Astropy_fitting

October 4, 2019

1 Astropy models and fitting

If you need to do least square fitting for data to a model a good place to start is astropy's modeling and fitting code.

1.1 Packages being used

- astropy: for modeling and fitting
- matplotlib: for plotting

1.2 Relevant documentation

- astropy: http://docs.astropy.org/en/stable/modeling/index.html

[3]:

```
import numpy as np
import matplotlib.pyplot as plt
from astropy.modeling import models, fitting
import mpl_style
%matplotlib inline
plt.style.use('default')
plt.style.use(mpl_style.style1)
```

1.3 1-D model fitting

For an example lets look at the problem of fitting a 1-D model to a spectral line. First we need to create some fake data:

[4]:

```
x = np.linspace(-5., 5., 200)
y = 3 * np.exp(-0.5 * (x - 1.3)**2 / 0.8**2)
y += np.random.normal(0., 0.2, x.shape)
```

1.3.1 A trapezoid model

[5]:

```
t_init = models.Trapezoid1D(amplitude=1.0, x_0=0.1, slope=0.5)
fit_t = fitting.LevMarLSQFitter()
t = fit_t(t_init, x, y)
print(t)
```

```
Model: Trapezoid1D
Inputs: ('x',)
Outputs: ('y',)
Model set size: 1
Parameters:
        amplitude            x_0               width             slope
    ----------------- ------------------ ----------------- ------------------
    2.981041925164166 1.3012631071071004 0.412605581307232 1.9174399244365046
```

1.3.2 A Gaussian model

[6]:

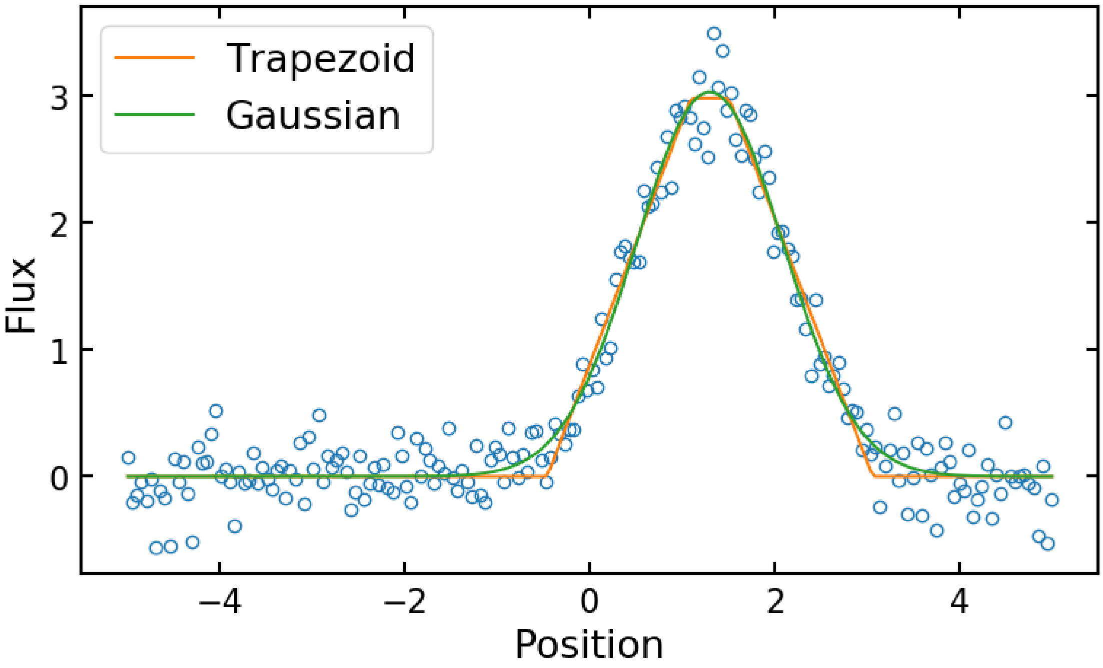
```
g_init = models.Gaussian1D(amplitude=1., mean=0, stddev=1.)
fit_g = fitting.LevMarLSQFitter()
g = fit_g(g_init, x, y)
print(g)
```

```
Model: Gaussian1D
Inputs: ('x',)
Outputs: ('y',)
Model set size: 1
Parameters:
       amplitude            mean              stddev
    ---------------- ------------------ ------------------
    3.02888699459514 1.2988080606762493 0.7934436269179235
```

1.3.3 Plotting the results

[7]:

```
plt.figure(1, figsize=(8,5))
plt.plot(x, y, 'o', mfc='none')
plt.plot(x, t(x), label='Trapezoid')
plt.plot(x, g(x), label='Gaussian')
plt.xlabel('Position')
plt.ylabel('Flux')
plt.legend(loc=2)
plt.tight_layout()
```



1.4 Compound models

Models can also be 'added' together before fitting. To demonstrate lets make a new dataset made up to two Gaussians.

[8]:
```
np.random.seed(42)
g1 = models.Gaussian1D(1, 0, 0.2)
g2 = models.Gaussian1D(2.5, 0.5, 0.1)
x = np.linspace(-1, 1, 200)
y = g1(x) + g2(x) + np.random.normal(0., 0.2, x.shape)
print(x.shape)
```

```
(200,)
```

1.4.1 Make the model

The model can be 'added' just like arrays:

[9]:
```
gg_init = models.Gaussian1D(1, 0, 0.1) + models.Gaussian1D(2, 0.5, 0.1)
fit_gg = fitting.SLSQPLSQFitter()
gg = fit_gg(gg_init, x, y)
print(gg)
```

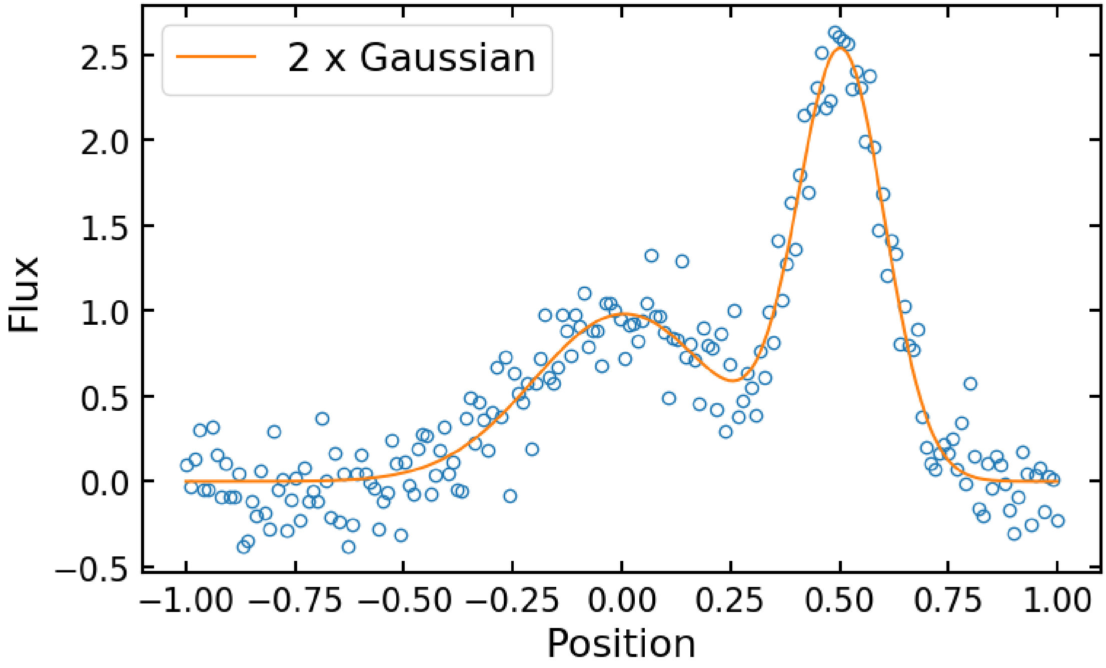
```
Optimization terminated successfully.    (Exit mode 0)
            Current function value: 6.8328593526514325
            Iterations: 15
            Function evaluations: 143
            Gradient evaluations: 15
Model: CompoundModel0
Inputs: ('x',)
Outputs: ('y',)
Model set size: 1
Expression: [0] + [1]
Components:
    [0]: <Gaussian1D(amplitude=1., mean=0., stddev=0.1)>

    [1]: <Gaussian1D(amplitude=2., mean=0.5, stddev=0.1)>
Parameters:
       amplitude_0             mean_0         ...       stddev_1
    ------------------ -------------------- ... -------------------
    0.9811897360111134 0.005976606921858548 ... 0.10000035337428576
```

1.4.2 Plot the result

[10]:

```python
plt.figure(2, figsize=(8, 5))
plt.plot(x, y, 'o', mfc='none')
plt.plot(x, gg(x), label='2 x Gaussian')
plt.xlabel('Position')
plt.ylabel('Flux')
plt.legend(loc=2)
plt.tight_layout()
```



1.5 `Astropy`'s models

`Astropy` has a large number of 1- and 2-D models built in. Check out http://docs.astropy.org/en/stable/modeling/index.html#module-astropy.modeling.functional_models for a full list. If the model you are looking for is not built in, you can always define your own: http://docs.astropy.org/en/stable/modeling/new.html.

1.6 Limitations

- Uses OLS (or similar) to maximize an objective function (and all the assumptions about the data that go into this, e.g. Gaussian errors)
- Cov of fit only returned for some fitters (fond on the `fitter.fit_info()` method)

[ ]: