micropolarray

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CONTENTS

MICROPOLARRAY PACKAGE

1.1 Subpackages

1.1.1 micropolarray.processing package

1.1.1.1 Submodules

1.1.1.2 micropolarray.processing.chen_wan_liang_calibration module

micropolarray.processing.chen_wan_liang_calibration.**build_S_input**(*single_pol_images*, *S_input*)

micropolarray.processing.chen_wan_liang_calibration.**calculate_chen_wan_lian_calibration**(*polarizer_orientatio*
file-
names_list,
mi-
cropol_phases_prev
out-
put_dir,
oc-
cul-
ter=True,
dark_filename=Non
flat_filename=None

Performs calibration from Chen-Wang-Liang paper 2014

> **Parameters**
>
> - **polarizer_orientations** (`list[float]`) – List of polarizer orienataions
>
> - **filenames_list** (`list[str]`) – List of filenames coupled with
>
> - **micropol_phases_previsions** (`list[float]`) – Previsions of the micropolarizer orientations inside a superpixel
>
> - **output_dir** (`str`) – output path for the calibration matrices
>
> - **occulter** (`bool, optional`) – wether to exclude the occulter area. Defaults to True.
>
> - **dark_filename** (`str, optional`) – path to the dark to be subtracted from the images. Defaults to None.
>
> - **flat_filename** (`str, optional`) – path to the dark to be subtracted from the images. Defaults to None.
>
> **Raises**

- **ValueError** – polarizer orientation list and filenames list do not have the same lenght

- **ValueError** – any of 0,45,90,-45 polarizarions is not included in the polarizer orientation list

micropolarray.processing.chen_wan_liang_calibration.**chen_wan_liang_calibration**(*data*, *calibration_matrices_dir: str*)

> Calibrates the images using Chen-Wang-Liang 2014 paper calibration
>
> > **Parameters**
> >
> > - **data** (`np.array`) – data to be calibrated
> >
> > - **calibration_matrices_dir** (`str`) – path to the calibration matrices
> >
> > **Returns**
> > calibrated data
> >
> > **Return type**
> > np.array

micropolarray.processing.chen_wan_liang_calibration.**ifov_jitcorrect**(*data*, *height*, *width*)

1.1.1.3 micropolarray.processing.congrid module

micropolarray.processing.congrid.**congrid**(*a*, *newdims*, *kind='linear'*) → ndarray

> Reshapes the data into any new lenght and width
>
> > **Parameters**
> >
> > - **a** (`np.array`) – data to be reshaped
> >
> > - **newdims** (`tuple | list`) – new lenght and width
> >
> > - **kind** (`str, optional`) – interpolation type. Defaults to "linear".
> >
> > **Returns**
> > numpy array of congridded image
> >
> > **Return type**
> > ndarray

micropolarray.processing.congrid.**interpolate**(*x*, *x_0*, *y_0*, *x_1*, *y_1*)

micropolarray.processing.congrid.**micropolarray_jitcongrid**(*data*, *width*, *height*, *scale*)

1.1.1.4 micropolarray.processing.convert module

micropolarray.processing.convert.**average_rawfiles_to_fits**(*filenames: list*, *new_filename: str*, *height: int*, *width: int*)

> Saves the mean of a list of rawfiles to a new fits file.
>
> > **Parameters**
> >
> > - **filenames** (`list`) – list of raw filenames
> >
> > - **new_filename** (`str`) – new fits filename
> >
> > - **height** (`int`) – image height in pix

> • **width** (`int`) – image width in pix

> **Raises**
>> **ValueError** – trying to save in a file that does not end with .fits

micropolarray.processing.convert.**convert_rawfile_to_fits**(*filename: str*, *height: int*, *width: int*, *remove_old: bool = False*)

> Converts a raw file to a fits one, using default header

>> **Parameters**

>>> • **filename** (`str`) – raw filename

>>> • **height** (`int`) – file height

>>> • **width** (`int`) – file width

>>> • **remove_old** (`bool, optional`) – remove old raw file after conversion. Defaults to False.

>> **Raises**
>>> **ValueError** – raised if the file does not end with ".raw"

micropolarray.processing.convert.**convert_set**(*filenames*, *new_filename*, *height*, *width*)

> ANTARTICOR ONLY: Sums a set of filenames and converts them to one fits file.

>> **Parameters**

>>> • **filenames** (`list`) – list of file names to be summed before being converted

>>> • **new_filename** (`str`) – new .fits file name

micropolarray.processing.convert.**nparr_from_binary**(*filename*)

> Converts a PolarCam binary file into a numpy array. Bytes are saved like this

> • **24 bit (3 bytes)**
>> 1 | 3 | 2 111111111111 | 1111 | 11111111

> • **2 numbers**
>> First number 12bit | Second number (little endian) 8+4=12 bit

>> **Parameters**
>>> **filename** (`str`) – name of the file to be converted

>> **Raises**
>>> **ValueError** – file lenghts is indivisible by the number of chunks requested to parallelize operations

>> **Returns**
>>> array of data from file

>> **Return type**
>>> np.array

micropolarray.processing.convert.**three_bytes_to_two_ints**(*filecontent*)

> Needed for parallelization, this will be run by each thread for a slice of the original array.

>> **Returns**
>>> array of saved data

>> **Return type**
>>> np.array

1.1.1.5 **micropolarray.processing.demodulation module**

class `micropolarray.processing.demodulation.`**Demodulator**(*demo_matrices_path: str*)

    Bases: `object`

    Demodulation class needed for MicropolImage demodulation.

    flip(*axis*)

    rebin(*binning*)

        DO NOT USE THIS, calculate the tensor from the binned images

    rot90(*k=1*)

    show(*vmin=-1*, *vmax=1*, *cmap='Greys'*) → tuple

        Shows the demodulation tensor

        Parameters

            • **vmin** (`int, optional`) – Minimum shown value. Defaults to -1.

            • **vmax** (`int, optional`) – Maximum shown value. Defaults to 1.

            • **cmap** (`str, optional`) – Colormap of the plot. Defaults to "Greys".

        Returns

            fig, ax tuple as returned by matplotlib.pyplot.subplots

        Return type

            tuple

`micropolarray.processing.demodulation.`**Malus**(*angle*, *throughput*, *efficiency*, *phase*)

`micropolarray.processing.demodulation.`**calculate_demodulation_tensor**(*polarizer_orientations*, *filenames_list*, *micropol_phases_previsions*, *gain*, *output_dir*, *binning=1*, *occulter=None*, *procs_grid=[4, 4]*, *dark_filename=None*, *flat_filename=None*, *normalizing_S=None*, *DEBUG=False*)

    Calculates the demodulation tensor images and saves them. Requires a set of images with different polarizations to fit a Malus curve model.

    Parameters

        • **polarizer_orientations** (`list[float]`) – List containing the orientations of the incoming light for each image.

        • **filenames_list** (`list[str]`) – List of input images filenames to read. Must include [0, 45, 90, -45].

        • **micropol_phases_previsions** (`list[float]`) – Previsions for the micropolarizer orientations required to initialize fit.

        • **gain** (`float`) – Detector [e-/DN], required to compute errors.

        • **output_dir** (`str`) – output folder to save matrix to.

- **binning** (*int, optional*) – Output matrices binning. Defaults to 1 (no binning). Be warned that binning matrices AFTER calculation is an incorrect operation.

- **occulter** (*list, optional*) – occulter y, x center and radius to exclude from calculations. Defaults to None.

- **procs_grid** (*[int, int], optional*) – number of processors per side [Y, X], parallelization will be done in a Y x X grid. Defaults to [4,4] (16 procs in a 4x4 grid).

- **dark_filename** (*str, optional*) – Dark image filename to correct input images. Defaults to None.

- **flat_filename** (*str, optional*) – Flat image filename to correct input images. Defaults to None.

- **normalizing_S** (*float, optional*) – maximum signal used to normalize single pixel signal. Defaults to None.

    Raises
        ValueError – Raised if any among [0, 45, 90, -45] is not included in the input polarizations.

Notes

In the binning process the sum of values is considered, which is ok because data is normalized over the maximum S before being fitted.

micropolarray.processing.demodulation.**compute_demodulation_by_chunk**(*splitted_dara_arr*, *normalizing_S*, *splitted_occulter_flag*, *polarizer_orientations*, *rad_micropol_phases_previsions*, *gain, DEBUG*)

Utility function to parallelize calculations.

1.1.1.6 micropolarray.processing.demosaic module

micropolarray.processing.demosaic.**demosaic**(*image_data*, *option='adjacent'*)

Returns a [4,n,m] array of polarized images, starting from a micropolarizer image array [n, m].

micropolarray.processing.demosaic.**demosaicadjacent**(*data*)

micropolarray.processing.demosaic.**demosaicmean**(*data*)

Loops over right polarization pixel location, takes 1/4 of that, stores it in the 2x2 superpixel. demo_images[0] = data[y=0, x=0] demo_images[1] = data[y=0, x=1] demo_images[2] = data[y=1, x=0] demo_images[3] = data[y=1, x=1]

micropolarray.processing.demosaic.**merge_polarizations**(*single_pol_images: ndarray*)

micropolarray.processing.demosaic.**split_polarizations**(*data: ndarray*)

1.1.1.7 micropolarray.processing.hotpix_cleaning module

`micropolarray.processing.hotpix_cleaning.`**`get_hot_pixels`**(*image*, *threshold=100*)

1.1.1.8 micropolarray.processing.nrgf module

`micropolarray.processing.nrgf.`**`find_occulter_position`**(*data: array*, *method: str = 'sigmoid'*, *threshold:*
float = 4.0)

>   Finds the occulter position of an image.

>>   **Parameters**

>>>   • **data** (`np.array`) – input data

>>>   • **method** (`str, optional`) – Method to find occulter edges. If "sigmoid" it will try to fit
four sigmoids at the image edges centers, inferring the occulter edges from the parameters.
If "algo" it will start from the image edge center and infer the occulter position when DN[i]
> threshold*mean(DN[:i]) Defaults to "sigmoid".

>>>   • **threshold** (`float, optional`) – Threshold for the algo method. Defaults to 4.0.

>>   **Raises**
>>>   **UnboundLocalError** – couldn't converge

>>   **Returns**
>>>   occulter y, occulter x, occulter radius

>>   **Return type**
>>>   list

`micropolarray.processing.nrgf.`**`map_polar_coordinates`**(*height*, *width*, *center*)

`micropolarray.processing.nrgf.`**`nrgf`**(*data: array*, *y_center: int | None = None*, *x_center: int | None = None*,
rho_min: int | None = None, *step: int = 1*, *phi_to_mean=[0.0, 360]*,
output_phi=[0.0, 360]) → array

>   Performs nrgf filtering on the image, starting from center and radius. Mean is performed between phi_to_mean,
0 is horizontal right, anti-clockwise.

>>   **Parameters**

>>>   • **data** (`np.array`) – input array

>>>   • **y_center** (`int, optional`) – pixel y coordinate of the nrgf center. Defaults to None (image y center).

>>>   • **x_center** (`int, optional`) – pixel x coordinate of the nrgf center. Defaults to (image x center).

>>>   • **rho_min** (`int, optional`) – minimun radius in pixels to perform nrgf to. Defaults to None (radius 0).

>>>   • **step** (`int, optional`) – step to which apply the nrgf from center, in pixels. Defaults to 1 pixel.

>>>   • **phi_to_mean** (`list[float, float], optional`) – polar angle to calculate the mean value from. Defaults to [0, 360].

>>>   • **output_phi** (`list[float, float], optional`) – polar angle to include in output data. Defaults to [0, 360].

> **Returns**
> nrgf-filtered input data

> **Return type**
> np.array

micropolarray.processing.nrgf.**reject_outliers**(*data*, *m=2.0*)

micropolarray.processing.nrgf.**remove_outliers_simple**(*original*, *neighbours=2*)

> EXPERIMENTAL DO NOT USE, for improving fitting on occulter position

micropolarray.processing.nrgf.**roi_from_polar**(*data: array*, *center: list | None = None*, *rho: list | None = None*, *theta=[0, 360]*, *fill: float = 0.0*, *return_boolean=False*) → array

Returns the input array in a circular selection, otherwise an arbitrary number. If a pixel is not in the selection the ENTIRE superpixel is considered out of selection. If return_boolean is True then a boolean array is returned instead (useful for mean/stdev operations).

> **Parameters**
> - **data** (`np.array`) – input data
> - **center** (`list, optional`) – pixel coordinates of the circle center. Defaults to None (image center).
> - **rho** (`list, optional`) – radius to exclude. Defaults to None (center to image border).
> - **theta** (`list, optional`) – polar selection angle, 0 is horizonta, anti-clockwise direction. Defaults to [0, 360].
> - **fill** (`float, optional`) – number to fill the outer selection. Defaults to 0.0.
> - **return_boolean** (`bool, optional`) – if set to true, function returns a boolean array of the roi. Defaults to False.

> **Returns**
> array containing the input data inside the selection, and fill otherwise

> **Return type**
> np.array

micropolarray.processing.nrgf.**sigmoid**(*x*, *max*, *min*, *slope*, *intercept*)

micropolarray.processing.nrgf.**tile_double**(*a*)

1.1.1.9 micropolarray.processing.rebin module

micropolarray.processing.rebin.**micropolarray_jitrebin**(*data*, *new_height*, *new_width*, *binning=2*)

> Fast rebinning function for the micropolarray image. Needs to be wrapped to print info.

micropolarray.processing.rebin.**micropolarray_jitrebin_old**(*data*, *height*, *width*, *binning=2*)

> Fast rebinning function for the micropolarray image.

micropolarray.processing.rebin.**micropolarray_rebin**(*data: ndarray*, *height: int*, *width: int*, *binning=2*)

> Wrapper for the faster rebinning donw with numba. First deletes last row/column until binning is possible, then calls binning on the result shape.

> **Parameters**
> - **data** (`np.ndarray`) – data to rebin

- **height** (*int*) – lenght of first axis

- **width** (*int*) – lenght of second axis

- **binning** (*int, optional*) – Binning to be performed. Defaults to 2.

> **Returns**
>> binned data, trimmed if necessary

> **Return type**
>> ndarray

micropolarray.processing.rebin.**print_trimming_info**(*height*, *width*, *new_height*, *new_width*)

micropolarray.processing.rebin.**standard_jitrebin**(*data*, *height*, *width*, *binning=2*)

micropolarray.processing.rebin.**standard_rebin**(*data*, *binning: int*) → array

> Rebins the data, binned each binningxbinning.

> **Parameters**

- **image** (*np.array*) – data to be binned

- **binning** (*int*) – binning to be applied. A value of 2 will result in a 2x2 binning (1 pixel is a sum of 4 neighbour pixels)

> **Raises**
>> **KeyError** – cannot divide image height/width by the binning value

> **Returns**
>> binned data

> **Return type**
>> np.array

micropolarray.processing.rebin.**trim_to_match_2xbinning**(*height: int*, *width: int*, *binning: int*)

> Deletes the last image pixels until superpixel binning is compatible with new dimensions

> **Parameters**

- **height** (*int*) – image height

- **width** (*int*) – image width

- **binning** (*int*) – image binning

> **Returns**
>> image new height and width

> **Return type**
>> int, int

micropolarray.processing.rebin.**trim_to_match_binning**(*height*, *width*, *binning*, *verbose=True*)

> Deletes the last image pixels until simple binning is compatible with new dimensions

> **Parameters**

- **height** (*int*) – image height

- **width** (*int*) – image width

- **binning** (*int*) – image binning

- **verbose** (*bool, optional*) – warns user of trimming. Defaults to True.

Returns
image new height and width

Return type
int, int

1.1.1.10 micropolarray.processing.shift module

micropolarray.processing.shift.**shift**(*data: ndarray*, *y: int*, *x: int*)

micropolarray.processing.shift.**shift_micropol**(*data: ndarray*, *y: int*, *x: int*)

Splits the image into single polarizations, shifts each of them by y,x and then merges them back.

Parameters

- **data** (`np.ndarray`) – array to shift

- **y** (`int`) – vertical shift (positive inside the image)

- **x** (`int`) – horizontal shift (positive inside the image)

Returns
shifted array

Return type
np.ndarray

1.1.1.11 Module contents

1.2 Submodules

1.3 micropolarray.cameras module

class micropolarray.cameras.**Antarticor**

Bases: `object`

class micropolarray.cameras.**Camera**

Bases: `object`

occulter_mask(*overoccult: int = 0*, *rmax: int | None = None*) → array

Returns an array of True inside the roi, False elsewhere. Useful for mean/std operations (where=occulter_mask).

Parameters

- **overoccult** (`int`, `optional`) – Pixels to overoccult. Defaults to 15.

- **rmax** (`int`, `optional`) – Maximum r of the ROI. Defaults to image nearest border.

Returns
Boolean roi array

Return type
np.array

occulter_roi(*data: array*, *fill: float = 0.0*, *overoccult: int = 0*) → array

    Returns the array in the polar ROI, else fill

        Parameters

- **data** (`np.array`) – Input array
- **fill** (`float, optional`) – Value for filling. Defaults to 0.0.
- **overoccult** (`int, optional`) – Pixels to overoccult. Defaults to 0.

        Returns

            Array if in ROI, fill elsewhere

        Return type

            np.array

class micropolarray.cameras.**Kasi**

    Bases: *Camera*

class micropolarray.cameras.**PolarCam**

    Bases: *Camera*

1.4 micropolarray.image module

class micropolarray.image.**Image**(*initializer: str | np.ndarray |* Image, *averageimages: bool = True*)

    Bases: object

    Basic image class. Can be initialized from a filename, a filenames list, a numpy array or another Image instance. If multiple filenames are provided, will perform the mean of them unless averageimages is False.

    property data: ndarray

    save_as_fits(*filename: str*, *fixto: str[float, float] = None*)

        Saves image as fits with current header

        Parameters

- **filename** (`str`) – output filename
- **fixto** (`str[float, float], optional`) – Set a maximum and minimum range for the data. Defaults to None.

        Raises

            ValueError – filename does not end with ".fits"

    save_as_raw(*filename: str*)

        Saves the image as a raw binary file

        Parameters

            filename (`str`) – output filename

        Raises

            ValueError – filename does not end with ".raw"

    show(*cmap='Greys_r'*, *vmin=None*, *vmax=None*) → tuple

        Shows the image data

        Parameters

- **cmap** (`str, optional`) – figure colorbar. Defaults to "Greys_r".

- **vmin** (*_type_*, *optional*) – Minimum value to plot. Defaults to None.

- **vmax** (*_type_*, *optional*) – Maximum value to plot. Defaults to None.

> **Returns**
>> fig, ax tuple as returned by matplotlib.pyplot.subplots
>
> **Return type**
>> tuple

show_histogram(*bins: int = 1000*) → tuple

> Print the histogram of the flattened image data
>
> **Parameters**
>> **bins** (*int*, *optional*) – Numbers of bin to compute the histogram from. Defaults to 1000.
>
> **Returns**
>> fig, ax tuple as returned by matplotlib.pyplot.subplots
>
> **Return type**
>> tuple

1.5 micropolarray.micropol_image module

class micropolarray.micropol_image.**MicropolImage**(*initializer: str | np.ndarray | list | MicropolImage, angle_dic: dict = None, dark: MicropolImage = None, flat: MicropolImage = None, averageimages: bool = True*)

> Bases: *Image*
>
> Micro-polarizer array image class. Can be initialized from a 2d array, a list of 1 or more file names (use the boolean keyword averageimages to select if sum or average is taken) or another MicropolImage. Dark and flat micropolarray images can also be provided to automatically correct the result.
>
> **property AoLP:** *PolParam*
>
> **property DoLP:** *PolParam*
>
> **property I:** *PolParam*
>
> **property Q:** *PolParam*
>
> **property U:** *PolParam*
>
> **clean_hot_pixels**(*flagged_hot_pix_map:* MicropolImage)
>
>> Returns a copy of the image with gaussian smeared pixels where flagged_hot_pix_map == 1.
>>
>> **Parameters**
>>> **flagged_hot_pix_map** (MicropolImage) – hot pixels map.
>>
>> **Returns**
>>> copy of the original image, gaussian smeared where flagged_hot_pix_map == 1
>>
>> **Return type**
>>> *MicropolImage*
>
> **congrid**(*newdim_y: int, newdim_x: int*) → *MicropolImage*

correct_flat(*flat:* MicropolImage) → *MicropolImage*

> Normalizes the flat and uses it to correct the image.
>
> > **Parameters**
> > > **flat** (MicropolImage) – flat image, does not need to be normalized.
> >
> > **Returns**
> > > copy of input image corrected by flat
> >
> > **Return type**
> > > *MicropolImage*

correct_ifov() → *MicropolImage*

> Corrects differences in single pixels fields of view inside each superpixel
>
> > **Returns**
> > > image with data corrected for field of view differences
> >
> > **Return type**
> > > *MicropolImage*

demodulate(*demodulator:* Demodulator) → *MicropolImage*

> Returns a MicropolImage with polarization parameters calculated from the demodulation tensor provided.
>
> > **Parameters**
> > > **demodulator** (Demodulator) – Demodulator object containing the demodulation tensor components (see processing.new_demodulation)
> >
> > **Raises**
> > > **ValueError** – raised if image and demodulator do not have the same dimension, for example in case of different binning
> >
> > **Returns**
> > > copy of the input imagreturn e with I, Q, U, pB, DoLP, AoLP calculated from the demodulation tensor.
> >
> > **Return type**
> > > *MicropolImage*

demosaic(*demosaic_mode='adjacent'*) → *MicropolImage*

> Returns a demosaiced copy of the image with updated polarization parameters. Demoisacing is done IN PLACE.
>
> > **Parameters**
> > > **demosaic_mode** (`str, optional`) – demosaicing mode (see processing.demosaic). Defaults to "adjacent".
> >
> > **Returns**
> > > demosaiced image
> >
> > **Return type**
> > > *MicropolImage*

first_call = True

mask_occulter(*y: int = 919, x: int = 950, r: int = 531, overoccult: int = 0*) → None

> Masks occulter for all image parameters
>
> > **Parameters**
> > > - **y** (`int, optional`) – Occulter y position. Defaults to PolarCam().occulter_pos_last[0].
> > > - **x** (`int, optional`) – Occulter x position. Defaults to PolarCam().occulter_pos_last[1].

- **r** (*int*, *optional*) – Occulter radius. Defaults to PolarCam().occulter_pos_last[2].

- **overoccult** (*int*, *optional*) – Pixels to overoccult. Defaults to 0.

- **camera** (*_type_*, *optional*) – Camera image type. Defaults to PolarCam().

Returns

None

property pB: *PolParam*

property pol0: *PolParam*

property pol45: *PolParam*

property pol90: *PolParam*

property pol_45: *PolParam*

property polparam_list: list

rebin(*binning: int*) → *MicropolImage*

Rebins the micropolarizer array image, binned each binningxbinning. Sum bins by default.

Parameters

binning (*int*) – binning to perform. A value of n will be translated in a nxn binning.

Raises

ValueError – negative binning provided

Returns

copy of the input image, rebinned.

Return type

MicropolImage

rotate(*angle: float*) → *MicropolImage*

Rotates an image of angle degrees, counter-clockwise.

save_all_pol_params_as_fits(*filename: str*) → None

Saves the image and all polarization parameters as fits file with the same name

Parameters

filename (*str*) – filename of the output image. Will be saved as filename_[I, Q, U, pB, AoLP, DoLP].fits

Raises

ValueError – filename is not a valid .fits file

save_demosaiced_images_as_fits(*filename: str*, *fixto: list[float, float] = None*) → None

Saves the four demosaiced images as fits files

Parameters

- **filename** (*str*) – filename of the output image. The four images will be saved as filename_POLXX.fits

- **fixto** (*list[float, float]*, *optional*) – set the minimum and maximum value for the output images. Defaults to None.

Raises

ValueError – an invalid file name is provided

---

save_param_as_fits(*filename: str*, *polparam:* PolParam, *fixto: list[float, float] = None*) → None

 Saves chosen polarization parameter as a fits file

  Parameters

- **filename** (*str*) – filename of the output image.

- **polparam** (PolParam) – polarization parameter to save. Can be one among [self.I, self.Q, self.U, self.pB, self.AoLP, self.DoLP]

- **fixto** (*list[float, float]*, *optional*) – set the minimum and maximum value for the output images. Defaults to None.

  Raises
   ValueError – filename is not a valid .fits file

save_single_pol_images(*filename: str*, *fixto: list[float, float] = None*) → None

 Saves the four polarized images as fits files

  Parameters

- **filename** (*str*) – filename of the output image. The four images will be saved as filename_POLXX.fits

- **fixto** (*list[float, float]*, *optional*) – set the minimum and maximum value for the output images. Defaults to None.

  Raises
   ValueError – an invalid file name is provided

shift(*y: int*, *x: int*) → *MicropolImage*

 Shifts image by y, x pixels and fills with 0 the remaining space. Positive numbers for up/right shift and negative for down/left shift. Image is split into polarizations, each one is shifted, then they are merged again.

  Parameters

- **y** (*int*) – vertical shift in pix

- **x** (*int*) – horizontal shift in pix

  Returns
   shifted image copied from the original

  Return type
   MicropolImage

show_demo_images(*cmap='Greys_r'*)

 Plots the four demosaiced images.

  Parameters
   cmap (*str*, *optional*) – colormap for the plot. Defaults to "Greys_r".

  Returns
   a (figure, axis) couple same as matplotlib.pyplot.subplots

  Return type
   tuple

show_pol_param(*polparam:* PolParam, *cmap='Greys_r'*, *vmin=None*, *vmax=None*)

 Plots a single polarization parameter given as input

  Parameters

- **polparam** ([PolParam](#)) – image PolParam containing the parameter to plot. Can be one among [self.I, self.Q, self.U, self.pB, self.AoLP, self.DoLP]

- **cmap** (`str, optional`) – colormap for the plot. Defaults to "Greys_r".

> **Returns**
>> a (figure, axis) couple same as matplotlib.pyplot.subplots
>
> **Return type**
>> tuple

show_single_pol_images(*cmap='Greys_r'*)

> Plots the four polarizations images.
>
> **Parameters**
>> **cmap** (`str, optional`) – colormap for the plot. Defaults to "Greys_r".
>
> **Returns**
>> a (figure, axis) couple same as matplotlib.pyplot.subplots
>
> **Return type**
>> tuple

show_with_pol_params(*cmap='Greys_r'*) → tuple

> Returns a fig for each set of image parameters. User must call plt.show after this is called. Returned parameters: - Original image - Stokes vector I, Q, U - Angle, degree of linear polarizaimagetion Polarized brightness
>
> **Parameters**
>> **cmap** (`str, optional`) – colormap string. Defaults to "Greys_r".
>
> **Returns**
>> a (figure, axis) couple same as matplotlib.pyplot.subplots for the image data and another for the six polarization parameters
>
> **Return type**
>> tuple

property single_pol_subimages

subtract_dark(*dark:* MicropolImage) → *[MicropolImage](#)*

> Correctly subtracts the input dark image from the image
>
> **Parameters**
>> **dark** ([MicropolImage](#)) – dark to subtract
>
> **Returns**
>> copy of input image with dark subtracted
>
> **Return type**
>> *[MicropolImage](#)*

class micropolarray.micropol_image.**PolParam**(*ID: str*, *data: ndarray*, *title: str*, *measure_unit: str*, *fix_data: bool = False*)

Bases: `object`

Auxiliary class for polarization parameters.

Members:

> ID (str): parameter identifier data (np.array): parameter image as numpy 2D array title (str): brief title of the parameter, useful for plotting measure_unit (str): initial measure units of the parameter fix_data (bool): controls whether data has to be constrained to [0, 4096] interval (not implemented yet)

```
ID: str

data: ndarray

fix_data: bool = False

measure_unit: str

title: str
```

micropolarray.micropol_image.**set_default_angles**(*angles_dic: dict*)

> Sets the default micropolarizer orientations for images.
>
> > **Parameters**
> > > **angles_dic** (`dict`) – dictionary {value : pos} where value is the angle in degrees from -90 to 90 and pos is the pixel position in superpixel, from 0 to 3 (position [y, x], fast index x)

1.6 micropolarray.polarization_functions module

micropolarray.polarization_functions.**AoLP**(*Stokes_vec_components*)

> Angle of linear polarization in [rad]

micropolarray.polarization_functions.**DoLP**(*Stokes_vec_components*)

> Degree of linear polarization in [%]

micropolarray.polarization_functions.**normalize2pi**(*angles_list*)

> Normalizes the input angle list in the -90,90 range
>
> > **Parameters**
> > > **angles_list** (`_type_`) – list of input angles in degrees
> >
> > **Returns**
> > > normalized angles
> >
> > **Return type**
> > > _type_

micropolarray.polarization_functions.**pB**(*Stokes_vec_components*)

> Polarized brighness in [%]

1.7 micropolarray.utils module

micropolarray.utils.**align_keywords_and_data**(*header*, *data*, *sun_center*, *platescale*, *binning=1*)

> Fixes antarticor keywords and data to reflect each other.
>
> > **Parameters**
> >
> > - **header** (`dict`) – fits file header
> > - **data** (`ndarray`) – data as np array
> > - **platescale** (`float`) – plate scale in arcsec/pixel
> > - **binning** (`int, optional`) – binning applied to image. Defaults to 1 (no binning).
> >
> > **Returns**
> > > new fixed header and data

> **Return type**
>> header, data

micropolarray.utils.**fix_data**(*data: array*, *min*, *max*)

micropolarray.utils.**get_Bsun_units**(*diffuser_I: float*, *texp_image: float = 1.0*, *texp_diffuser: float = 1.0*) →
float

> Returns the conversion unit for expressing brightness in units of sun brightness. Usage is data [units of B_sun]
> = data[DN] * get_Bsun_units(mean_Bsun_brightness, texp_image, texp_diffuser)

>> **Parameters**
>>> - **mean_sun_brightness** (`float`) – diffuser mean in DN.
>>> - **texp_image** (`float, optional`) – image exposure time. Defaults to 1.0.
>>> - **texp_diffuser** (`float, optional`) – diffuser exposure time. Defaults to 1.0.

>> **Returns**
>>> Bsun units conversion factor

>> **Return type**
>>> float

micropolarray.utils.**get_malus_normalization**(*four_peaks_images*, *show_hist=False*)

micropolarray.utils.**make_abs_and_create_dir**(*filename: str*)

micropolarray.utils.**make_abs_and_create_dir_old**(*filenames: str*)

micropolarray.utils.**mean_minus_std**(*data: array*, *stds_n: int = 1*) → float

> Returns the value at the mean - standard deviation for the input data

>> **Parameters**
>>> - **data** (`np.array`) – input data
>>> - **stds_n** (`int, optional`) – number of standard deviations. Defaults to 1.

>> **Returns**
>>> mean value - n*stdevs

>> **Return type**
>>> float

micropolarray.utils.**mean_plus_std**(*data: array*, *stds_n: int = 1*) → float

> Returns the value at the mean + standard deviation for the input data

>> **Parameters**
>>> - **data** (`np.array`) – input data
>>> - **stds_n** (`int, optional`) – number of standard deviations. Defaults to 1.

>> **Returns**
>>> mean value + n*stdevs

>> **Return type**
>>> float

micropolarray.utils.**median_minus_std**(*data: array*, *stds_n: int = 1*) → float

> Returns the value at the median - median deviation for the input data

>> **Parameters**

- **data** (*np.array*) – input data

- **stds_n** (*int, optional*) – number of standard deviations. Defaults to 1.

> **Returns**
> median value - n*mediandevs

> **Return type**
> float

micropolarray.utils.**median_plus_std**(*data: array*, *stds_n: int = 1*) → float

> Returns the value at the median + median deviation for the input data

> **Parameters**
>
> - **data** (*np.array*) – input data
>
> - **stds_n** (*int, optional*) – number of standard deviations. Defaults to 1.
>
> **Returns**
> median value + n*mediandevs
>
> **Return type**
> float

micropolarray.utils.**normalize2pi**(*angles_list*)

micropolarray.utils.**sigma_DN**(*pix_DN*)

micropolarray.utils.**timer**(*func*)

> Use this to time function execution

> **Parameters**
> **func** (*function*) – function of which to measure execution time

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