **resources** and will send you to point **8**.
6. There are two ways to find the level of noise, mean value gives the average value and median is a value with an equal number of values above and below it.
7. You will see a histogram with the distribution of pixel intensity. You are asked to pick the sigma value that will border everything but the bad pixels. An example is shown below, in Figure 2.1. After pressing OK repeat the process for each camera.
8. Now, you are moving on the flat field. You have the option to either read or calculate master flat as it was for master dark. Also, the conditions for reading and methods of calculation (mean and median) are the same as well.
9. Next is determination of curvature and/or rotation of spectra (and slit jaw image) on ccd images. Click on the image to mark a spectral line or the slit region. If it is possible, it is recommended to mark two spectral lines, one from each side of the image. Marking, or bordering, includes a click around each side of the line, an example is given on Figure 2.2. To mark the position of the hairs, first border the upper one and then the lower one, see Figure 2.3. XLOADCT is an IDL procedure used only for changing display options. It is mentioned also in Chapter 4.

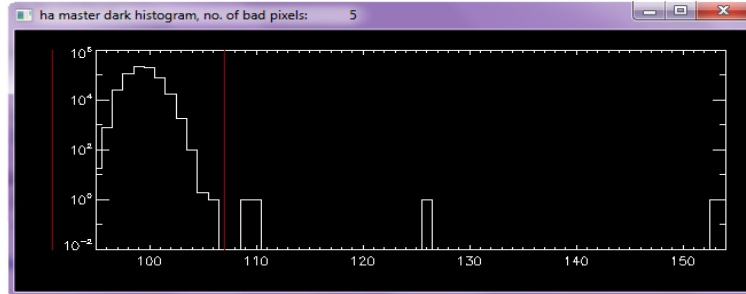


Figure 2.1 Histogram.

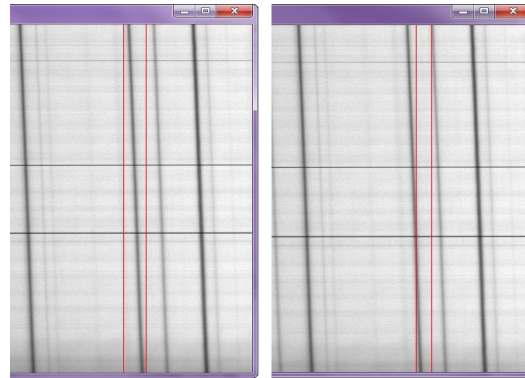


Figure 2.2 Correct marking of the spectral line (left), and incorrect (right).

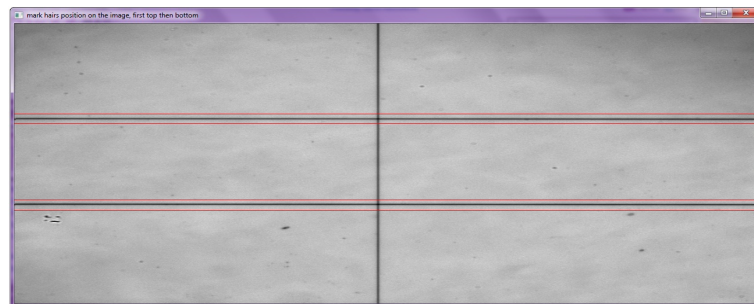


Figure 2.3 Marking of the position of the hairs.

10. As a result, in folder 'resources' the following files will be made (for each camera): bad_pxl_ha.txt, cameras.txt, coefficients_hair.txt, coefficients_line.txt, hard_flat_ha.fit, nol_flat_ha.fit, master_flat_ha.fit, master_dark_ha.fit. These files will be used for calibration using 1_data_100.pro.

Chapter 3

Calibrating images

1. Open IDL workspace and if there is any running program in IDL, close it. Open 1_data_100.pro, click **compile**, and then, click **start execution**.
2. Pick the address where the non-calibrated images of the object are. The program will recognize them by having 'N' in the name.
3. The program will now inform you about the number of images that have been found, and click YES to continue.
4. Continue by choosing one of the following options:
 - **NEXT IMAGE**: Takes a set of images chronologically, for all cameras at once. For each click, program picks the next date(time).
 - **QUIT**: Ends the program.
 - **PROCESS ALL IMAGES**: Automatically takes all images for all cameras.
 - **CHOOSE MANUALLY**: You are given the list of all found images. Chose the interval that you wish to be processed. If you want only one particular image, click on the same date(time) twice.
5. The calibrated images will be saved in the 'reduced_data' folder.

Chapter 4

Analyzing data

1. Open IDL workspace and if there is any running program in IDL, close it. Open 2_anal_102.pro, click **compile**, and then, click **start execution**.
2. Pick a combination of cameras that you need, if the wanted combination is not given in the first window, click OTHER SELECTION to choose cameras separately.
3. With the option to pick the images MANUALLY, you have to select one image for each camera (they must be in folder 'reduced_data'). In the case of clicking AUTO, select the image for the first camera and the program will automatically take all the others having the same date(time).
4. The program can analyze the image on several different aspects, choose the ones you need, but keep in mind that some of the actions are related. For example, EXTRACT SPECTRUM is required for many of them.

★ EXTRACT SPECTRUM

From the slit jaw image, select the region of interest. Note that the spectra can only be taken from the slit. Concerning the saving of the spectra, see SAVE SPECTRA.

★ ANOTHER FILE

Opens the browser so you can choose the next set of data.

★ WAVELENGTH CORRECTION

On the x axis of the extracted spectra are pixels. Pick the camera you want and based on the leige.txt file, you will be given the reference spectra. If your spectra is descending on the wavelength scale, you must click REVERSE. To assign spectral lines with the correct wavelength click DISPERSION CURVE and the number of lines you are going to match. When the reference spectra is shown with labeled spectral lines you have to click alternatively, on the reference spectra then on the observed one, to get the dispersion curve. If the whole width error is grater then 1, you are advised to repeat the process. After this point, the spectra will have wavelength (in Angstroms) on the x axis.

★ CALCULATE DISC CENTER

The program does not recognize where the disc center is. Therefore, when you have the images of the Sun limb, you can mark the limb, example is given on Figure 3.1. Number of points is your

choice as well, so the program will fit those points. Mark either photosphere or chromosphere, and click on the appropriate button when you are given the option. For the case of an image from somewhere in the disc, click DISC CENTER, and the center of your image will be approximated as the center of the Sun's disc.

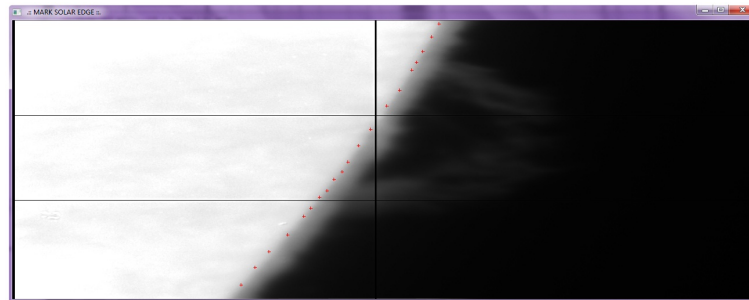


Figure 3.1 Marking the Sun limb.

★ REFERENCE PHOTOSPHERE PROFILE

David's profile and the reference spectrum are displayed next to the extracted spectra from the part of the slit along the Sun disc. Choose the camera. Move the David's profile along wavelength and intensity axis, until it is nearly in the same position as the extracted spectrum. Then mark the continuum level for either David's profile or the reference spectrum (maybe David's profile will also be red).

★ LIVE PROFILE

By moving along the y axis of the fits image (image taken from any camera but slit jaw), the profile from that raw is going to be displayed in a new window. Similar can be done for every column by clicking on the fits image. You can exit from this section with the right mouse button on the fits image.

★ CALCULATION SCATTERED LIGHT

Choose a number of points to extract scattered light and select less structured area, see Figure 3.2. The profiles are shown for each region. You have the option to save or repeat the process. Saved files are named: 'scat_light_position_cameraindex.txt' and 'scat_light_profiles_cameraindex.txt'.

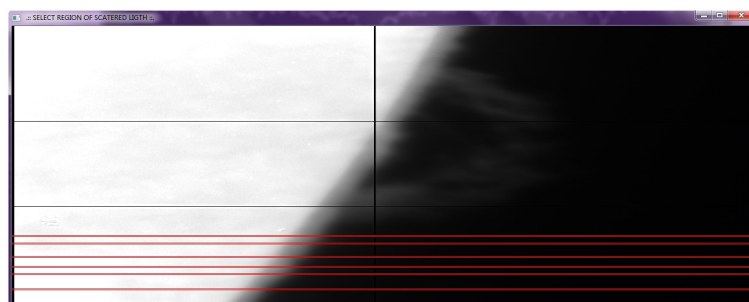


Figure 3.2 Example of taking profiles from the less structured area.

★ SUBTRACTION SCATTERED LIGHT

There are two methods for subtraction the scattered light, SCAT LIGHT MATRIX, and CONTINUUM LEVEL. It is necessary that you have calculated the scattered light before this step. To mark the continuum level click twice around the wanted interval (around the wanted spectral line). After this step, program will save a file, named 'scat_light_position.txt' consisting..... . SCAT LIGHT MATRIX

★ DOPPLER VELOCITY

When you have some extracted spectrum, you can choose an option to find Doppler velocity. There are two methods, bisection method and fitting with the Gauss function. Either way, the results can be saved in the 'velocity.dat' file, by clicking on OK AND SAVE. The file will contain information about the time when the image was taken, position of the slit, centrum of the analyzed area and the calculated velocity. If the process had been repeated for several slit positions or even different images, all the information will be added in the same file.

★ SAVE COEFFICIENTS

Saves the file 'calibration_coefficients.txt'. By going through 2_anal_102.pro and saving the coefficients information will be added or changed.

★ CGS AND INTEGRAL

First you have to chose the wanted camera. With the first option: MARK INTEGRAL LIMITS AND CALCULATE, choose the limits and you will get the integral value at the top of the window. SMOOTH options will use the IDL procedure **smooth** with various arguments (3, 5, 7 or 9). SAVE INTEGRAL makes the file: 'flux_integral_time' that can be ether in **fits** format or **ascii**. OK returns you to the main menu.

★ SHOW OTHER IMAGES

Shows slit jaw images, just for preview. You pick the first one, and then the last one, from the wanted interval.

★ SAVE SPECTRA

You can save the spectra by choosing this option, but if you need more then one spectra from the same image, there is a problem. The program replaces the previous saved image with the next one, because it is saved in the form of: 'spectrum_data_time(0)_cameraindex.fit', therefore, they all have the same name.

★ XLOADCT

This is an IDL procedure which displays the current Direct Graphics table and shows a list of available predefined color tables. Clicking on the name of a color table and applying it is used to display a particular dataset better. Usually, there is a conflict between IDL and the system concerning this procedure, therefore, it might not work.

★ CREDITS

There is some information about the author and credits, also the you can relax by playing a game.

* QUIT
Ends the program.