

lucy_deconvolution_plus

This program executes the Richardson-Lucy deconvolution in a data cube with a single or variable PSF determined using different methods. To the correct execution of this program, it's necessary that the data cube has a header with the parameters "CRVAL3", "CRPIX3" and "CDELTA3" (related to the wavelength calibration). If that is not the case, then, these parameters can be added to the data cube's header using the program "header_correct_plus". The data cube generated by "lucy_deconvolution_plus" will also have a header containing these three parameters. To use this program, first of all, it's necessary to provide the following parameters (which must be added to the section "input parameters" in the program's script):

cube: name of the data cube (full path) to be deconvolved.

niter: number of iterations to be used in the deconvolution process.

extension: value of the extension of the data cube that will be used by the program. If the cube has just one extension, then it must be taken the value 0 for this parameter.

logfile: name of the logfile (full path) to be created.

finalcube: name of the deconvolved data cube (full path).

After providing these parameters, the program shall be initiated. The following question will, then, appear to the user:

"Do you wish to enlarge the spatial dimensions of the datacube before the deconvolution (yes/no)?" (1)

The option of enlarging the spatial dimensions of the data cube eliminates possible border effects caused by the deconvolution, however, this procedure isn't always necessary. The user must answer "yes" or "no" to this question (the answers "y" and "n" will also be accepted by the program). If the answer to this question is "yes" (or "y"), the following questions will appear sequentially to the user:

"How many columns do you wish to add at the left side?" (2)

"How many columns do you wish to add at the right side?" (3)

"How many rows do you wish to add below?" (4)

"How many rows do you wish to add above?" (5)

These questions must be answered according to the user's will. After this step (which may be executed or not, according to the user's will), the following question will appear to the user:

"Do you wish to perform a Richardson-Lucy deconvolution with a single or a variable PSF (single/variable)?" (6)

The user must answer to this question by typing the word "single" or "variable" (the answers "s" and "v" will also be accepted by the program). If the user's answer to the question (6) is "single", then a single PSF will be used in the entire procedure of the Richardson-Lucy deconvolution. If that is the case, the following question will appear to the user:

"Do you want to use a gaussian or a real PSF (gaussian/real)?" (7)

The possible answers to this question are "gaussian" or "real" (the answers "g" and "r" will also be accepted by the program). If the answer is "gaussian", then the following message will appear:

"Enter the value of the FWHM (in pixels) to be used to construct a gaussian PSF image:" (8)

From the value of the FWHM (in pixels) provided by the user, the program will create a single image of a gaussian PSF and will use it in the entire procedure of deconvolution. If the user's answer to the question (7) is "real", the following message will appear:

"Enter the name (full path) of the image to be used as PSF in the deconvolution:" (9)

The program will, then, use the image of the PSF provided by the user (the full path of the file must be provided) to execute the Richardson-Lucy deconvolution. It's important to mention that it's possible to use the image of any punctual structure as a PSF, but this structure must be located at the center of the image.

If the answer to the question (6) is variable, the following question will appear to the user:

"Which method do you want to use to determine the PSF for the Richardson-Lucy deconvolution (1/2/3)?" (10)

The possible answers to this question are "1", "2" or "3". If the answer is "1", the program will execute a Richardson-Lucy deconvolution in the images of the data cube with a PSF as a function of the wavelength determined using method 1. This method obtains the values of the FWHM of the PSF as a function of the wavelength using the equation:

$$FWHM(\lambda) = (FWHM_{ref}) \cdot \left(\frac{\lambda}{\lambda_{daref}} \right)^{-0.484} \quad (I)$$

where λ = wavelength

λ_{daref} = reference wavelength

FWHMref = FWHM at the reference wavelength

From these values of the FWHM, the program will create an image of a gaussian PSF for each wavelength and will be able, then, to execute the Richardson-Lucy deconvolution. If the user chooses method 1, the following messages will appear sequentially:

"Enter the size of each spatial pixel in arcsec (sizepix):" (11)

"Enter the value of the reference wavelength (lambdaref):" (12)

"Enter the unity of the reference wavelength:" (13)

"Enter the value of the reference FWHM (FWHMref) in pixels:" (14)

The user must provide, then, all the necessary parameters. It is worth to mention that, in the case of the message (13), any wavelength unity like "Angstroms", "microns" and etc can be used.

If the answer to the question (10) is "2", the program will execute a Richardson-Lucy deconvolution in the images of the data cube with a PSF as a function of the wavelength determined using method 2. This method obtains the values of the FWHM of the PSF as a function of the wavelength using a weighted mean between the values of the FWHM at the blue and red edges of the spectral range covered by the data cube. This weighted mean is given by the following expression:

$$FWHM(\lambda) = (FWHMB) \cdot \left(1 - \left(\frac{\lambda - \lambda_{dB}}{\lambda_{dR} - \lambda_{dB}} \right) \right) + (FWHMR) \cdot \left(\frac{\lambda - \lambda_{dB}}{\lambda_{dR} - \lambda_{dB}} \right) \quad (II)$$

where λ = wavelength

FWHMB = FWHM at the blue edge of the spectral range covered by the data cube

FWHMR = FWHM at the red edge of the spectral range covered by the data cube

λ_{dB} = wavelength corresponding to the blue edge of the spectral range covered by the data cube

λ_{dR} = wavelength corresponding to the red edge of the spectral range covered by the data cube

From these values of the FWHM, the program will create the image of a gaussian PSF for each wavelength and will be able to execute the Richardson-Lucy deconvolution. If the user chooses method 2, the following messages will appear sequentially:

"Value of the FWHM at the blue border of the spectrum (FWHMB) in pixels: " (15)

"Value of the FWHM at the red border of the spectrum (FWHMR) in pixels: " (16)

"Unity used for wavelength measure: " (17)

The user must provide, then, all the necessary parameters. In the case of the message (17), any wavelength unity like "Angstroms", "microns" and etc can be used.

If the answer to the question (10) is “3”, the program will execute a Richardson-Lucy deconvolution in the images of the data cube with a PSF as a function of the wavelength determined using method 3. This method obtains the image of the PSF for each wavelength using a weighted mean between the images of the PSF at the blue and red edges of the spectral range covered by the data cube. This weighted mean is given by the following expression:

$$PSF(\lambda) = (PSFB) \cdot \left(1 - \left(\frac{\lambda - \lambda_B}{\lambda_R - \lambda_B} \right) \right) + (PSFR) \cdot \left(\frac{\lambda - \lambda_B}{\lambda_R - \lambda_B} \right) \quad (III)$$

where λ = wavelength

PSFB = image of the PSF at the blue edge of the spectral range covered by the data cube

PSFR = image of the PSF at the red edge of the spectral range covered by the data cube

λ_B = wavelength corresponding to the blue edge of the spectral range covered by the data cube

λ_R = wavelength corresponding to the red edge of the spectral range covered by the data cube

If the user chooses method 3, the following messages will appear sequentially:

"Enter the name (full path) of the image representing the PSF at the blue border of the spectrum (PSFB):" (18)

"Enter the name (full path) of the image representing the PSF at the red border of the spectrum (PSFR):" (19)

"Enter the unity of wavelengths provided above:" (20)

The user must provide, then, all the necessary parameters. In the case of the message (20), any wavelength unity like “Angstroms”, “microns” and etc can be used.