MDIA

A Difference Imaging Tool for AstroWISE

AstroWISE workshop, Leiden 31.03.2008

Difference Imaging

image 1

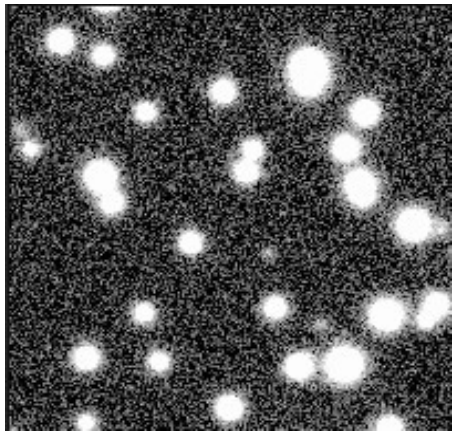


image 2

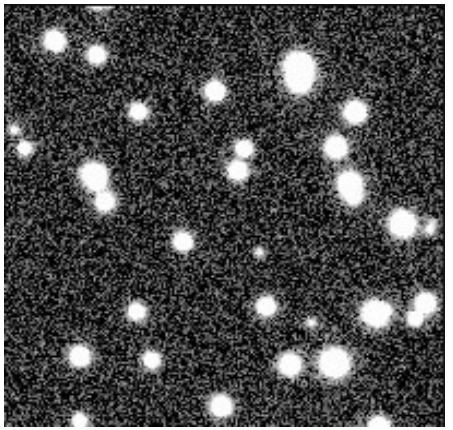


image 1 – image 2

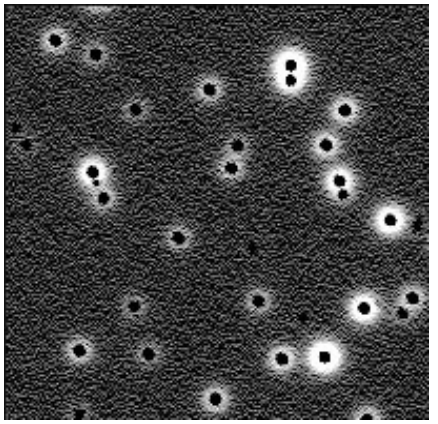
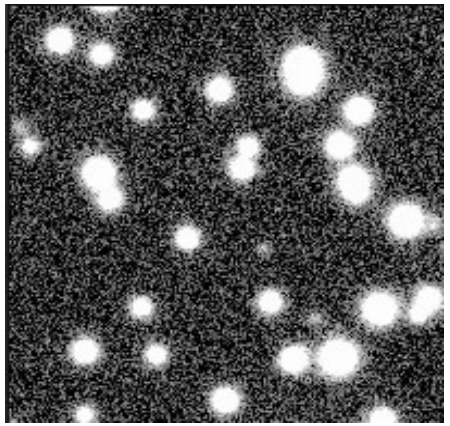
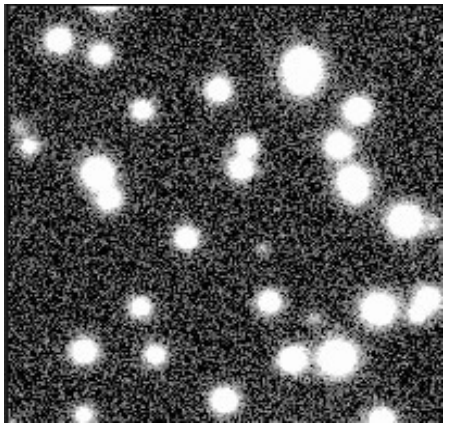


image 1



convolved image 2



difference image

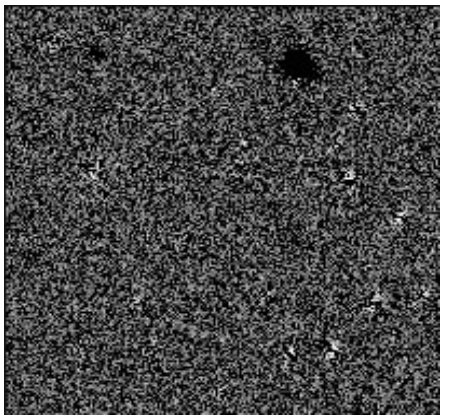


Image Convolution

$$I(x,y) \approx R(u,v) \otimes K(u,v) + bg(x,y)$$

where $(R \otimes K)(x,y) = \sum_{u,v} R(x+u, y+v) K(u,v)$

I: single image
R: reference image
K: convolution kernel

example:

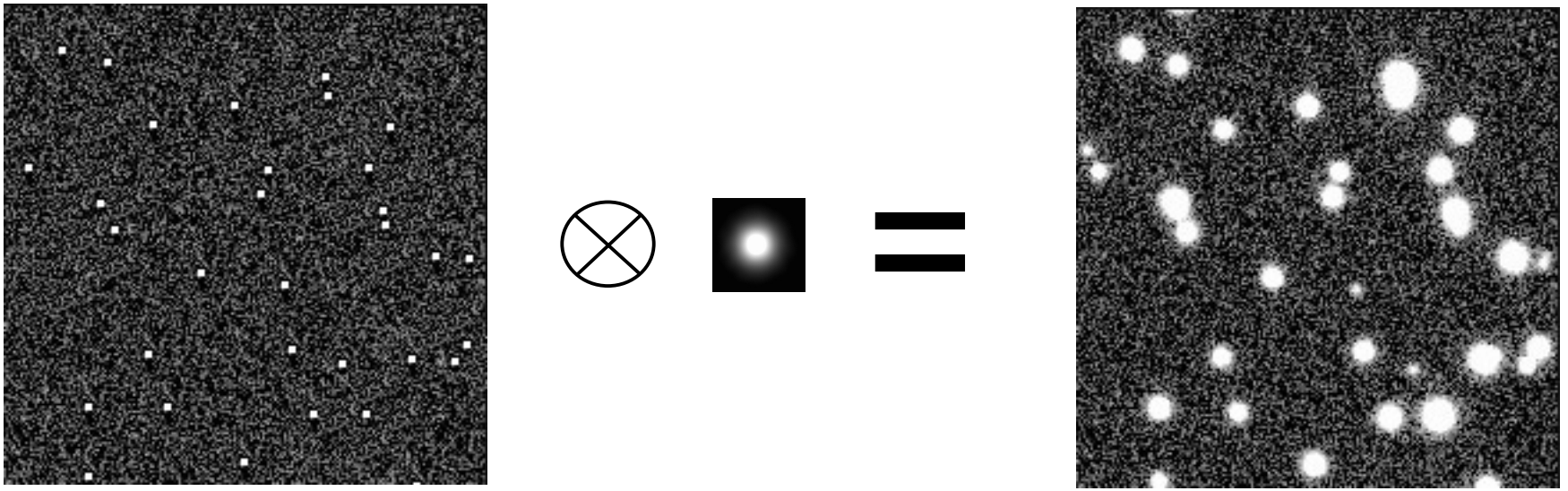


Image Convolution

I: single image
R: reference image
K: convolution kernel

$$I(x,y) \approx R(u,v) \otimes K(u,v) + bg(x,y)$$

$$K(u,v) = \sum_i a_i B_i(u,v) = \sum_l e^{-\frac{u^2+v^2}{2\sigma_l^2}} \sum_{j=0}^{p_l} \sum_{k=0}^{p_l - j} a_{ljk}\, u^j v^k$$

proposed by Alard and Lupton 1998:

l=3, p_l={6, 4, 2} => 49 parameters

$$\sigma_1 = 1 : e^{-\frac{u^2+v^2}{2\sigma_1^2}} \; (a_1 + \cdots + a_{22}u^6 + \cdots + a_{28}v^6)$$
$$\sigma_2 = 3 : e^{-\frac{u^2+v^2}{2\sigma_2^2}} \; (a_{29} + \ldots + a_{39}u^4 + \ldots + a_{43}v^4)$$
$$\sigma_3 = 9 : e^{-\frac{u^2+v^2}{2\sigma_3^2}} \; (a_{44} + \cdots + a_{47}u^2 + a_{48}uv + a_{49}v^2)$$

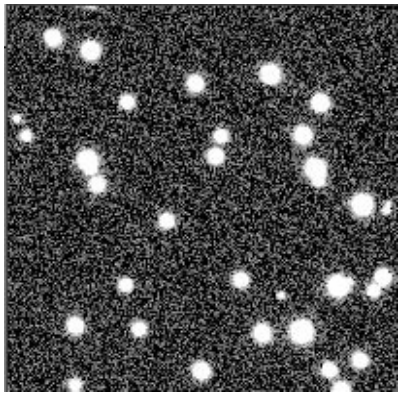
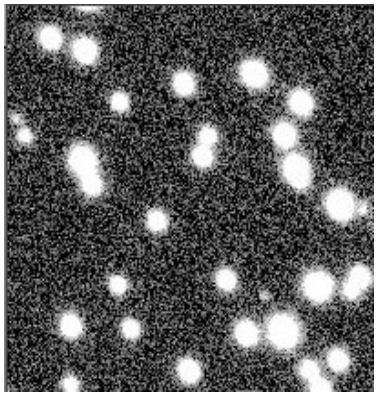
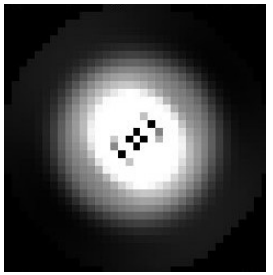
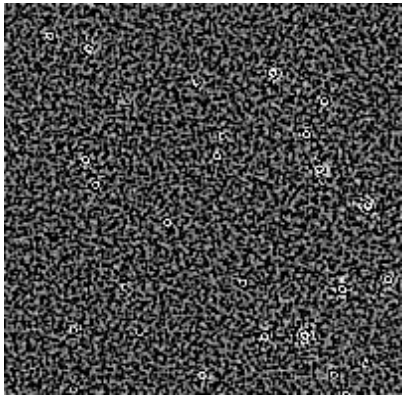
$$bg(x,y) = a_{50} + a_{51}x + a_{52}y$$

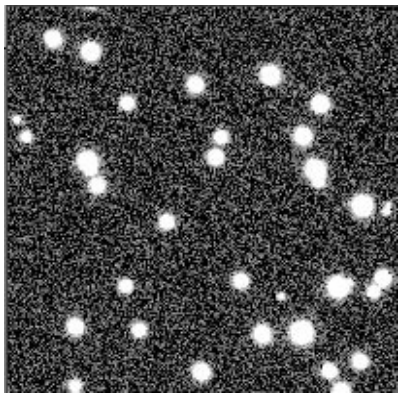
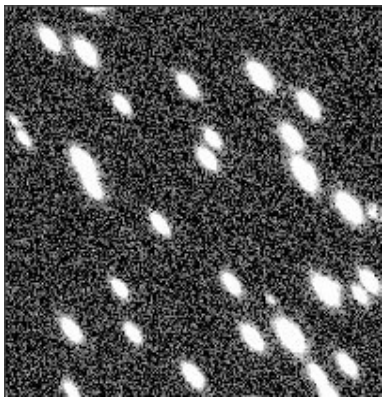
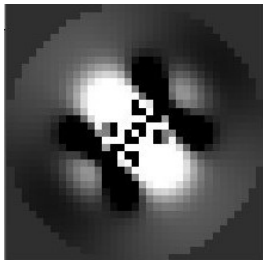
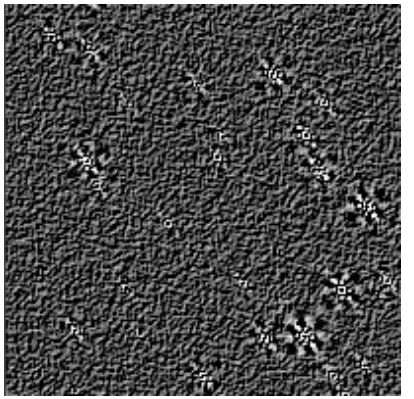
+additional parameters for sky background

$$\chi^2 = \sum_{x,y} \frac{1}{\sigma_{x,y}^2} \left[(R \otimes K)(x,y) + bg(x,y) - I(x,y) \right]^2 \stackrel{!}{=} \min$$

Two Examples

reference | single image | kernel | difference

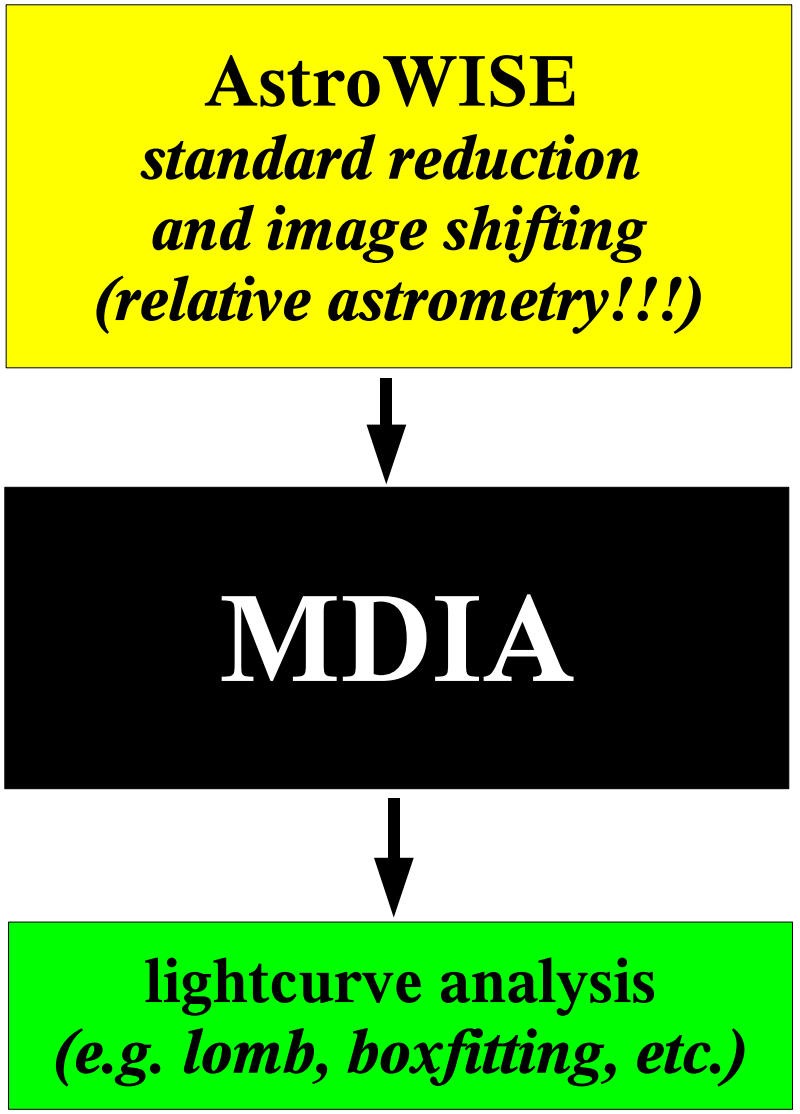





MDIA - Flowchart

input:

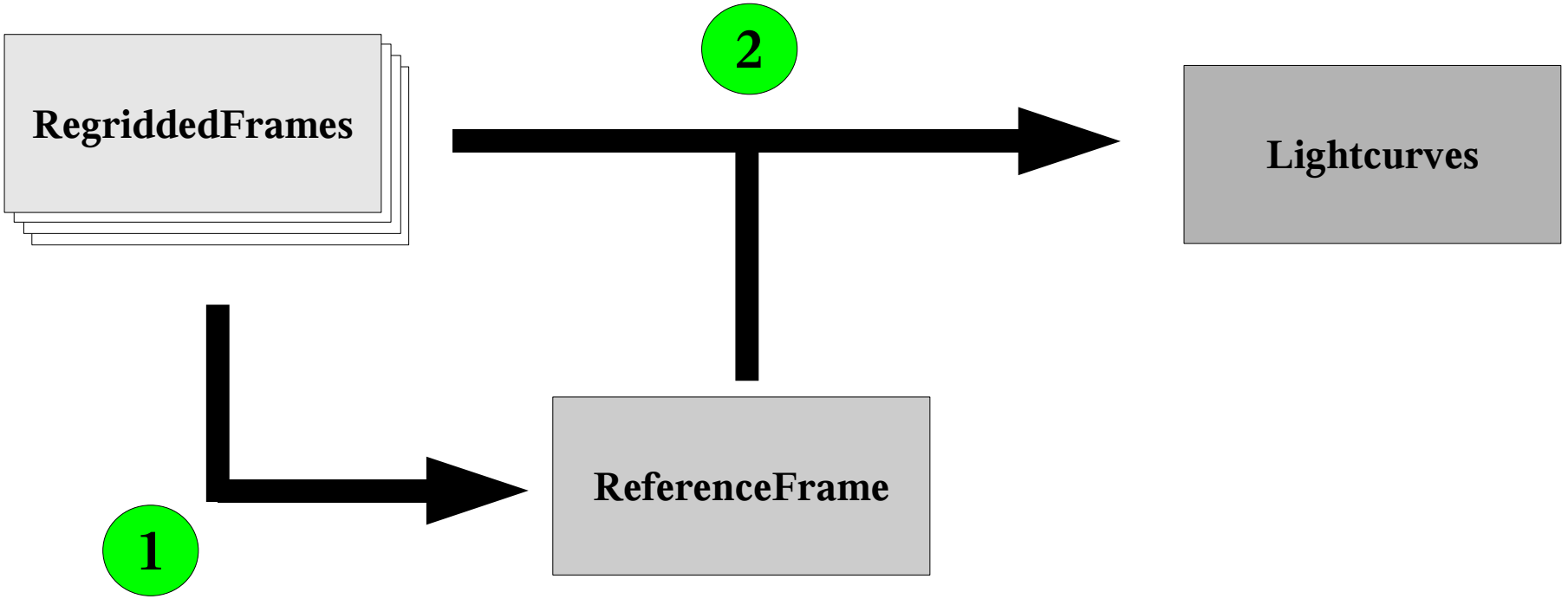
RegriddedFrames,
SourceLists,
Parameters



output:

ReferenceFrame,
LightCurves

The MDIA Functionality



1 Creating a reference frame

- preparation: creation of error frames, expanding images
- sky-subtract best seeing image (2^{nd} order polynomial)
- photometrically align images (constant absorption, 2^{nd} order sky)
- measure PSF in all images (moffat-fit: x- & y-fwhm, angle, beta)
- replace masked pixel/regions with most similar other image
- weighted stacking (by seeing, background noise)
- PSF-photometry on reference frame
- calculation of kernel basis images

class ReferenceFrame

- all properties of RegriddedBaseFrame

- ReferenceFrame.regridded_frames	input RegriddedFrames
- ReferenceFrame.process_params	process parameters
(- ReferenceFrame.sources	SourceList of all sources)
(- ReferenceFrame.variables	SourceList of all variable sources)
- ReferenceFrame.error	associated error frame

How-To create a ReferenceFrame in AstroWISE:

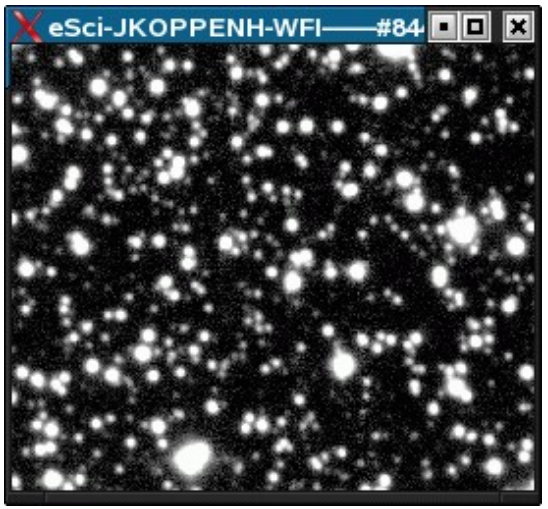
```
awe> ref = ReferenceFrame()
awe> ref.regridded_frames = my_regridded_list
awe> ref.process_params.VERBOSE = 1
awe> ref.make()
awe> ref.store()
awe> ref.commit()
```

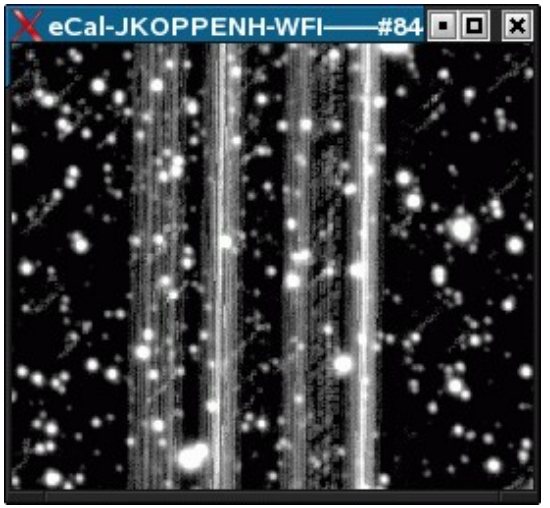
filenames: Sci-JKOPPENH-WFI-------#844---Ref---Sci-54048...
Cal-JKOPPENH-WFI-------#844---Ref---Err-54048...
Cal-JKOPPENH-WFI-------#844---Ref---Wei-54048...

The MDia error frames

created from photon- and readout noise

pixel by pixel error propagation in each MDIA reduction step





2 Creating lightcurves

- preparation: creation of error frames, cutting/expanding images
- photometrically align images (constant absorption, 2nd order sky)
- difference imaging in whole frame at once or in subframes
- PSF- or aperture-photometry in difference images
- lightcurve creation (ascii/fits tables)
- barycentric time correction

class Lightcurve

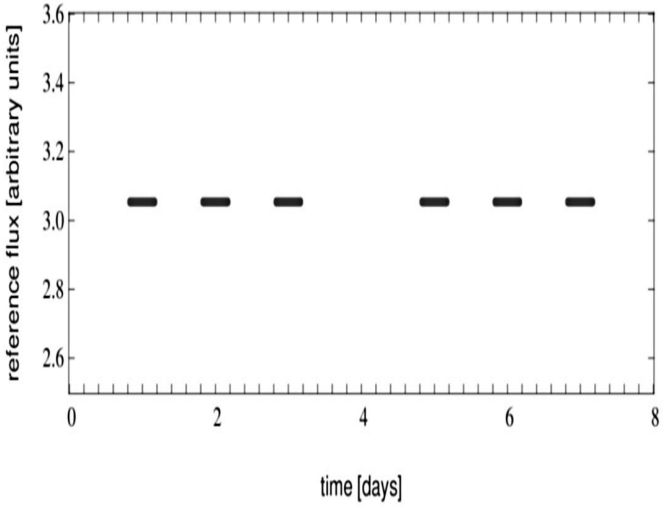
- LightCurve.reference_frame	input ReferenceFrame
- LightCurve.regridded_frames	input RegriddedFrames
- Lightcurve.process_params	process parameters
(- LightCurve.sources	SourceList of all sources)
(- LightCurve.variables	SourceList of all variable sources)

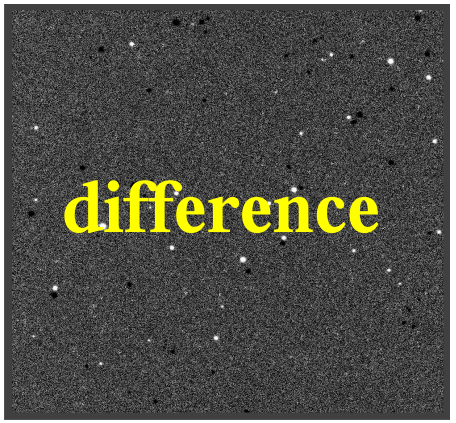
How-To create a Lightcurves in AstroWISE:

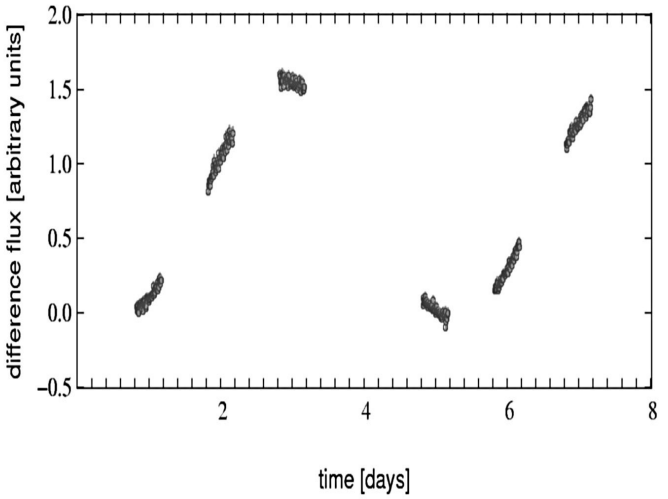
```
awe> my_lightcurve = Lightcurve()
awe> my_lightcurve.reference_frame = my_reference_frame
awe> my_lightcurve.regridded_frames = my_regridded_list
awe> my_lightcurve.process_params.VERBOSE = 1
awe> my_lightcurve.make()
awe> my_lightcurve.store()
awe> my_lightcurve.commit()
```

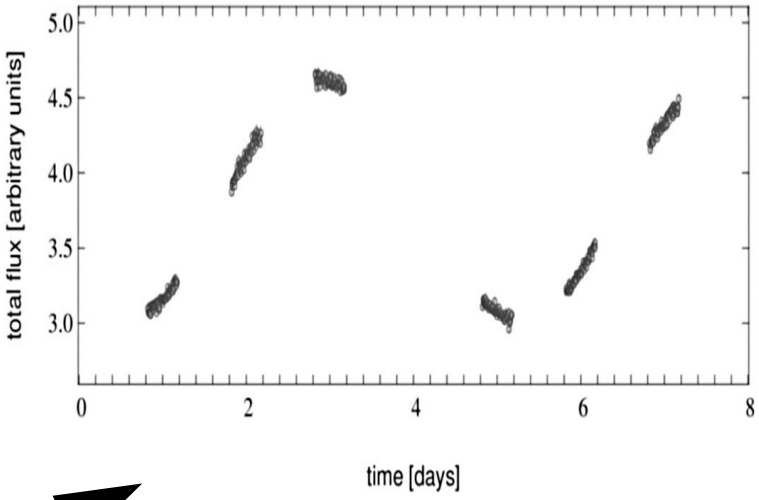
filenames: Sci-JKOPPENH-WFI-------#844---LC---Asc-54048...

The Amplitude of the Variation:

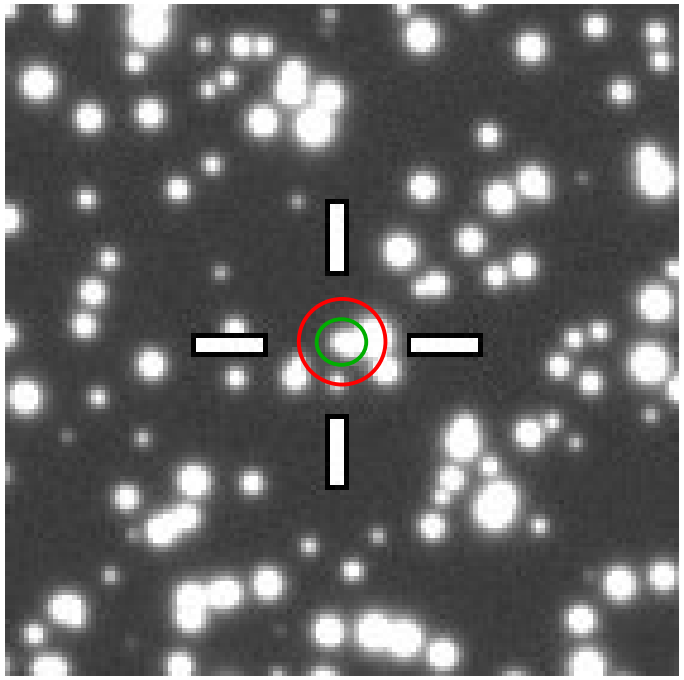


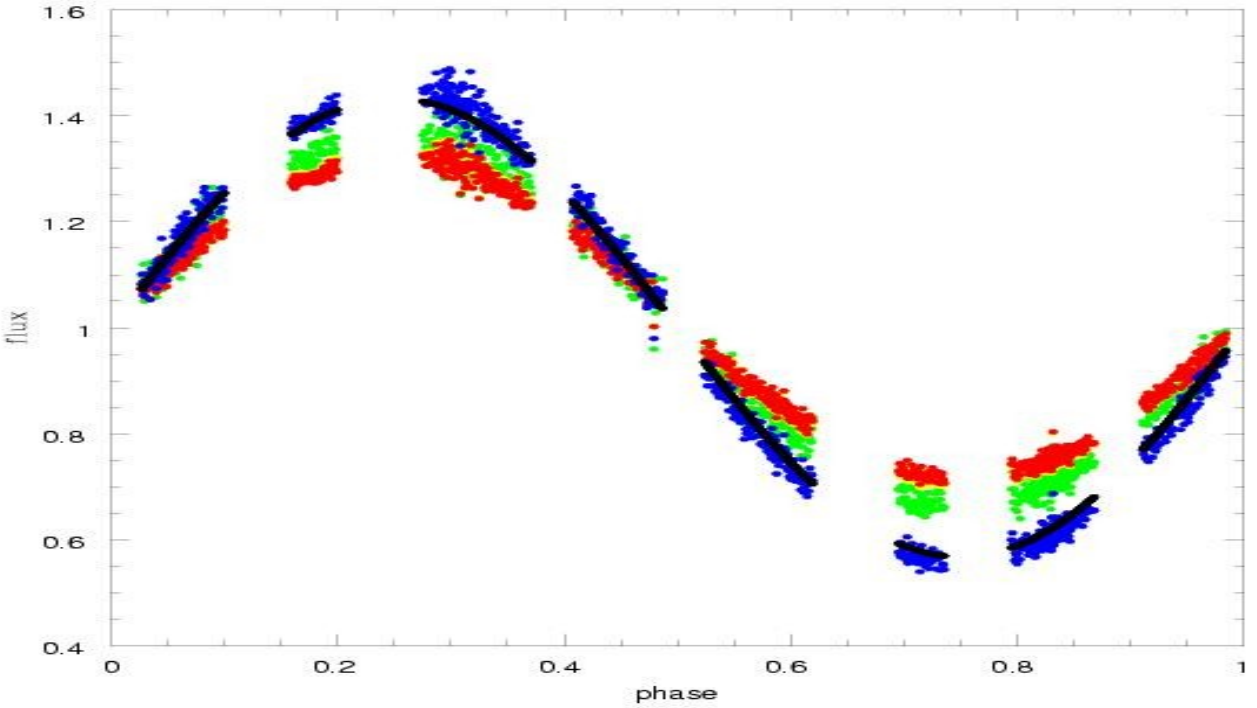






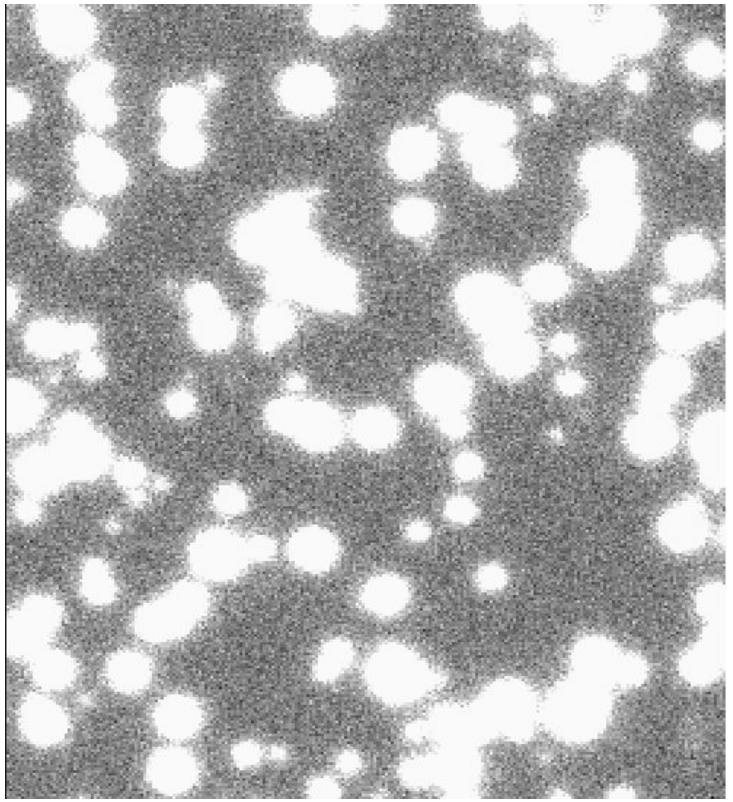
The Box-Size Dependency

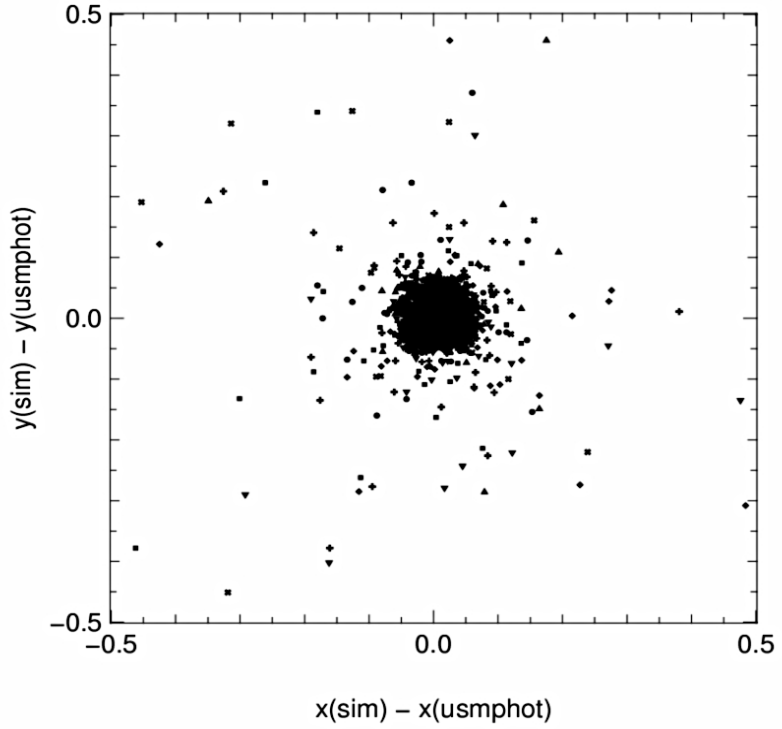


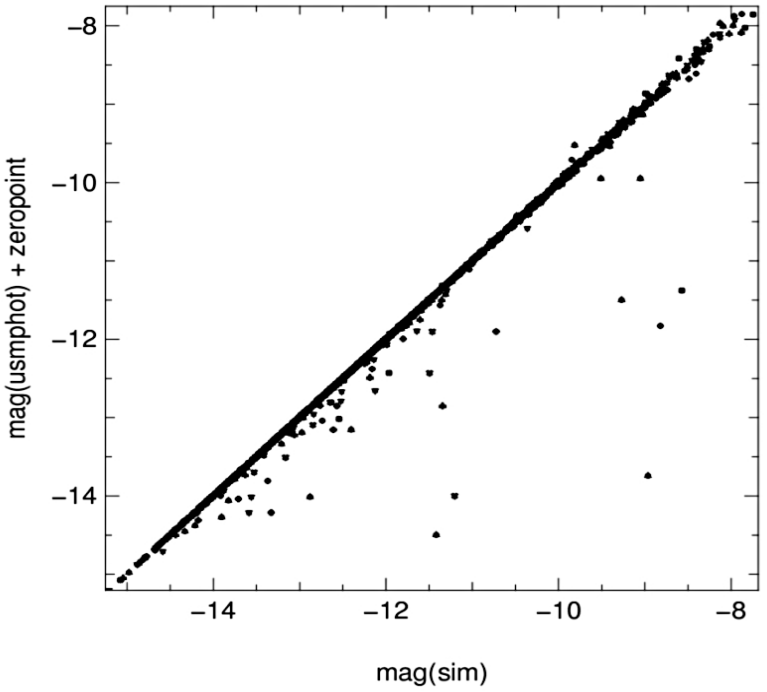


true amplitude = 1.00
small box-radius = 0.80
bigger box-radius = 0.69
USMPHOT = 1.03

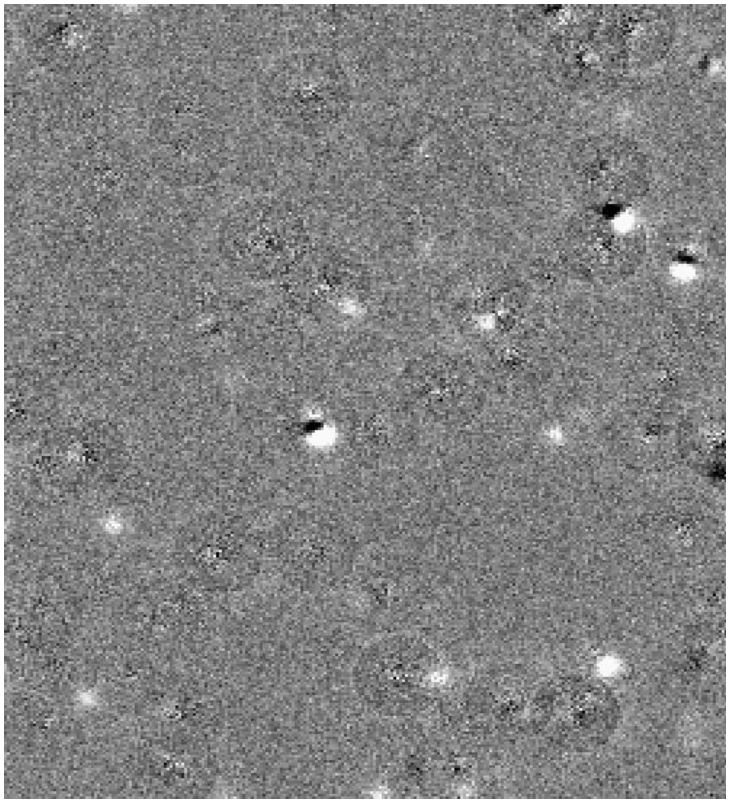
USMPHOT:

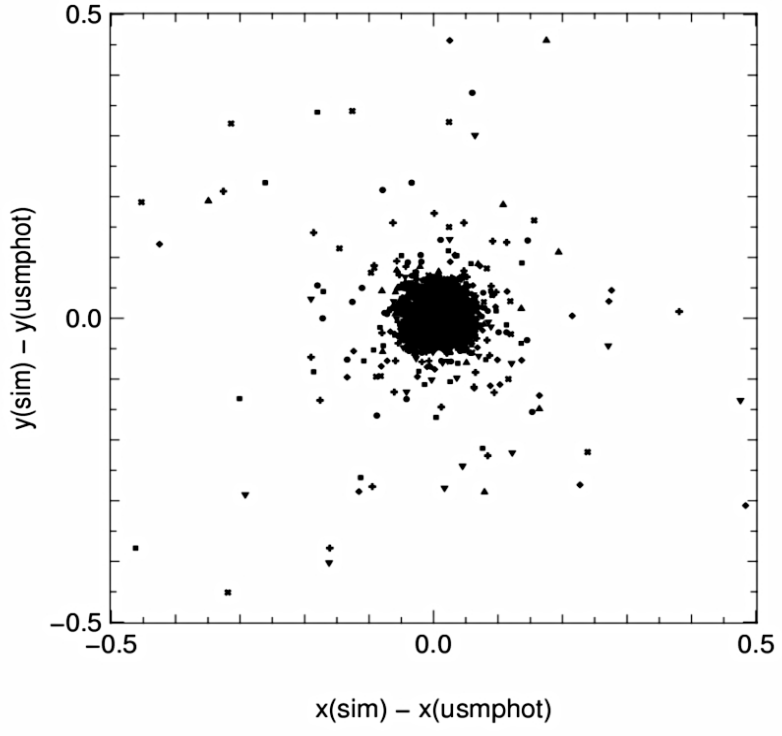


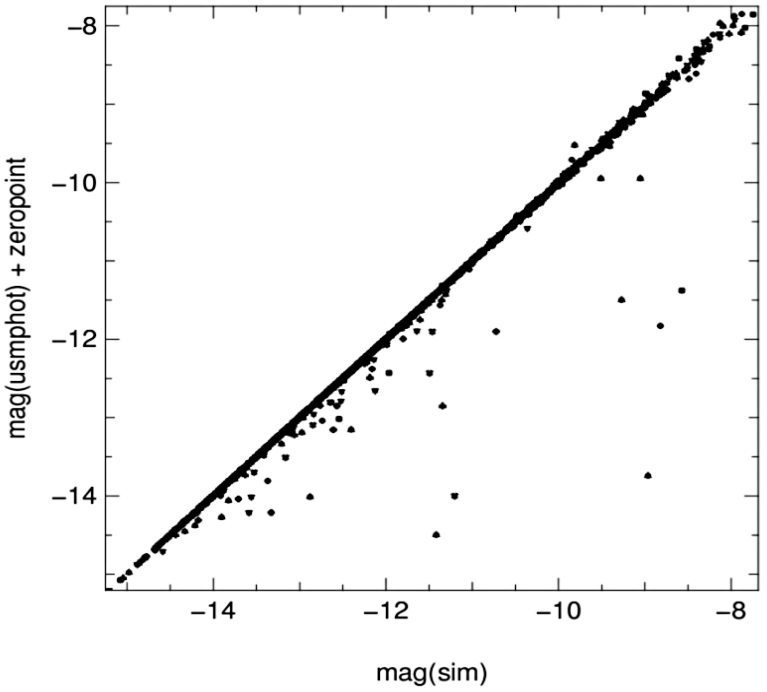

0.5
0.0
−0.5
−0.5
0.0
0.5
y(sim) – y(usmphot)
x(sim) – x(usmphot)


−8
−10
−12
−14
−14
−12
−10
−8
mag(usmphot) + zeropoint
mag(sim)

USMPHOT:




0.5
0.0
−0.5
−0.5
0.0
0.5
y(sim) – y(usmphot)
x(sim) – x(usmphot)


−8
−10
−12
−14
−14
−12
−10
−8
mag(usmphot) + zeropoint
mag(sim)

...to be done (Nov 2006):

- decide about DB object design
- integrate USMPHOT (or use psfex)?
- implement dpu-interface
- add barycentric time correction
- provide full documentation

...to be done (today):

- decide about DB object design ✓ **to be improved?**
- integrate USMPHOT (or use psfex)? ✓ **psfex?**
- implement dpu-interface ✓
- add barycentric time correction ✓
- provide full documentation

How-To &
html help pages
for individual C-programs