

omphotom

April 16, 2023

Abstract

Program for recomputing the photometry of one or more sources in a source-list file, using one of several methods.

1 Instruments/Modes

Instrument	Mode
OM	FAST
OM	IMAGING

2 Use

pipeline processing	no
interactive analysis	yes

3 Description

This program is designed to allow a user to recompute the photometry of one or more sources in an **OM** product source-list file, in one of several different ways, using specified parameters. Whilst **omsource** can be used to recompute the photometry from a given source-list file, **omphotom** will be quicker if a list of sources from various source-list files need reprocessing. **Omphotom** also allows the photometry to be re-computed using several different methods.

The program allows **OM FAST** data to be reprocessed, and in order to estimate the background more reliably the appropriate **IMAGING** image can be used to determine the background.

The photometry can be computed by least-squares fitting of the point-spread function to one or more sources. This can significantly increase the accuracy of the photometry in the case of sources with one or more close neighbours. Currently, the photometry carried out by **omdetect** is done by aperture photometry, and therefore it may be desirable to use **omphotom** to re-compute the photometry of some sources. For the case of **FAST** mode data, **omlcbuild** uses the **PSF** to compute the photometry and obtains the background from pixels surrounding the source, but since it does not take account of close neighbours **omphotom** may also prove useful. We note here, that since the **OM** photometry has



been calibrated by aperture-photometry, the **PSF** method should only be used when you think there are good reasons for using it instead of aperture-photometry.

4 Parameters

This section documents the parameters recognized by this task (if any).

Parameter	Mand	Type	Default	Constraints
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paramfile	no	string	” ”	
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name of text file containing all the parameters to be used by omphotom

logfile	no	string	” ”	
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name of text file for output to be written to

imageset	no	string	” ”	
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Input image file

backgroundimageset	no	string	“”	
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Input background-image file (can be the same as that given for the taskparameter imageset)

oldsrclistset	no	string	” ”	
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Input product source-list

newsrclistset	no	string	” ”	
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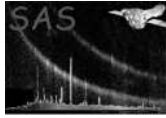
Output source-list set

sourceno	no	integer	” ”	
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List of sources to be reprocessed. NB: these correspond to the order of the sources in the input source list not the SRCNUM column value.

phototype	no	integer	” ”	
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List containing photometry method to be used for each source



aperturer	no	real	” ”	
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List containing aperture radius (pixels) to be used for each source For high-resolution images that allowed range is 4 to 12 pixels, and for low-resolution images 2 to 6 pixels.

innera	no	real	” ”	
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List containing inner background-annulus radius (pixels) to be used for each source

outeraa	no	real	” ”	
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List containing outer background-annulus radius (pixels) to be used for each source

axialratio	no	real	” ”	
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List containing aperture axial-ratio (semi-major/semi-minor axes) to be used for each source

pa	no	real	” ”	
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List containing aperture position angle to be used for each source (Measured anti-clockwise from the positive x axis.)

background	no	real	” ”	
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List containing background counts per pixel to be used for a given source

weighting	no	integer	1	1–2
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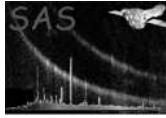
Defines the weighting function to be used in PSF fitting(inverse variance of unit weights)

5 Usage

5.1 Command-line lists of parameters

1. omphotom imageset=P0123920101OMS006IMAGE.1000.FIT backgroundimageset=P0123920101OMS006IMAGE.1000.FIT
oldsrcalistset=P0123920101OMS006SWSRLI1000.FIT newsrclistset=test.fits sourceno=1 phototype=0
aperturer=6 innera=8 outera=13

Recomputing the photometry for source no 1 from the source-list file P0123920101OMS006SWSRLI1000.FIT, using the image P0123920101OMS006IMAGE.1000.FIT. The photometry is computed by aperture photometry (phototype=0) with an aperture of 6 image pixels (aperturer=6), an inner background



annulus radius of 8 image pixels (innera=8) and an outer background annulus radius of 13 image pixels (outera=13).

2. `omphotom imageset=P0123920101OMS006IMAGE_1000.FIT backgroundimageset=P0123920101OMS006IMAGE_1000.FIT oldsrcolistset=P0123920101OMS006SWSRLI1000.FIT newsrclistset=test.fits sourceno=1 phototype=1 aperturer=6.0 background=10.0`

Recomputing the photometry for source no 1 from the source-list file P0123920101OMS006SWSRLI1000.FIT, using the image P0123920101OMS006IMAGE_1000.FIT. The photometry is computed by aperture photometry (phototype=1) with an aperture of 6 image pixels (aperturer=6), and using a value for the background counts per pixel of 10 counts.

3. `omphotom imageset=P0123920101OMS006IMAGE_1000.FIT oldsrcolistset=P0123920101OMS006SWSRLI1000.FIT newsrclistset=test.fits sourceno="1 2" phototype="0 0" aperturer="6 8" innera="8 10" outera="13 16"`

Recomputing the photometry for sources numbered 1 and 2 from the source-list file P0123920101OMS006SWSRLI1000.FIT using the image P0123920101OMS006IMAGE_1000.FIT. For both sources the photometry is computed using aperture photometry (phototype="1, 1") with apertures of 6 and 8 image pixels (aperturer="6 8"), inner background annulus radii of 8 and 10 image pixels (innera="8 10") and outer background annulus radii of 13 and 16 image pixels (outera="13 16").

4. `omphotom imageset=P0123920101OMS006IMAGE_1000.FIT oldsrcolistset=P0123920101OMS006SWSRLI1000.FIT newsrclistset=test.fits sourceno=1 phototype=-1 aperturer=6 innera=8 outera=13 axialratio=5 pa=90`

Recomputing the photometry for source no 1 from the source-list file P0123920101OMS006SWSRLI1000.FIT, using the image P0123920101OMS006IMAGE_1000.FIT. The source is treated as being extended (phototype=-1) and aperture photometry is conducted using an aperture of 6 image pixels (aperturer=6), an inner background annulus radius of 8 image pixels (innera=8) and an outer background annulus radius of 13 image pixels (outera=13), an axial-ratio (semi-major/semi-minor axis) of 5 and a semi-major position angle of (90 degrees).

5. `omphotom imageset=P0123920101OMS006IMAGE_1000.FIT oldsrcolistset=P0123920101OMS006SWSRLI1000.FIT newsrclistset=test.fits sourceno="1 2" phototype="0 -1" aperturer="6 8" innera="8 10" outera="13 16" axialratio="0 5" pa="0 95"`

Recomputing the photometry for sources numbered 1 and 2 from the source-list file P0123920101OMS006SWSRLI1000.FIT using the image P0123920101OMS006IMAGE_1000.FIT.

Source number 1 is treated as a point-source and the photometry is computed using aperture photometry (phototype=1) with an aperture of 6 image pixels (aperturer=6), an inner background annulus radius of 8 image pixels (innera=8) and an outer background annulus radius of 13 image pixels (outera=13).

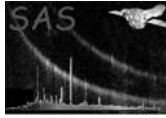
Source number 2 is treated as being extended (phototype=-1). Extended photometry is conducted using an elliptical aperture of semi-major axis 6 image pixels (aperturer=6), an axial-ratio (semi-major/semi-minor axis) of 5 and a semi-major position angle of (95 degrees).

The background is subtracted using the pixels within the elliptical annulus with an inner background annulus radius of 8 image pixels (innera=8) and an outer background annulus radius

5.1.1 Notes

Whilst there are a large number of command-line parameters, frequently many of them will not be required.

Please note the following:



1. The parameters **imageset**, **oldsrclistset** and **newsrclistset** are always required.
2. The parameters **sourceno** and **phototype** are always required.
3. If all the sources are going to be computed using a “fixed” background, then the parameters **innera** and **outera** are not required.
4. If all the sources are going to be treated as “point-sources” then the parameters **axialratio** and **pa** are not required.
5. If all the values in the parameter **photometrytype** list are 3 to 7 (PSF fitting), then the parameter **aperturer** is not required.
6. If more than one source is listed in the parameter **sourceno** then the length of the lists of each photometry parameter must be the same as the number of the sources. The number of the parameter in the list corresponds to the source number in the **sourceno** list.

5.2 Using a parameter file

The parameters for a list of sources can be stored in a text file, which **omphotom** can access through the parameter **paramfile**. This method also allows sources from different images and source-list files to be reprocessed. Blank lines will be ignored and any error found in the file will be reported and the program stopped- the error message may indicate where the “error” in the file is.

An example parameter file is shown below, the line number on the left (not in the file) corresponds to that in the section **notes**

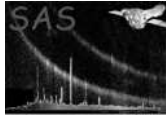
1. P0135720601OMS016IMAGE_1000.FIT
2. P0135720601OMS016IMAGE_1000.FIT
3. P0135720601OMS016SWSRLI1000.FIT
4. test3.fits
5. 9
6. 1 0 6.0 8.0 13.0
7. 1 1 10.0 6.0
8. 2 2 8.0 13.0
9. 3 3 0
10. 3 3 1 1
11. 4 4 10.0 1 2
12. 4 5 0
13. 4 6 10.0 0
14. 4 5 0 2
15. P0135720601OMS046IMAGE_1000.FIT
16. testimage.fits



17. P0135720601OMS046SWSRLI1000.FIT
18. test3.fits
19. 1
20. 1 0 6.0 8.0 13.0

5.2.1 notes

1. Input image file (either a background image produced by omdetect or the input image file)
2. Input background image file (either a background image produced by omdetect or the input image file)
3. Input source-list file - one produced by omatt
4. Output source-list file
5. No of sources to reprocess (9)
6. source no (1), photometry method (0 aperture photometry), aperture radius (6.0), inner background annulus radius (8.0), outer background radius (13.0)
7. source no (1), photometry method (1 aperture photometry with fixed background), background (10.0), aperture radius (6.0)
8. source no (2), photometry method (2 PSF fit with background from annulus), inner background annulus radius (8.0), outer background radius (13.0) (no aperture radius necessary)
9. source no (3), photometry method (3 PSF fit to one source, including background) (no aperture parameters necessary)
10. source no (3), photometry method (3 PSF fit including source 1, including background) (no aperture parameters necessary)
11. source no (4), photometry method (4 PSF fit including source 2, excluding background), background=10.0 no of additional sources to be included in the fit (1), source no/s (2) to be included.
12. source no (4), photometry method (5, PSF fit including background and positional fit), no of additional sources to be included in the fit (0)
13. source no (4), photometry method (6, PSF fit including positional fit but excluding background), background (10.0), no of additional sources to be included in the fit (0)
14. source no (4), photometry method (5, PSF fit including positional fit and background), no of additional sources to be included in the fit (0), pixel weighting factor of unity
15. Next image file
16. Next background image file
17. next source-list file
18. next output source-list file
19. No of sources to reprocess
20. source no, photometry method (0, aperture photometry), aperture radius, inner background annulus radius, outer background radius



6 Errors

This section documents warnings and errors generated by this task (if any). Note that warnings and errors can also be generated in the SAS infrastructure libraries, in which case they would not be documented here. Refer to the index of all errors and warnings available in the HTML version of the SAS documentation.

image file is not 2D (*fatal*)

different binning in x and y axes (*fatal*)

Could not allocate memory for: *name* (*fatal*)

Memory allocation for the named allocatable array failed

Failed to release memory for: *name* (*warning*)

corrective action: Memory deallocation for the named allocatable array failed

7 Input Files

1. Intermediate FITS image file (output from OMMODMAP)

8 Output Files

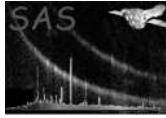
1. FITS source-list file
2. Log file (optional)

9 Algorithm

- Input the image set, background image set and source-list set.

10 Photometry

The parameter “phototype” (one value for each source) determines the photometry method for a particular source. Positive values of phototype (1 to 7) apply to point-sources, and negative values (currently -1) to extended sources.



10.1 Point sources

There are 7 methods (**parameter phototype= 0, 1, 2, 3, 4, 5, or 6**) available for recomputing the photometry of a point-source. The method to be used for a given source is set by the parameter “**phototype**”.

For **FAST** mode data, the background image can be obtained from the **IMAGING** image containing that source, if it exists.

1. phototype=0 Aperture photometry using the specified aperture and inner and outer background annulus radii and the background subtracted using the given background image (if **parameter backgroundset** is not set then the background is obtained from the actual image. If no background image is given the input image will be used instead.
2. phototype=1 Aperture photometry using the specified aperture and inner and outer background annulus radii and the background subtracted using the given value for the background counts per pixel (**parameter background**).
3. phototype=2 Least-squares fit to the point-spread function, excluding a constant term, using a background determined from the background annulus.
4. phototype=3 A least-squares fit to the point-spread function, for one or more sources), which includes a constant term for the background.
5. phototype=4 Least-squares fit to the point-spread function for one or more sources, excluding the background. The background is subtracted using a given value for the background counts per pixel.
6. phototype=5 Least-squares fit to the point-spread function for one or more sources, including the background and source-position.
7. phototype=6 Least-squares fit to the point-spread function for one or more sources, including the source-positions, but excluding a fit to the background.

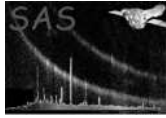
10.1.1 Recommendations

For **FAST** mode data, method 3 (PSF fit including background) is recommended. If the source has one or more close neighbours, then those sources should be included in the fit. Method 6 (PSF fit including background and a fit to the positions), may/may not give a slightly better fit, and should be used with caution.

For **IMAGING** mode data, if the source has one or more close neighbours, then method 3 (PSF fit to the source and its neighbours and including the background) is recommended if the source has one or more close neighbours. Method 6 (PSF fit including background and a fit to the positions), may give a slightly better fit, but should be used with caution.

10.2 Point-Spread Function Fitting

As mentioned in the previous section, **omphotom** can compute the photometry of a source by fitting the PSF to it, and other close sources may also be included in the fit. This method was included primarily for **FAST** mode data and **High-resolution Imaging** mode data, but can also be used for **Low-resolution Imaging** mode data. for the latter it is recommended that this method is only used for sources with one or more close neighbours, sources near an image edge, or sources affected by scattered-light features, etc.



The counts for a source are obtained by solving the following set of equations for each pixel included in the fit by least-squares-

$c(i, j) = background + \sum_{k=1}^n a_k PSF(\Delta x_k, \Delta y_k)$, where, the background is either the constant term in the least-squares fit or a fixed value, n the number of sources are included in the fit, a_k is the central height of the fitted PSF source k and $\Delta x_k, \Delta y_k$ are the distances from the centre of source k to the image point (i, j) in the x and y directions, respectively. All pixels within a radius of 7 unbinned pixels from the centre of a source are included in the fit.

A discrete PSF function is used based on the PSF image obtained through the **CAL** subroutine **CAL_omGetPSFmap**. Interpolation is used to compute the value of the PSF at any $\Delta x, \Delta y$, distance from the centre.

The total raw counts of a source k is then equal to the value of a_k multiplied by the total counts in the PSF image within a radius of 12 unbinned pixel from it centre, which has been normalized to a central height of 1.

For the case where also the positions of each source are also to be “fitted”, a function minimization scheme, using a modified simplex method, is used to determine the best fit coordinates of each source. The function that is minimized carries out the least-squares fit just discussed, using the current coordinates of each source, and the function value is the standard deviation of this fit. Obviously, the CPU time increases rapidly with the number of sources included in the fit. If you think that the coordinates of the sources you wish to include in the fit, it may be better to change them by editing the input source-list file, rather than by trying to include them in the fit.

10.2.1 Interpolation method

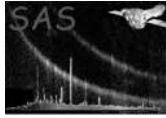
The interpolation scheme used to interpolate the PSF at any point from the centre of a source is one that is published in **Transactions on Mathematical Software, Vol 32, No 3, September 1996, pages 357-361**. The subroutine performs interpolation of a bivariate function, $z(x, y)$, on a rectangular grid in the x - y plane and is based on the revised Akima method. The interpolating function is a piecewise function composed of a set of bicubic (bivariate third-degree) polynomials, each applicable to a rectangle of the input grid in the x - y plane. Each polynomial is determined locally and has the accuracy of a bicubic polynomial, i.e., it interpolates accurately when all the data points lie on a surface of a bicubic polynomial.

10.2.2 Weighting of the equations

The weighting factor for each pixel used in the least-squares fit depends on the parameter **weighting**, which can have a value of either 1 (the default value with weights of $1/\sigma$, where *sigma* is the pixel variance ($\sqrt{pixelvalue}$), or 2 with a pixel weighting value of 1.

10.3 Extended Sources

There are two methods available (phototype=-1 and -2) for recomputing the photometry of an extended source- For both cases, the total source-counts is the sum of the counts within the elliptical aperture specified by the parameters “aperturer, innera, outera, axialratio and pa”. Innera corresponds to the semi-major axis of the ellipse, axial-ratio to the ratio of the semi-major to semi-minor axes of the ellipse, and pa to the position-angle of the major-axis of the ellipse measured anti-clockwise from the +ve x -axis.



For phototype -1, the background at each pixel within the source is subtracted by interpolation using the background pixels within the background elliptical annulus. Each pixel is coincidence-loss corrected.

For phototype -2, the background at each pixel within the source is subtracted by using the given value for the background counts per pixel (**parameter "background"**).

11 Future developments

References