Exercise 1:Convolution

astropy

A Community Python Library for Astronomy

Available Kernels

`AiryDisk2DKernel`(radius, **kwargs)	2D Airy disk kernel.
`Box1DKernel`(width, **kwargs)	1D Box filter kernel.
`Box2DKernel`(width, **kwargs)	2D Box filter kernel.
`CustomKernel`(array)	Create filter kernel from list or array.
`Gaussian1DKernel`(stddev, **kwargs)	1D Gaussian filter kernel.
`Gaussian2DKernel`(x_stddev[, y_stddev, theta])	2D Gaussian filter kernel.
`MexicanHat1DKernel`(width, **kwargs)	1D Mexican hat filter kernel.
`MexicanHat2DKernel`(width, **kwargs)	2D Mexican hat filter kernel.
`Model1DKernel`(model, **kwargs)	Create kernel from 1D model.
`Model2DKernel`(model, **kwargs)	Create kernel from 2D model.
`Ring2DKernel`(radius_in, width, **kwargs)	2D Ring filter kernel.
`Tophat2DKernel`(radius, **kwargs)	2D Tophat filter kernel.
`Trapezoid1DKernel`(width[, slope])	1D trapezoid kernel.
`TrapezoidDisk2DKernel`(radius[, slope])	2D trapezoid kernel.

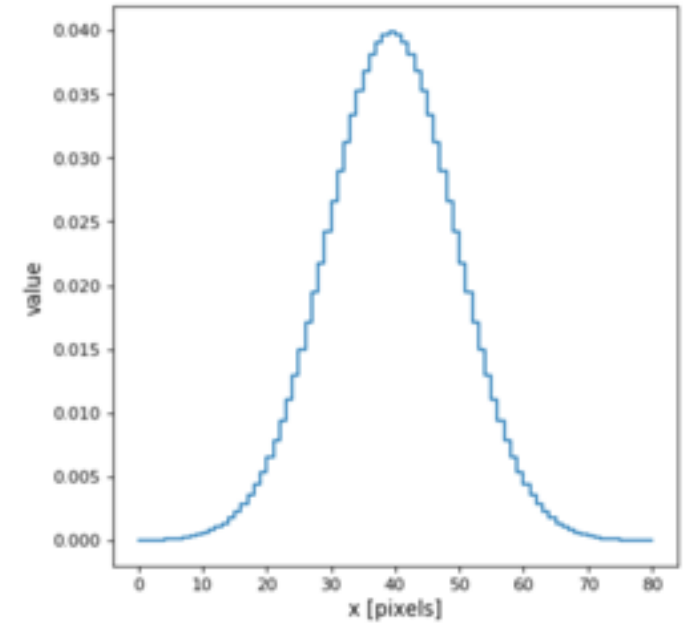
Gaussian1DKernel¶

class `astropy.convolution.` **`Gaussian1DKernel`**(*stddev*, ***kwargs*) [edit on github][source]

Bases: `astropy.convolution.Kernel1D`

1D Gaussian filter kernel.

The Gaussian filter is a filter with great smoothing properties. It is isotropic and does not produce artifacts.



Parameters:

stddev : number

Standard deviation of the Gaussian kernel.

x_size : odd int, optional

Size of the kernel array. Default = 8 * stddev

mode : str, optional

One of the following discretization modes:

- 'center' (default)

  Discretize model by taking the value at the center of the bin.

- 'linear_interp'

  Discretize model by linearly interpolating between the values at the corners of the bin.

- 'oversample'

  Discretize model by taking the average on an oversampled grid.

- 'integrate'

  Discretize model by integrating the model over the bin. Very slow.

factor : number, optional

Factor of oversampling. Default factor = 10. If the factor is too large, evaluation can be very slow.

Gaussian2DKernel

class `astropy.convolution.` **`Gaussian2DKernel`**(*x_stddev*, *y_stddev=None*, *theta=0.0*, ***kwargs*) ¶ [source] [edit on github]

Bases: `astropy.convolution.Kernel2D`

2D Gaussian filter kernel.

The Gaussian filter is a filter with great smoothing properties. It is isotropic and does not produce artifacts.

Parameters:

x_stddev : float

Standard deviation of the Gaussian in x before rotating by theta.

y_stddev : float

Standard deviation of the Gaussian in y before rotating by theta.

theta : float

Rotation angle in radians. The rotation angle increases counterclockwise.

x_size : odd int, optional

Size in x direction of the kernel array. Default = 8 * stddev.

y_size : odd int, optional

Size in y direction of the kernel array. Default = 8 * stddev.

mode : str, optional

One of the following discretization modes:

- 'center' (default)

  Discretize model by taking the value at the center of the bin.

- 'linear_interp'

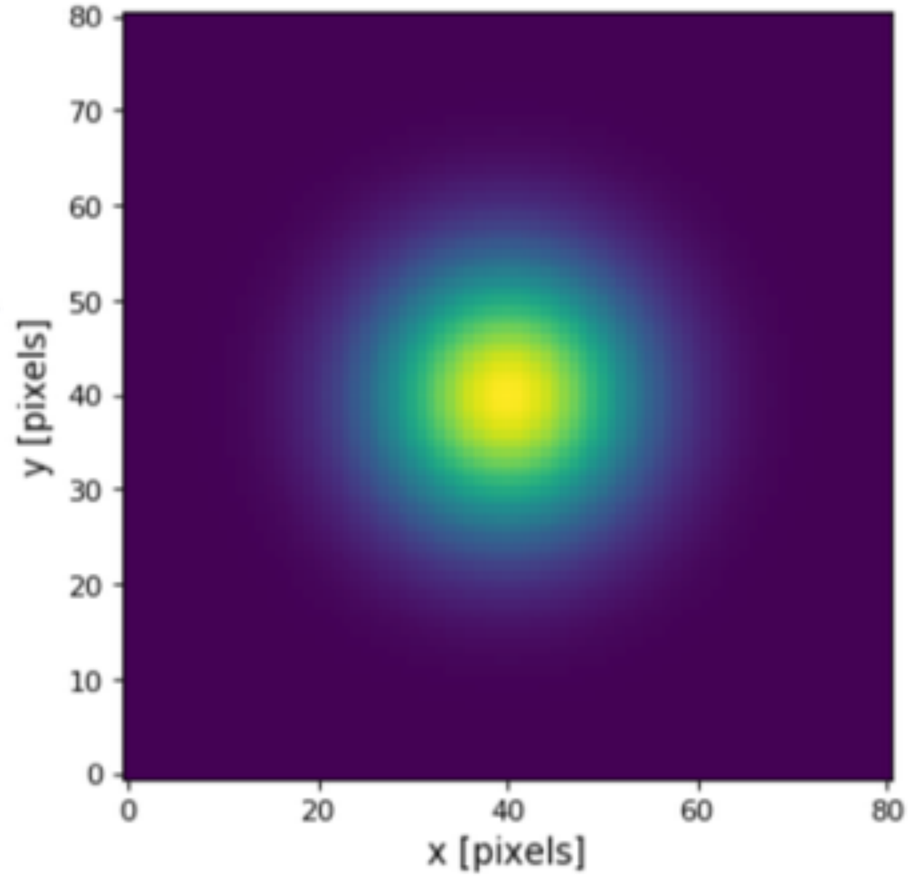
  Discretize model by performing a bilinear interpolation between the values at the corners of the bin.

- 'oversample'

  Discretize model by taking the average on an oversampled grid.

- 'integrate'

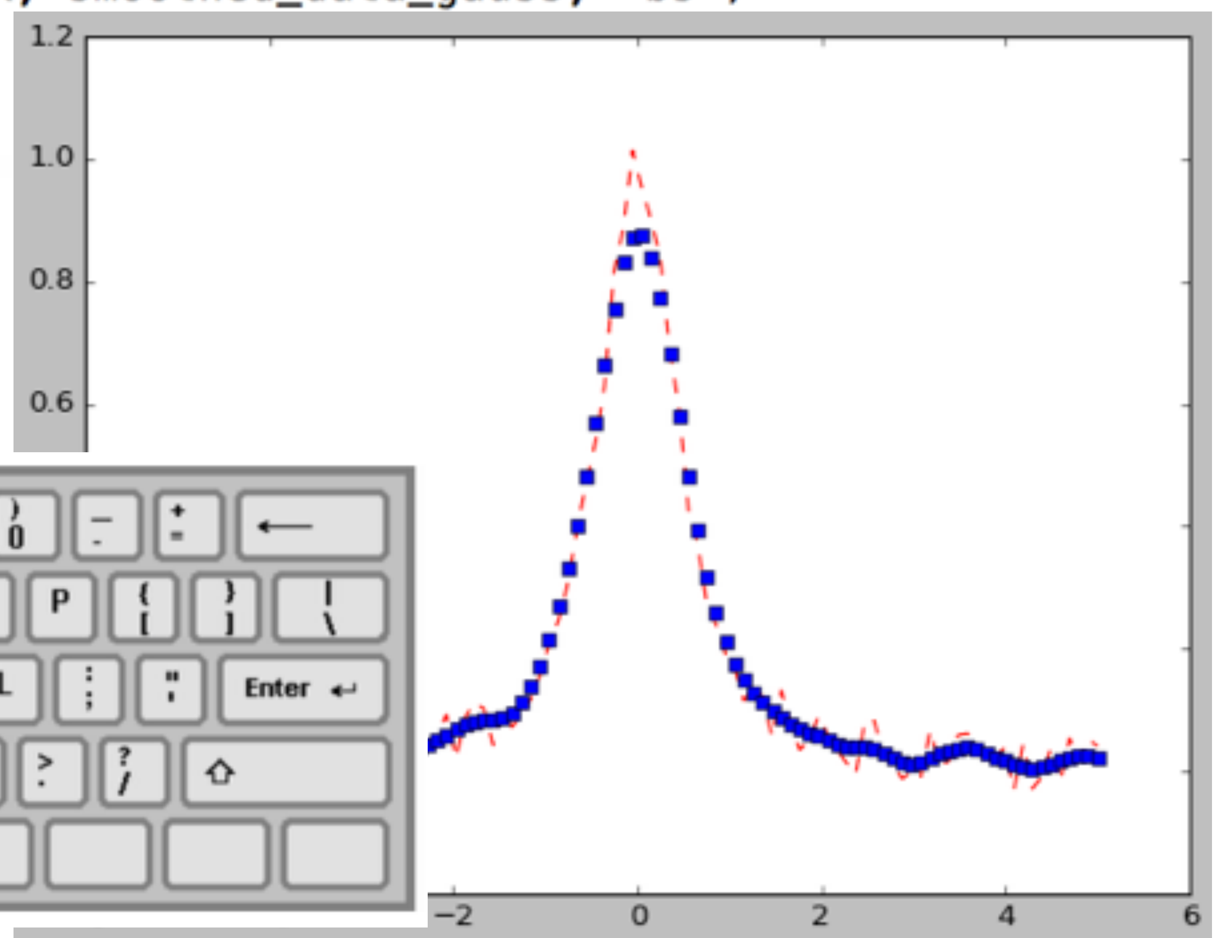
  Discretize model by integrating the model over the bin.



```
>>> import numpy as np
>>> from astropy.modeling.models import Lorentz1D
>>> from astropy.convolution import convolve, Gaussian1DKernel, Box1DKernel
>>> lorentz = Lorentz1D(1, 0, 1)
>>> x = np.linspace(-5, 5, 100)
>>> data_1D = lorentz(x) + 0.1 * (np.random.rand(100) - 0.5)
```

```
gauss_kernel = Gaussian1DKernel(2)
smoothed_data_gauss = convolve(data_1D, gauss_kernel)
```

```
>>> import matplotlib.pyplot as plt
>>> plt.plot(x, data_1D, 'r--', x, smoothed_data_gauss, 'bs')
[<matplotlib.lines.Line2D object
ject at 0x2b5cea4ac650>]
>>> plt.show()
```



Exercise 2: image matching and subtraction of astronomical images

Can you spot the supernova? Maybe, image subtraction would help ...

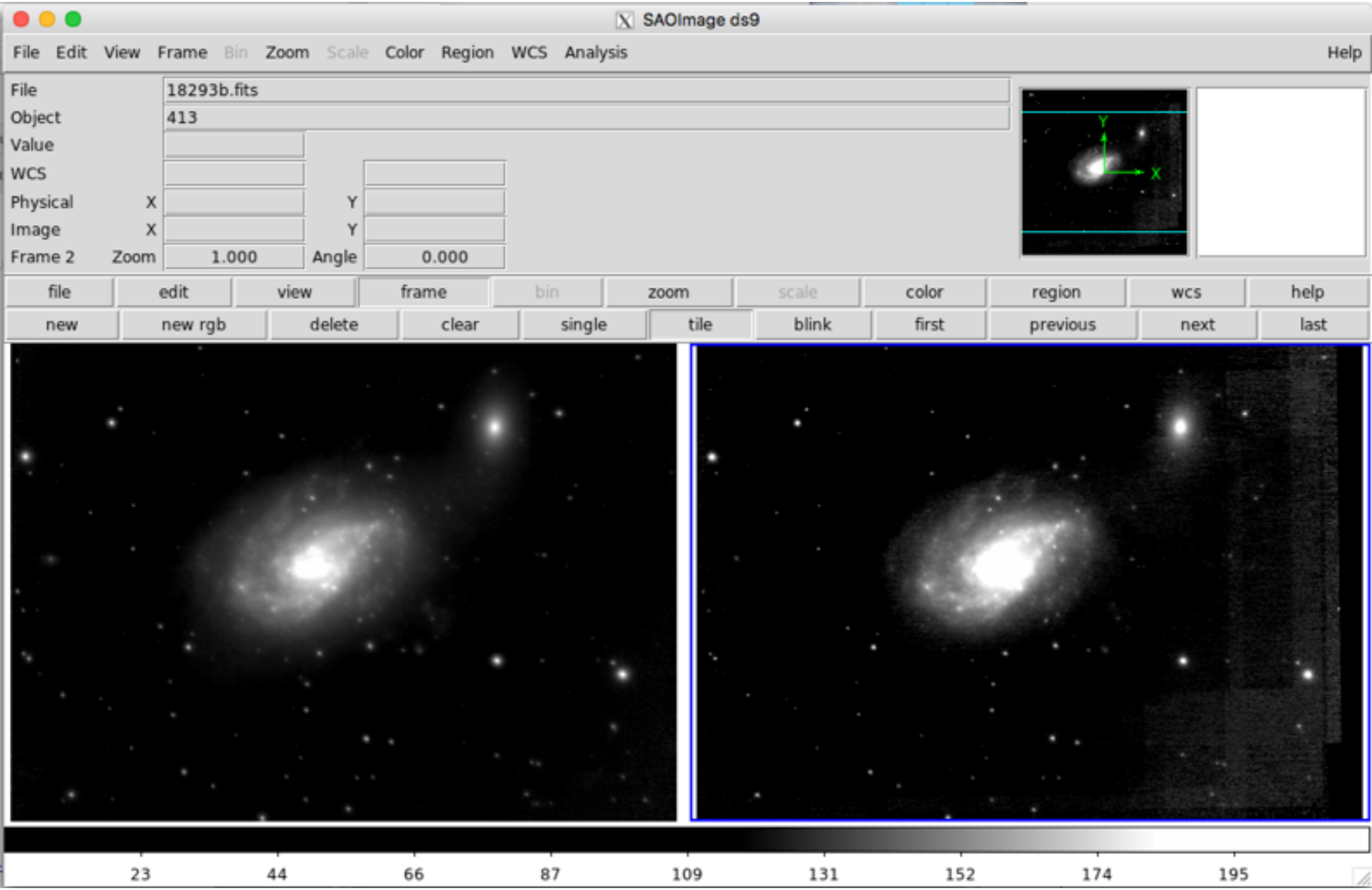


image matching and subtraction of astronomical images

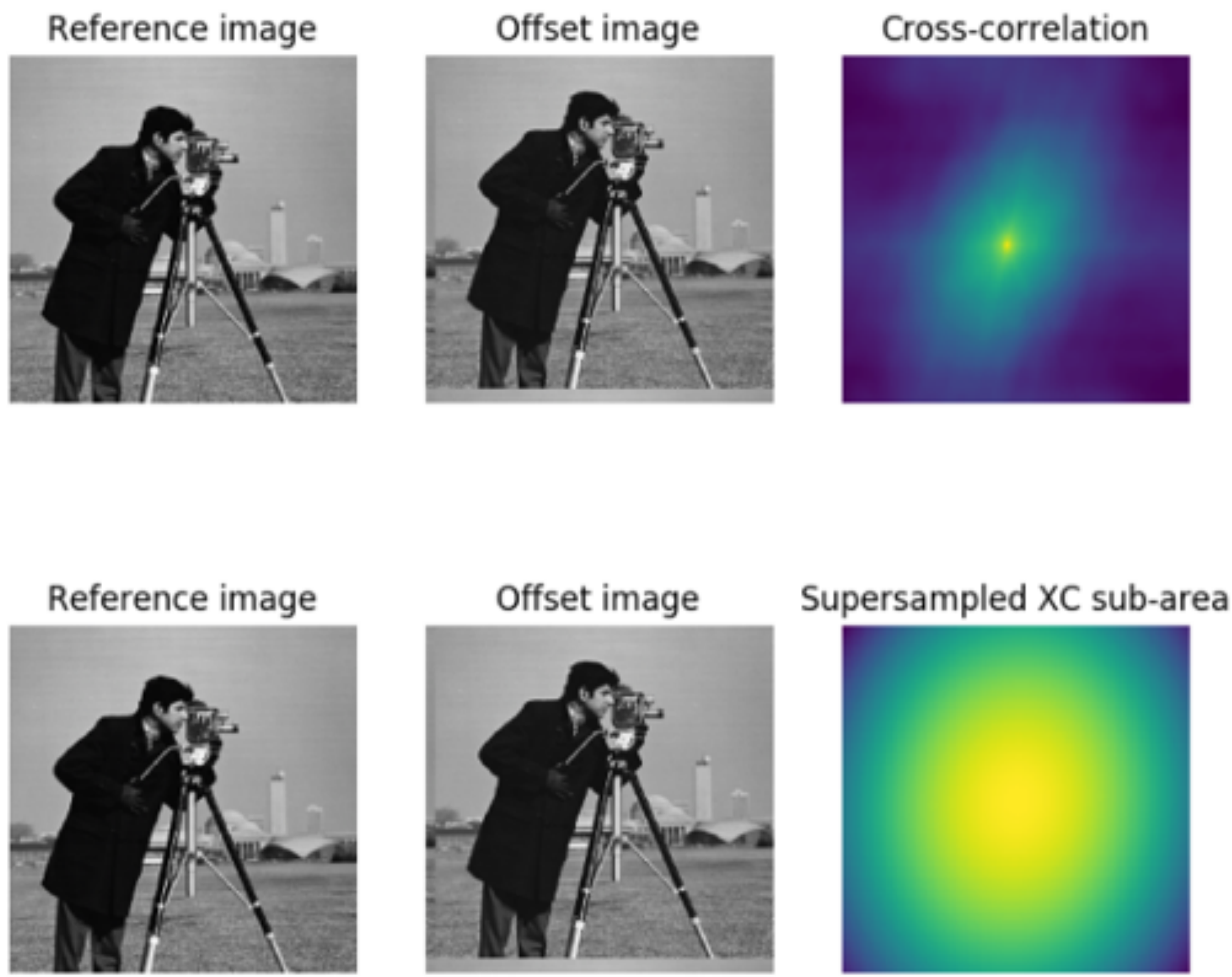
```
/home/s/sepmat/ISIS/package/bin/mrj_phot image1.fits image2.fits -c
config.txt

/home/s/sepmat/sub/18293a.fits
/home/s/sepmat/sub/18293b.fits
/home/s/sepmat/sub/config.txt
```

Exercise 3: Richardson-Lucy deconvolution

- color_exposure
- edges
- features_detection
- filters
  - plot_cycle_spinning.py
  - plot_deconvolution.py
  - plot_denoise_wavelet.py
  - plot_denoise.py
  - plot_entropy.py
  - plot_frangi.py
  - plot_hysteresis.py
  - plot_inpaint.py
  - plot_nonlocal_means.py
  - plot_phase_unwrap.py
  - plot_rank_mean.py
  - plot_restoration.py
- numpy_operations
  - plot_camera_numpy.py
  - plot_view_as_blocks.py
- segmentation
- transform
  - plot_edge_modes.py
  - plot_fundamental_matrix.py
  - plot_matching.py
  - plot_piecewise_affine.py
  - plot_pyramid.py
  - plot_radon_transform.py
  - plot_ransac.py
  - plot_ransac3D.py
  - plot_register_translation.py
  - plot_rescale.py
  - plot_seam_carving.py
  - plot_ssim.py
  - plot_swirl.py
- xx_applications

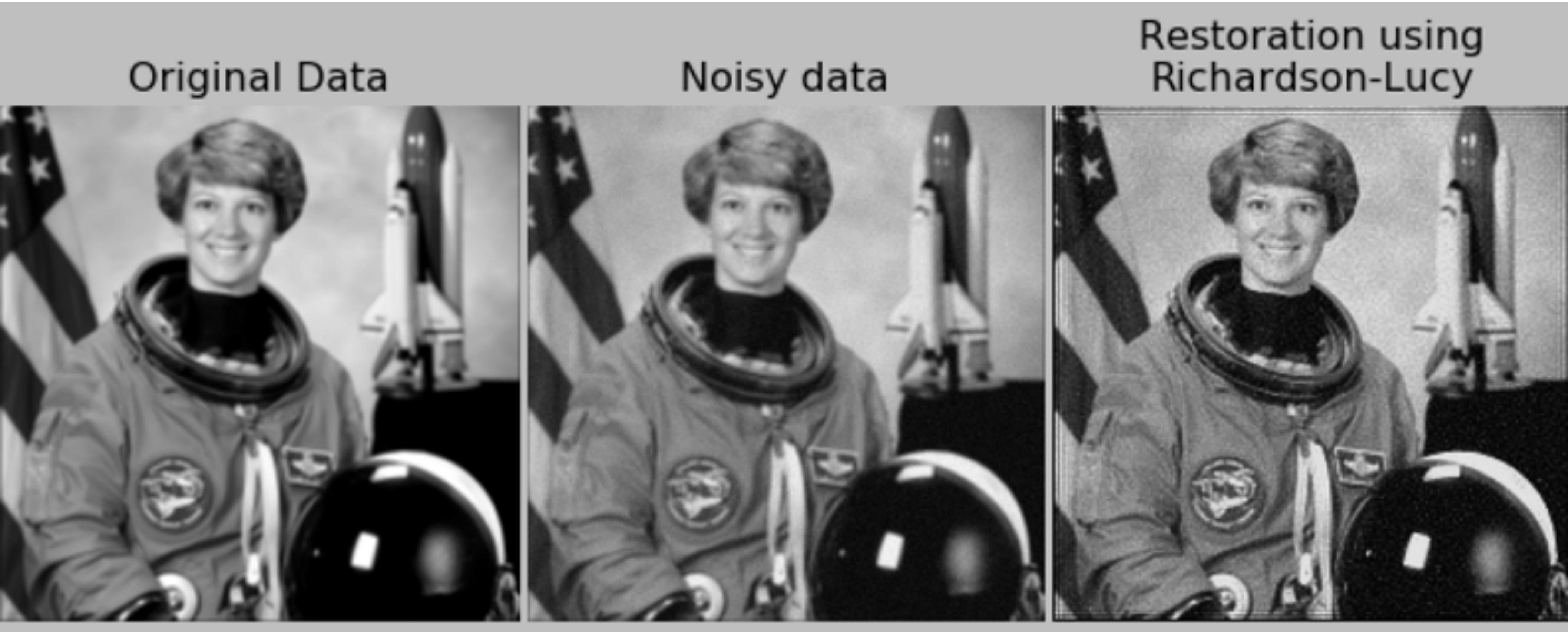
scikit-image
image processing in python



http://scikit-image.org/docs/dev/auto_examples/filters/plot_deconvolution.html

Download Python source code: plot_deconvolution.py

python plot_deconvolution.py



```
import numpy as np
import matplotlib.pyplot as plt

from scipy.signal import convolve2d as conv2

from skimage import color, data, restoration

astro = color.rgb2gray(data.astronaut())

                        View documentation for
psf = np.ones((5,       skimage.color.rgb2gray
astro = conv2(astro, psf, 'same')
# Add Noise to Image
astro_noisy = astro.copy()
astro_noisy += (np.random.poisson(lam=25, size=astro.shape) - 10) / 255.

# Restore Image using Richardson-Lucy algorithm
deconvolved_RL = restoration.richardson_lucy(astro_noisy, psf, iterations=30)

fig, ax = plt.subplots(nrows=1, ncols=3, figsize=(8, 5))
plt.gray()

for a in (ax[0], ax[1], ax[2]):
       a.axis('off')

ax[0].imshow(astro)
ax[0].set_title('Original Data')

ax[1].imshow(astro_noisy)
ax[1].set_title('Noisy data')

ax[2].imshow(deconvolved_RL, vmin=astro_noisy.min(), vmax=astro_noisy.max())
ax[2].set_title('Restoration using\nRichardson-Lucy')


fig.subplots_adjust(wspace=0.02, hspace=0.2,
                    top=0.9, bottom=0.05, left=0, right=1)
plt.show()
```

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View documentation for
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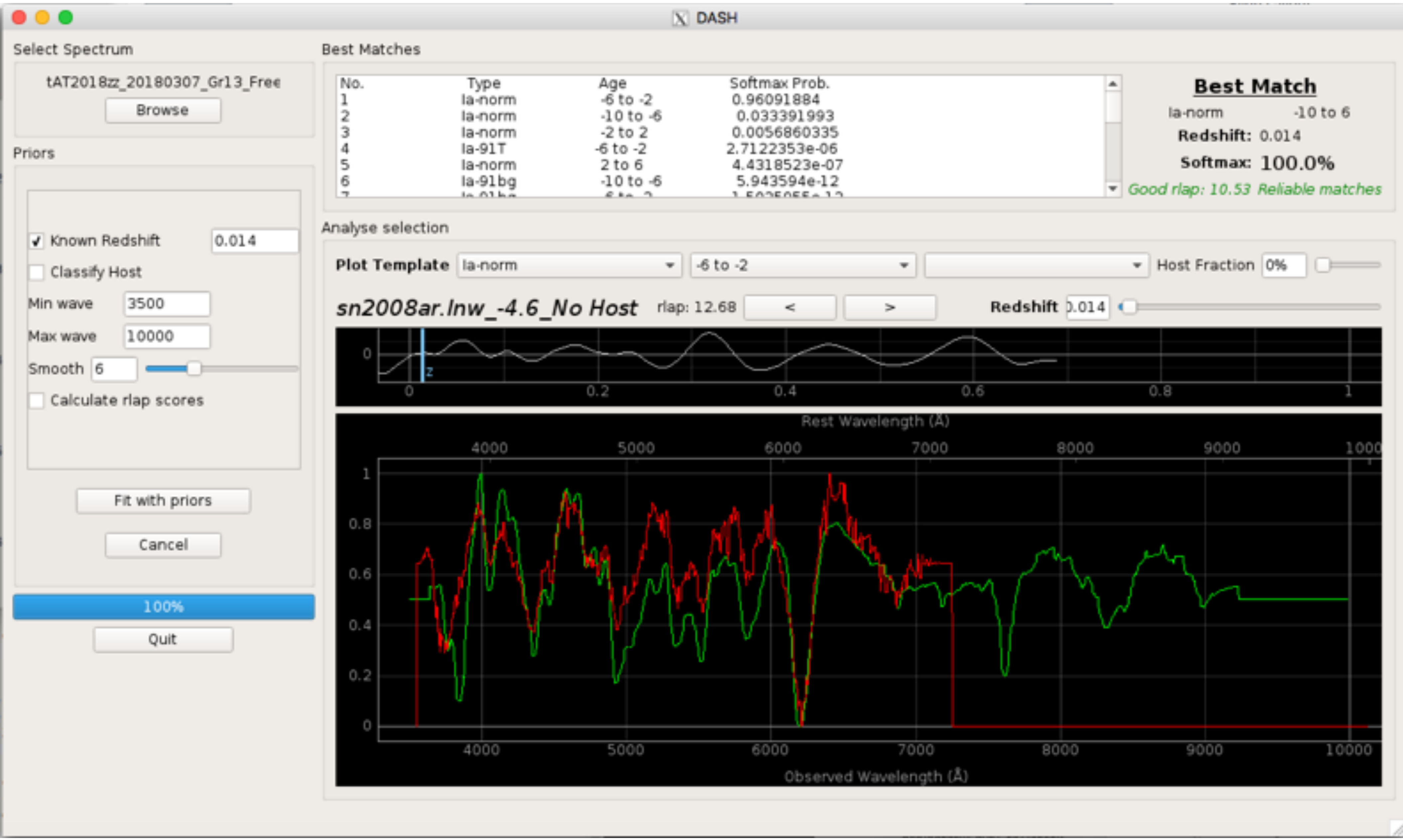
```

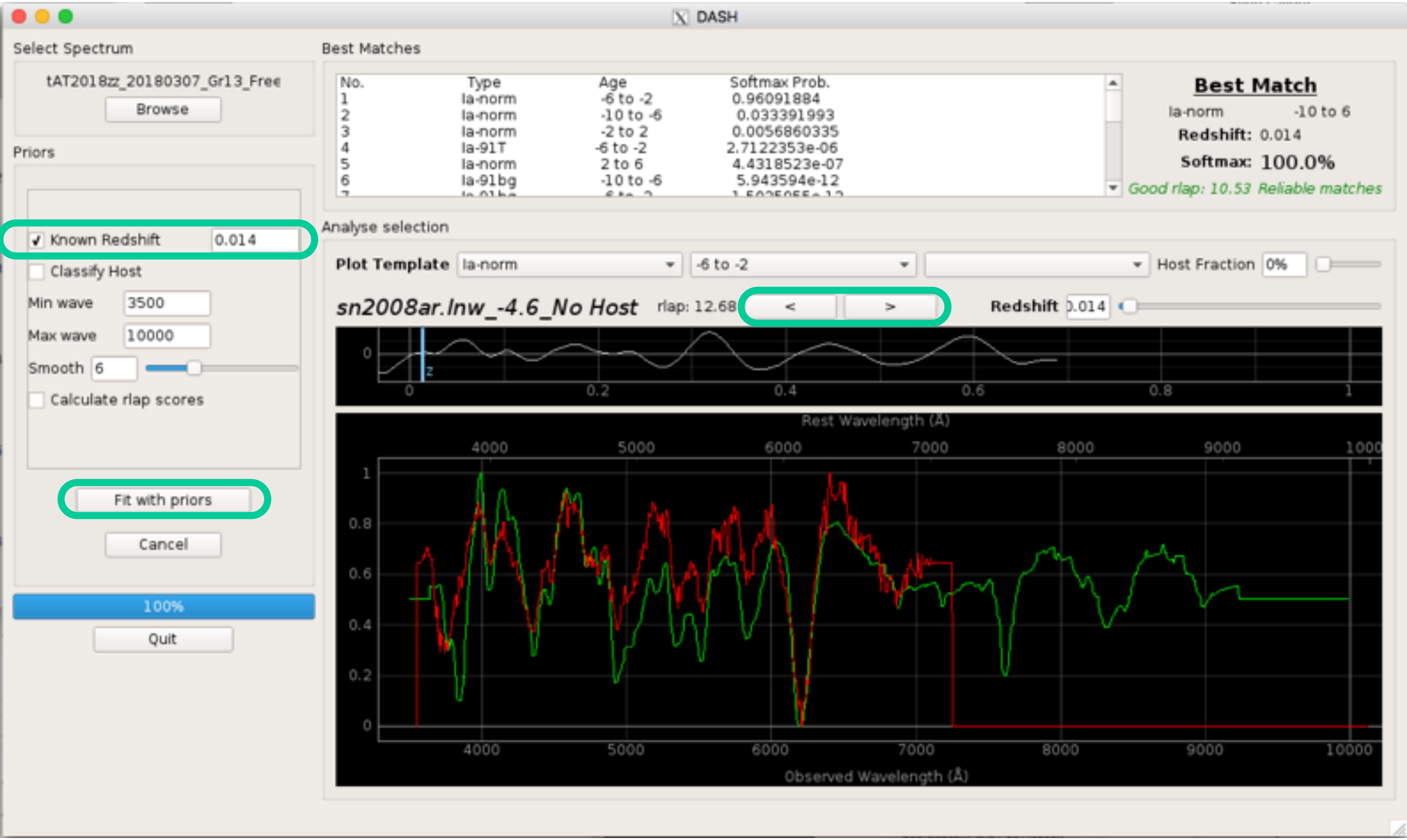
View documentation for
skimage.color.rgb2gray

Exercise 4: Deep learning for the automated spectral classification of supernovae

https://github.com/daniel-muthukrishna/DASH

```
sepmat@signal:~$ iraf27
(iraf27) sepmat@signal:~$ python
Python 2.7.12 |Continuum Analytics, Inc.| (default, Jul  2 2016, 17:42:40)
[GCC 4.4.7 20120313 (Red Hat 4.4.7-1)] on linux2
Type "help", "copyright", "credits" or "license" for more information.
Anaconda is brought to you by Continuum Analytics.
Please check out: http://continuum.io/thanks and https://anaconda.org
>>> import dash
WARNING: AstropyDeprecationWarning: astropy.utils.compat.odict.OrderedDict
w deprecated - import OrderedDict from the collections module instead [astr
tils.compat.odict]
>>> dash.run_gui()
```


DASH
Select Spectrum
tAT2018zz_20180307_Gr13_Free
Browse
Priors
Known Redshift
0.014
Classify Host
Min wave
3500
Max wave
10000
Smooth
6
Calculate rlap scores
Fit with priors
Cancel
100%
Quit
Best Matches
No. Type Age Softmax Prob.
1 Ia-norm -6 to -2 0.96091884
2 Ia-norm -10 to -6 0.033391993
3 Ia-norm -2 to 2 0.0056860335
4 Ia-91T -6 to -2 2.7122353e-06
5 Ia-norm 2 to 6 4.4318523e-07
6 Ia-91bg -10 to -6 5.943594e-12
Best Match
Ia-norm -10 to 6
Redshift: 0.014
Softmax: 100.0%
Good rlap: 10.53 Reliable matches
Analyse selection
Plot Template
Ia-norm
-6 to -2
Host Fraction
0%
sn2008ar.lnw_-4.6_No Host
rlap: 12.68
<
>
Redshift
Rest Wavelength (Å)
Observed Wavelength (Å)


DASH
Select Spectrum
tAT2018zz_20180307_Gr13_Free
Browse
Priors
Known Redshift 0.014
Classify Host
Min wave 3500
Max wave 10000
Smooth 6
Calculate rlap scores
Fit with priors
Cancel
100%
Quit
Best Matches
No. Type Age Softmax Prob.
1 Ia-norm -6 to -2 0.96091884
2 Ia-norm -10 to -6 0.033391993
3 Ia-norm -2 to 2 0.0056860335
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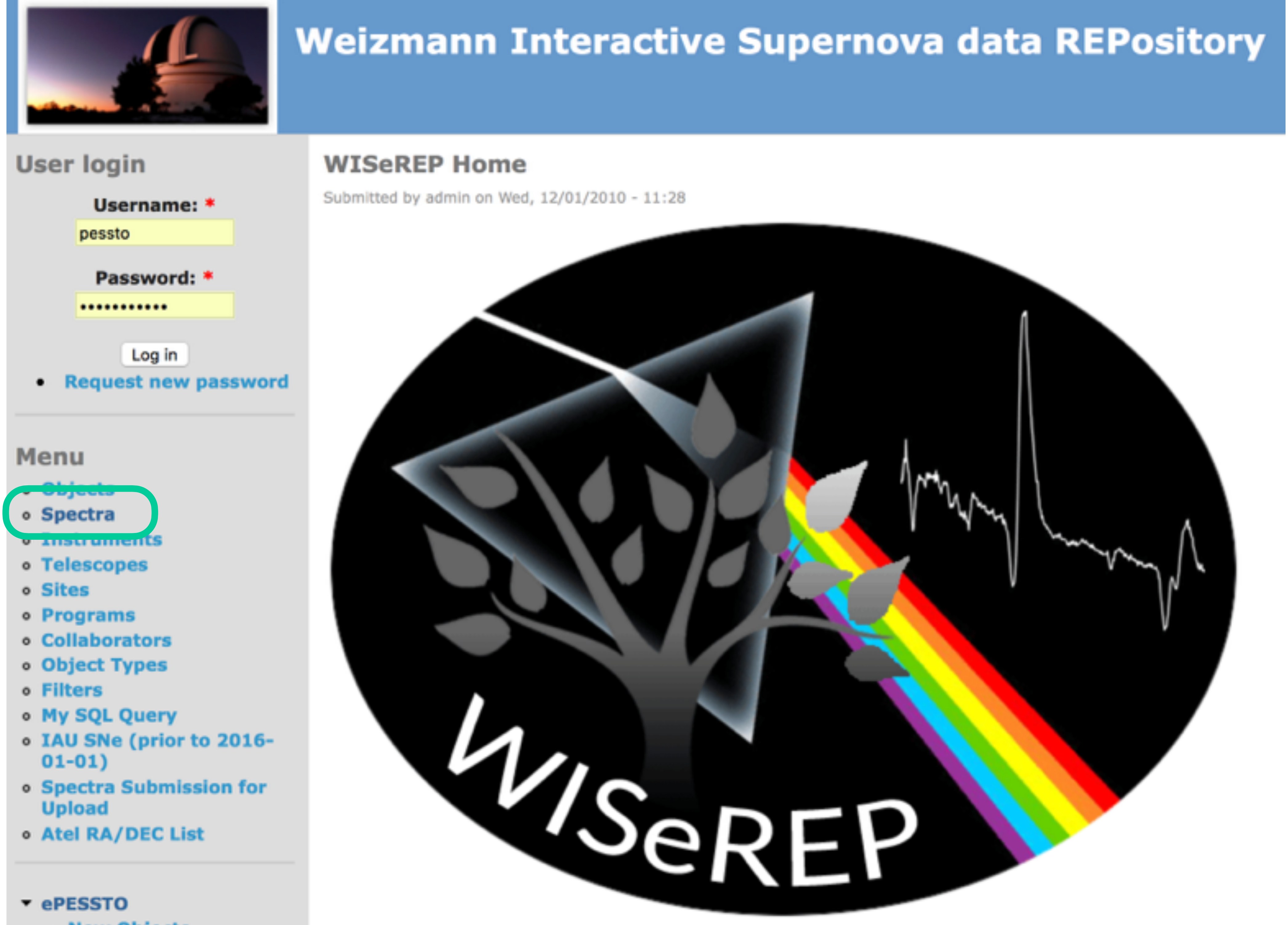
Best Match
Ia-norm -10 to 6
Redshift: 0.014
Softmax: 100.0%
Good rlap: 10.53 Reliable matches
Analyse selection
Plot Template Ia-norm -6 to -2 Host Fraction 0%
sn2008ar.lnw_-4.6_No Host rlap: 12.68 < >
Redshift 0.014
Rest Wavelength (Å)
Observed Wavelength (Å)



https://wiserep.weizmann.ac.il

Spectra

Submitted by admin on Tue, 12/07/2010 - 04:55

Search: Object: SN2018zz OR Obj Name like (free text):

Obj Type: All Types OR Obj Type like (free text):

Instrument: All Instruments Spec Type: All Types

Program: All Programs Added within the last No limit Public: All

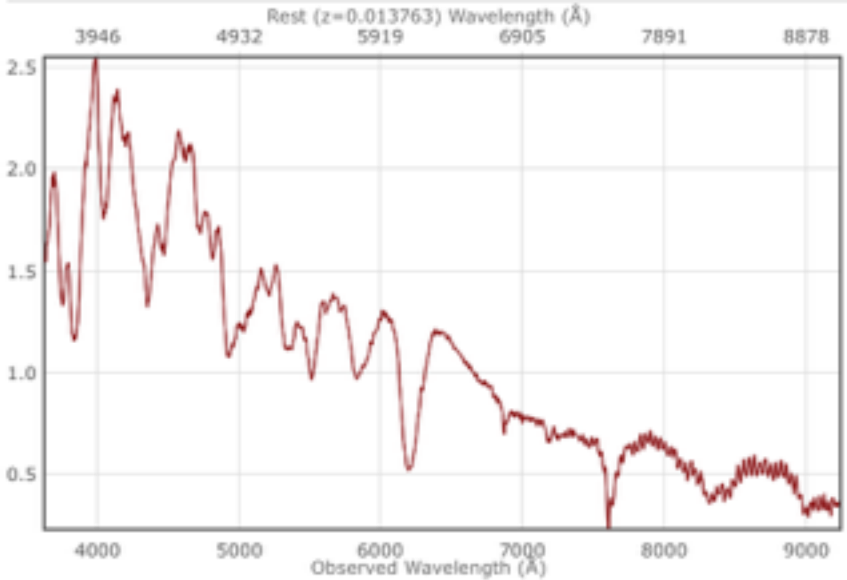
Show additional query fields

Sort by: (1) Observation Date Asc (2) Asc (3) Asc **Limit:** 100

Show plots: Yes No

2 row(s) returned.

Id	Obj. Name	Type	Spec. Program	Instrument	Obs. Date	Observer	Red. Date	Reducer	Exp. Time	Slit	Public	Ascii File Fits File	Created By
44939	SN2018zz	SN Ia	ePESSTO	ESO-NTT - EFOSC2-NTT	2018-03-08	Christian Vogl, Andreas Flörs, Stefan Taubenberger	2018-03-08	Stefano Benetti	450	1	Y	tAT2018zz_20180307_Gr13_Free_slit1.0_1_f.asci tAT2018zz_20180307_Gr13_Free_slit1.0_1_f.fits	nikola-UploadSet



Show H at z= 0.01376 v_{exp}= 0 km/s

Show He at z= 0.01376 v_{exp}= 0 km/s

Show He II at z= 0.01376 v_{exp}= 0 km/s

Show O at z= 0.01376 v_{exp}= 0 km/s

Show O II at z= 0.01376 v_{exp}= 0 km/s

Show O III at z= 0.01376 v_{exp}= 0 km/s

Show Na at z= 0.01376 v_{exp}= 0 km/s

Show Å at z= 0.01376 v_{exp}= 0 km/s

Show Å at z= 0.01376 v_{exp}= 0 km/s

Show Mg at z= 0.01376 v_{exp}= 0 km/s

Show Mg II at z= 0.01376 v_{exp}= 0 km/s

Show Si II at z= 0.01376 v_{exp}= 0 km/s

Show S II at z= 0.01376 v_{exp}= 0 km/s

Show Ca II at z= 0.01376 v_{exp}= 0 km/s

Show Fe II at z= 0.01376 v_{exp}= 0 km/s

Show Fe III at z= 0.01376 v_{exp}= 0 km/s

Show Tellurics

Galaxy lines at z= 0.01376

WN WC/O Wolf-Rayet lines at z= 0.01376

Spec Type: Object

Quality: Rapid

Spectra

Submitted by admin on Tue, 12/07/2010 - 04:55

Search: Object: SN2018zz OR Obj Name like (free text):

Obj Type: All Types OR Obj Type like (free text):

Instrument: All Instruments Spec Type: All Types

Program: All Programs Added within the last No limit Public: All

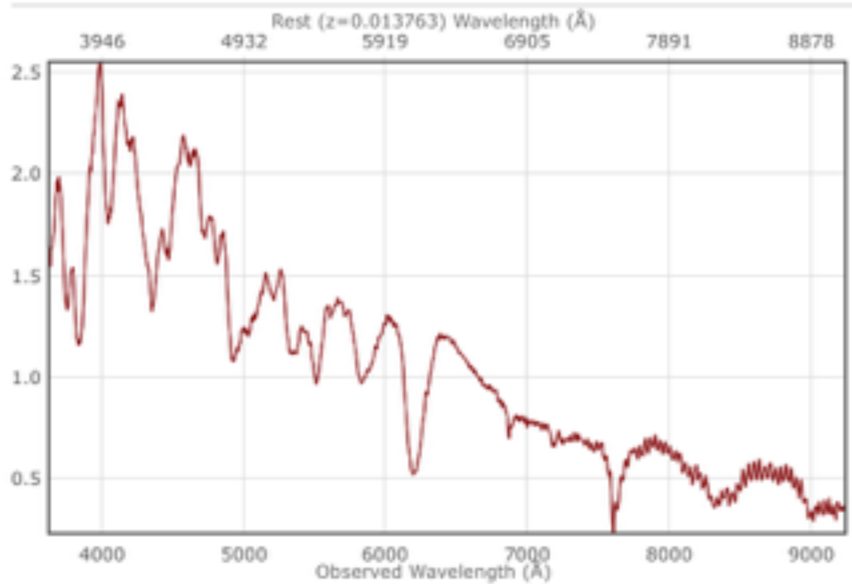
Show additional query fields

Sort by: (1) Observation Date Asc (2) Asc (3) Asc **Limit:** 100

Show plots: Yes No

2 row(s) returned.

Id	Obj. Name	Type	Spec. Program	Instrument	Obs. Date	Observer	Red. Date	Reducer	Exp. Time	Slit	Public	Ascii File Fits File	Created By
44939	SN2018zz	SN Ia	ePESSTO	ESO-NTT - EFOSC2-NTT	2018-03-08	Christian Vogl, Andreas Flörs, Stefan Taubenberger	2018-03-08	Stefano Benetti	450	1	Y	tAT2018zz_20180307_Gr13_Free_slit1.0_1_f.asci tAT2018zz_20180307_Gr13_Free_slit1.0_1_f.fits	nikola-UploadSet



Show H at $z=$ 0.01376 $v_{exp}=$ 0 km/s

Show He at $z=$ 0.01376 $v_{exp}=$ 0 km/s

Show He II at $z=$ 0.01376 $v_{exp}=$ 0 km/s

Show O at $z=$ 0.01376 $v_{exp}=$ 0 km/s

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Show O III at $z=$ 0.01376 $v_{exp}=$ 0 km/s

Show Na at $z=$ 0.01376 $v_{exp}=$ 0 km/s

Show Å at $z=$ 0.01376 $v_{exp}=$ 0 km/s

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Show Mg at $z=$ 0.01376 $v_{exp}=$ 0 km/s

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Show Fe II at $z=$ 0.01376 $v_{exp}=$ 0 km/s

Show Fe III at $z=$ 0.01376 $v_{exp}=$ 0 km/s

Show Tellurics

Galaxy lines at $z=$ 0.01376

WN WC/O Wolf-Rayet lines at $z=$ 0.01376

Spec Type: Object

Quality: Rapid

Un-framed version or Framed version
Mirror sites: (Main page) (Purdue mirror)
(thistlethwaites mirror)
(RochesterAstronomy.com mirror)

LATESTSUPERNOVAE *Supported by* PURDUE UNIVERSITY | Physics and Astronomy COLLEGE OF SCIENCE

All active SN over mag 17.0

Name	Mag	Type
AT2018bsm	15.2	unk
2018zd	15.3	IIn
2018aoz	15.3	Ia
2018aoq	15.7	II
AT2018cej	15.8	unk
AT2018cbg	15.8*	unk
AT2018cgs	16.0	unk
ASASSN-18lp	16.0	unk
ASASSN-18kd	16.0	Ia
ASASSN-18kz	16.2	Ia
AT2018bim	16.3*	unk
ASASSN-18eo	16.3*	II
AT2018bcl	16.4*	unk
2018bta	16.4	Ia
AT2018cjj	16.5	CV
ASASSN-18le	16.5	Ia
2018bie	16.5	Ia-91T
ASASSN-18en	16.6*	Ia
AT2018bip	16.6*	unk
ASASSN-18lz	16.6	Ia-91T

A long time ago, in a galaxy far far away, a star exploded. This star exploded so violently that for a few weeks the star outshone its parent galaxy. This type of explosion is called a Supernova. The last one in our galaxy was 400 years ago, making us about 300 years overdue for the next one. On this web page you will find a list of the currently observable supernovae, along with information on their location, reference images, and their last reported brightness. The data on this page comes from CBET and ATEL circulars. Data also comes from IAU's Transient Name Server web page. These web pages have brought you the latest in supernovae data and images since April 1997. 21 years and counting.

Web page last modified on 06/13/2018 12:33:27 . For yesterday's updates, go to the updates page.

- Created entries for AT2018cmi (Mag 17.7 in M31)
- Updated the entries for 2018cib (= ASASSN-18lz, Type Ia-91T)

News: 2018aoz (Type Ia in NGC 3923) is now fading. 2018zd is a Type II in nearby NGC 2146. 2018gv (a Type Ia in NGC 2525) is now fading. 2017eaw (Type II in NGC 6946), is our most prolific galaxy with now 10 supernovae is still visible. Please note my new e-mail address: dbishopx at gmail.com. Dan Green via the TOCP no longer will be officially naming supernovae. The IAU's Transient Name Server is now the official way to post your discoveries. This is the TNS getting started page. For supernovae light curves, look at the new Open supernova Catalog (see OSC links). Please see Padova-Asiago Supernova Group for the latest spectra. For the year 2018, 2253 supernovae (365 CBAT, 1639 unconfirmed, and 249 other sources) have been reported. (7114 last year) The brightest SN of the year is 2018aoz (Mag 12.7) and 2018pv (Mag 12.7) followed by 2018gv (Mag 12.8).

The http://www.rochesterastronomy.org/snimages/ mirror is not updating. Latest Supernovae is now supported by Purdue University and maintains a new mirror hosted in the Department of Physics and Astronomy that is overseen by Dan Milisavljevic. Purdue mirror page: http://www.physics.purdue.edu/brightsupernovae/. **New features:** All galactic objects (CV novae, etc) will be banished on a weekly basis to the boneyard. Thanks for all of the images, I have been posting them on flickr. Join the discussion! Facebook Supernova Enthusiasts Group. The Active supernovae page is a version of this page which is designed to be easier to read. I've done extensive work recently in the Archives. If anybody knows who some of the "unknown" discoverers are, please let me know. *Does anybody know of a grant that I could apply to for supporting this page?* I probably spend about 2 hours a night working on it. Please note my backup e-mail address: dbishopx at gmail.com . To turn off the icons, use this link. I am (re)starting a supernova e-mail list. Please sign up if interested. VSNet is partially back up! LOSS ask people who discover supernovae to provide an offset from a nearby star to make spectroscopy easier.

Some groups are not reporting all of their discoveries to CBAT.

- ASAS-SN: Transients, Supernovae
- ATLAS (no published list)
- Catalina Real-Time Transient Survey:
  - MLS search page (Supernovae only, Possible supernovae)
  - Supernova hunt page
- Dark Energy Survey Bright Transients
- Gaia Photometric Science Alerts programme Alert index
- La Silla-QUEST (no published list)
- MASTER robotic Net List of optical transients, Supernovae
- OGLE-IV wide field survey Discovery images Rapid Transient Detection system
- Intermediate Palomar Transient Factory (no published list)
- PS1 Science Consortium Discoveries
- ROTSE collaboration: Discoveries page
- SkyMapper Supernovae search Zooniverse supernova sighting Results from Supernova Sighting

Spectra targets New These are objects in need of spectra (now automatically generated, either a low Z or a repeat host)

- AT2018chr in IC 1516
- AT2018chc in NGC 5548
- AT2018cfl in NGC 5123
- AT2018cdx in NGC 4788
- AT2018cai in NGC 4693
- AT2018bwn in NGC 7056
- AT2018bvu in 2MASX J13531661-3721182
- AT2018bsk in NGC 4454
- AT2018bro in NGC 5943
- AT2018bgo in UGC 8733
- AT2018bch in IC 4612
- AT2018azj in 2MASX J13340192-1449200
- AT2018awm in IC 5353
- AT2018awk in NGC 3588
- AT2018auy in MCG -4-53-33

http://www.rochesterastronomy.org/snimages/

ePESSTO spectroscopic classification of optical transients

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ePESSTO, the extended Public ESO Spectroscopic Survey for Transient Objects (see Smartt et al. 2015, A&A, 579, 40; http://www.pessto.org), reports the following supernova classifications. Targets were supplied by the the All Sky Automated Survey for SuperNovae ASAS-SN (see Shappee et al. 2014, ApJ, 788, 48 and http://www.astronomy.ohio-state.edu/~assassin/index.shtml) and the ATLAS survey, see Tonry et al. (2011, PASP, 123, 58) and Tonry et al. (ATel #8680). All observations were performed on the ESO New Technology Telescope at La Silla on 2018 March 8, using EFOSC2 and Grism 13 (3985-9315A, 18A resolution). Classifications were done with SNID (Blondin & Tonry, 2007, ApJ, 666, 1024) and GELATO (Harutyunyan et al., 2008, A&A, 488, 383). Classification spectra and additional details can be obtained from http://www.pessto.org (via WISeREP) and the IAU Transient Name Server.

Survey Name	IAU Name	RA (J2000)	Dec (J2000)	Disc. Date	Source	Disc Mag	z	Type	Phase	Notes
ASASSN-18et	SN 2018aay	10 32 34.85	-02 41 18.6	2018 03 06.07	ASAS-SN	17.5 (g)	0.030900	Ia	at max	(1)
ASASSN-18en	SN 2018zz	14 03 39.05	-33 58 42.5	2018 03 03.92	ASAS-SN	16.0 (g)	0.013763	Ia	at max	(1)
ATLAS18mgm	SN 2018zp	16 43 39.77	+26 35 45.67	2018 03 03.92	ASAS-SN	18.33 (o)	0.0605	Ia	at max	(2)

(1) The spectra of ASASSN-18et and ASASSN-18en resemble those of normal type Ia SNe at around maximum light. The expansion velocities inferred from the position of the minimum of the Si II 635.5 nm line are about 10500 km/s and 11000 km/s, respectively.
(2) The spectrum of ATLAS18mgm resembles that of a normal type Ia SN near the maximum light. The redshift of the host galaxy is uncertain. Adopting z=0.0605 from the main SN features as inferred by SNID, we obtain an expansion velocity of about 12600 km/s, as inferred from the position of the minimum of the Si II 635.5 nm line.