Notebook - March 18 - Part 1

March 21, 2016

1 March 18 Notes

2 Fitting data to models

1. Build a model
2. Create a "fitness function", i.e. something that returns a scalar "distance" between the model and the data
3. Apply an "optimizer" to get the best-fit parameters

In [9]:
```
from astropy import units as u
```

In [21]:
```
def gaussian_model(xarr, amplitude, offset, width):
    amplitude = u.Quantity(amplitude, u.K)
    offset = u.Quantity(offset, u.km/u.s)
    width = u.Quantity(width, u.km/u.s)
    xarr = u.Quantity(xarr, u.km/u.s)

    return amplitude * np.exp(-(xarr-offset)**2/(2.*width**2))
```

In [14]:
```
x = 5
u.Quantity(x, u.km/u.s)
```

Out[14]:

$$5 \ \frac{\mathrm{km}}{\mathrm{s}}$$

In [15]:
```
x = 5 * u.m/u.s
u.Quantity(x, u.km/u.s)
```

Out[15]:

$$0.005 \ \frac{\mathrm{km}}{\mathrm{s}}$$

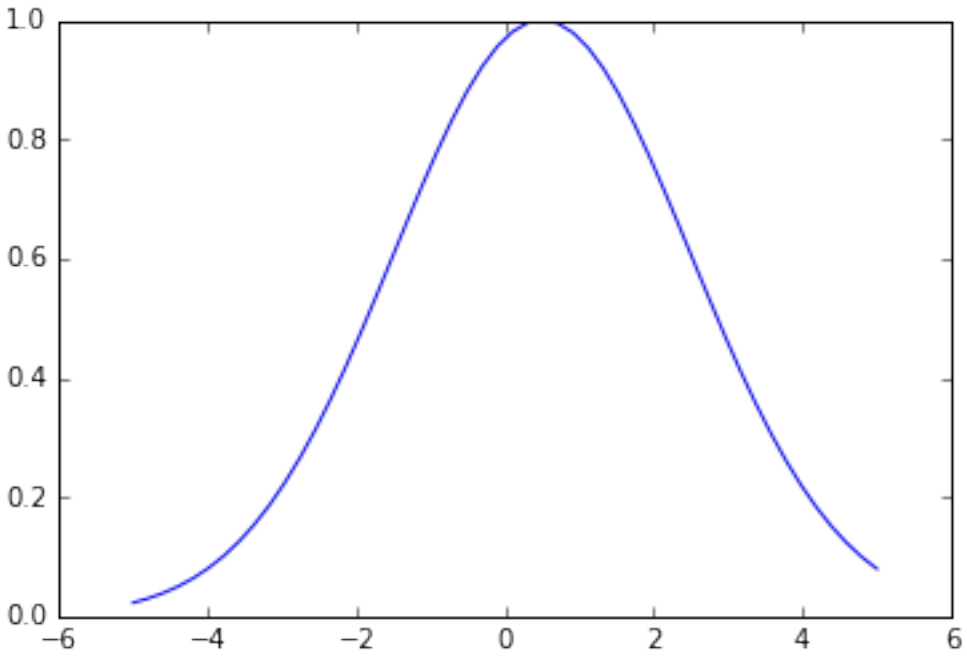
In [16]:
```
xarr = np.linspace(-5,5,50) * u.km/u.s
```

In [18]:
```
gaussian(xarr, 1*u.K, 0.5*u.km/u.s, 2000*u.m/u.s)
```

Out[18]:

In [12]:
```
%matplotlib inline
import pylab as pl
pl.plot(xarr, gaussian(xarr, 1, 0.5, 2))
```

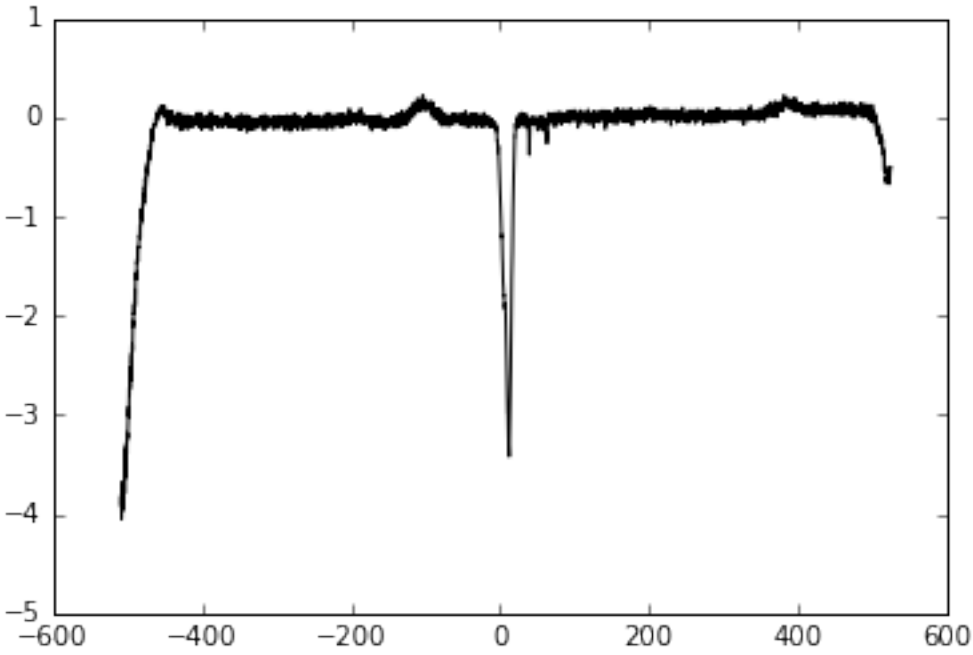
Out[12]: [<matplotlib.lines.Line2D at 0x10d71e6a0>]



In [19]:
```
from specutils.io import fits
spec = fits.read_fits_spectrum1d('gbt_1d.fits')
```

In [20]:
```
pl.plot(spec.velocity, spec.flux, 'k-')
```

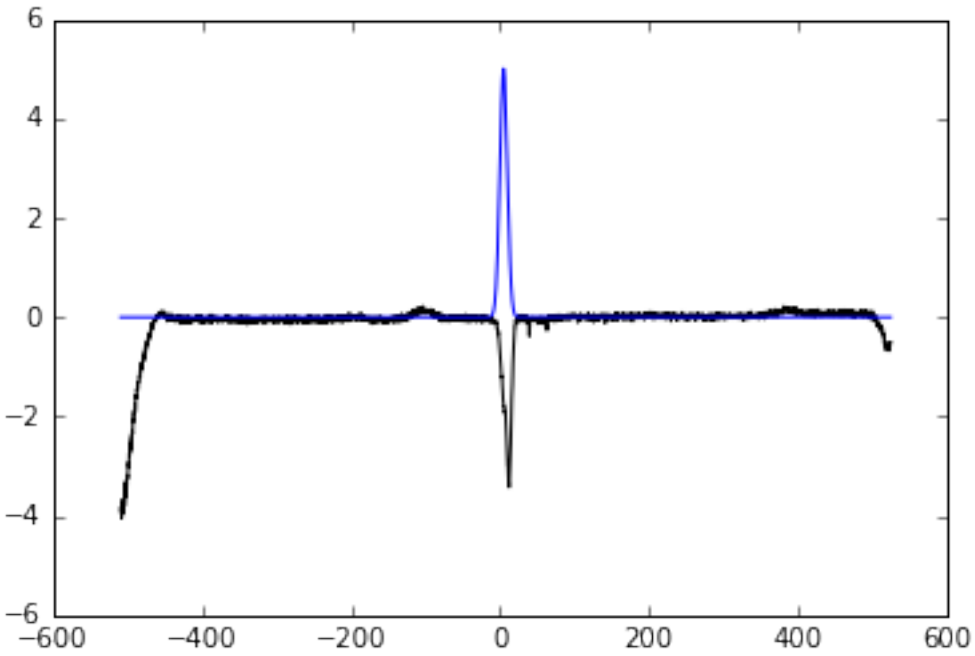
Out[20]: [<matplotlib.lines.Line2D at 0x111057550>]



In [22]:
```
model = gaussian_model(spec.velocity, amplitude=5*u.K, offset=5*u.km/u.s, width=5*u.km/u.s)
```

In [23]:
```
pl.plot(spec.velocity, spec.flux, 'k-')
pl.plot(spec.velocity, model, 'b-')
```

Out[23]:
```
[<matplotlib.lines.Line2D at 0x11108fcc0>]
```



In [32]:
```
spec.flux * u.K
```

Out[32]:

$$[-0.50829212,\ -0.49870891,\ -0.52269076,\ \ldots,-3.8145078,\ -3.8554833,\ -3.9074813]\ \mathrm{K}$$

In [28]:
```
def cost_function(params, data_range=None):
    if data_range is not None:
        data = spec.flux[data_range]
    else:
        data = spec.flux
    return (((data * u.K) - gaussian_model(spec.velocity, *params))**2).sum().value
```

In [29]:
```
params = (1,2,3)
def f(a,b,c):
    print("a={0}, b={1}, c={2}".format(a,b,c))
f(1,2,3)
f(*params)
```

```
a=1, b=2, c=3
a=1, b=2, c=3
```

```
In [30]: cost_function((5*u.K, 5*u.km/u.s, 5*u.km/u.s))
```

```
Out[30]: 2894.608469233504
```

```
In [33]: from scipy.optimize import minimize
```

```
In [36]: result = minimize(cost_function, (5, 5, 5), args=(slice(100,200),))
         result
```

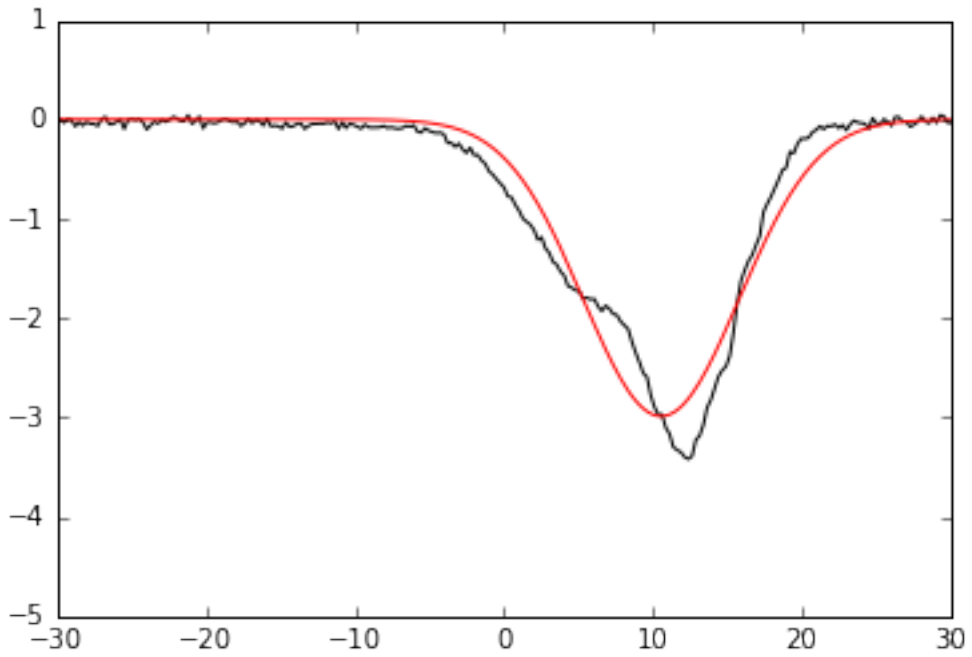
```
Out[36]:       fun: 874.0808553828039
          hess_inv: array([[ 0.02083241, -0.00701251,  0.02573938],
                [-0.00701251,  0.09174813, -0.02584566],
                [ 0.02573938, -0.02584566,  0.09195859]])
               jac: array([ -7.62939453e-06,   0.00000000e+00,  -7.62939453e-06])
           message: 'Optimization terminated successfully.'
              nfev: 130
               nit: 19
              njev: 26
            status: 0
           success: True
                 x: array([ -2.98664886,  10.56106784,   5.22460432])
```

```
In [38]: (amplitude, offset, width) = result.x
```

```
In [39]: best_fit_model = gaussian_model(spec.velocity, *result.x)
```

```
In [41]: pl.plot(spec.velocity, spec.flux, 'k-')
         pl.plot(spec.velocity, best_fit_model, 'r-')
         pl.xlim(-30, 30)
```

```
Out[41]: (-30, 30)
```



3 Exercise

1. Get a better fit to the data (create a better model & fit it)

- try using different optimizers in scipy.optimize

```
In [42]: arr = np.arange(100)

In [43]: arr[10:50]

Out[43]: array([10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26,
                27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43,
                44, 45, 46, 47, 48, 49])

In [44]: arr[slice(10,50)]

Out[44]: array([10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26,
                27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43,
                44, 45, 46, 47, 48, 49])

In [ ]:
```