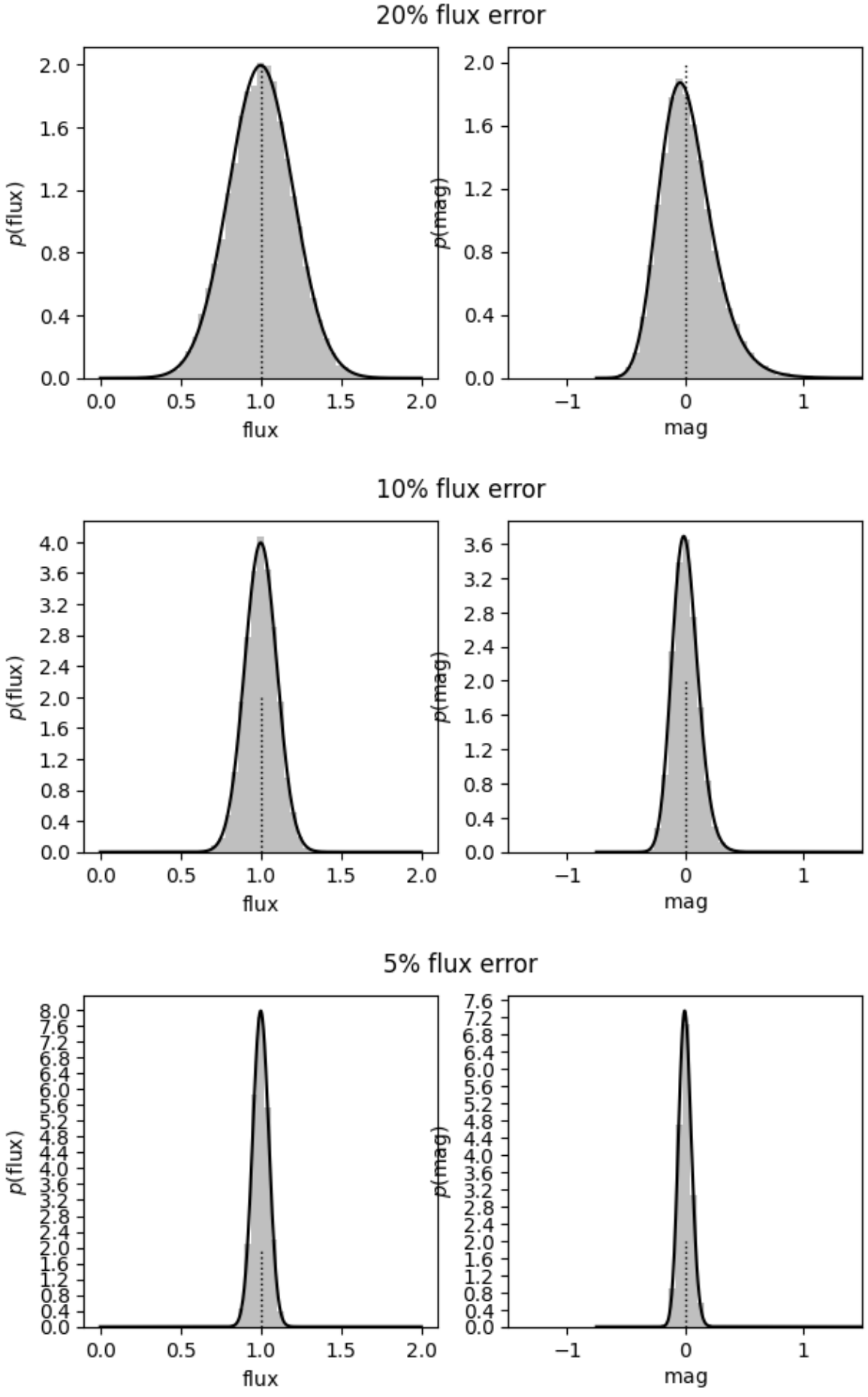
In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
import scipy.stats as stats
import numpy as np
import pandas as pd
```

Problem 1

In [4]:
```
def solve_p1(err):
    fig, axs = plt.subplots(1, 2, figsize=(7,3))

    dist = stats.norm(1, err/100)
    flux = dist.rvs(10000)
    flux_fit = np.linspace(0.001, 2, 1000)
    pdf_flux_fit = dist.pdf(flux_fit)

    mag = -2.5 * np.log10(flux)
    mag_fit = -2.5 * np.log10(flux_fit)
    pdf_mag_fit = pdf_flux_fit.copy()
    pdf_mag_fit[1:] /= abs(mag_fit[1:] - mag_fit[:-1])
    pdf_mag_fit /= np.dot(pdf_mag_fit[1:], abs(mag_fit[1:] - mag_fit[:-1]

    ax1,ax2=axs

    ax1.hist(flux, bins=np.linspace(0, 2, 50),histtype='stepfilled', fc='
    ax1.plot(flux_fit, pdf_flux_fit, '-k')
    ax1.plot([1, 1], [0, 2], ':k', lw=1)
    ax1.set_xlabel(r'${\rm flux}$')
    ax1.set_ylabel(r'$p({\rm flux})$')
    ax1.yaxis.set_major_locator(plt.MultipleLocator(0.4))

    ax2.hist(mag, bins=np.linspace(-1, 2, 50),histtype='stepfilled', fc='
    ax2.plot(mag_fit, pdf_mag_fit, '-k')
    ax2.plot([0, 0], [0, 2], ':k', lw=1)
    ax2.set_xlim(-1.5,1.5)
    ax2.set_xlabel(r'${\rm mag}$')
    ax2.set_ylabel(r'$p({\rm mag})$')
    ax2.yaxis.set_major_locator(plt.MultipleLocator(0.4))

    plt.suptitle('{}% flux error'.format(err))
```

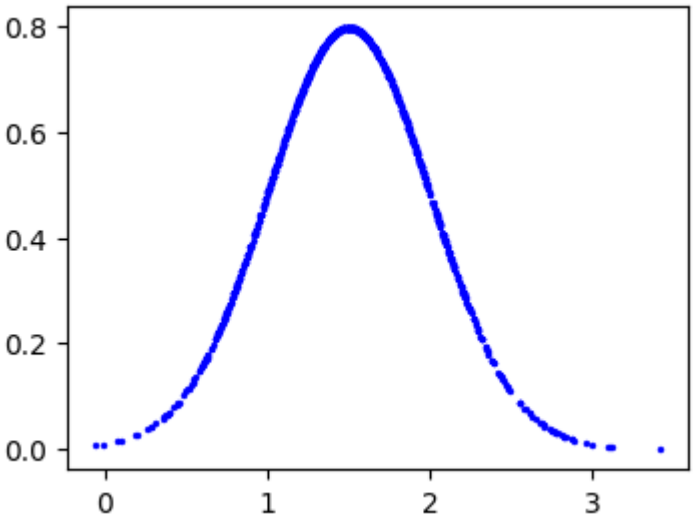
In [5]:
```
solve_p1(20)
solve_p1(10)
solve_p1(5)
```



With a decrease in the flux error there is a decrease in the asymmetry of the magnitude graph which stems from the logarithmic dependence of the magnitude on the flux.

Problem 2

In [6]:
```
dist=stats.norm(1.5,0.5)
r=dist.rvs(1000)
p=dist.pdf(r)
plt.figure(figsize=(4,3))
plt.scatter(r,p,color='blue',s=2)
plt.show()
```



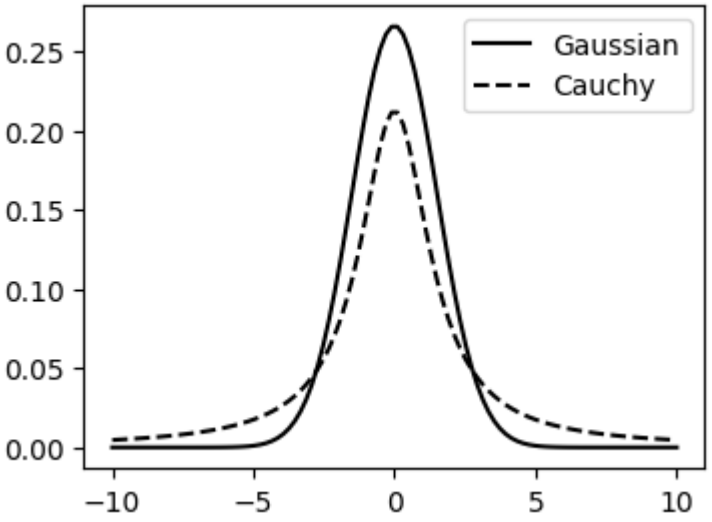
In [7]:
```
mean,variance,skewness,kurtosis=dist.stats(moments='mvsk')
mad=np.median(np.abs(r-np.median(r)))
sigma_g=0.7413*(np.percentile(r,75)-np.percentile(r,25))

print('mean=',mean)
print('variance=',variance)
print('skewness=',skewness)
print('kurtosis=',kurtosis)
print('Std using MAD=',1.482*mad)
print('Sigma_g=',sigma_g)
```

```
mean= 1.5
variance= 0.25
skewness= 0.0
kurtosis= 0.0
Std using MAD= 0.5124995245167813
Sigma_g= 0.5076696407778214
```

Problem 3

In [8]:
```
x=np.linspace(-10,10,100)
gauss=stats.norm.pdf(x,0,1.5)
cauchy=stats.cauchy.pdf(x,0,1.5)
plt.figure(figsize=(4,3))
plt.plot(x,gauss,color='black',label='Gaussian')
plt.plot(x,cauchy,'--',color='black',label='Cauchy')
plt.legend()
```

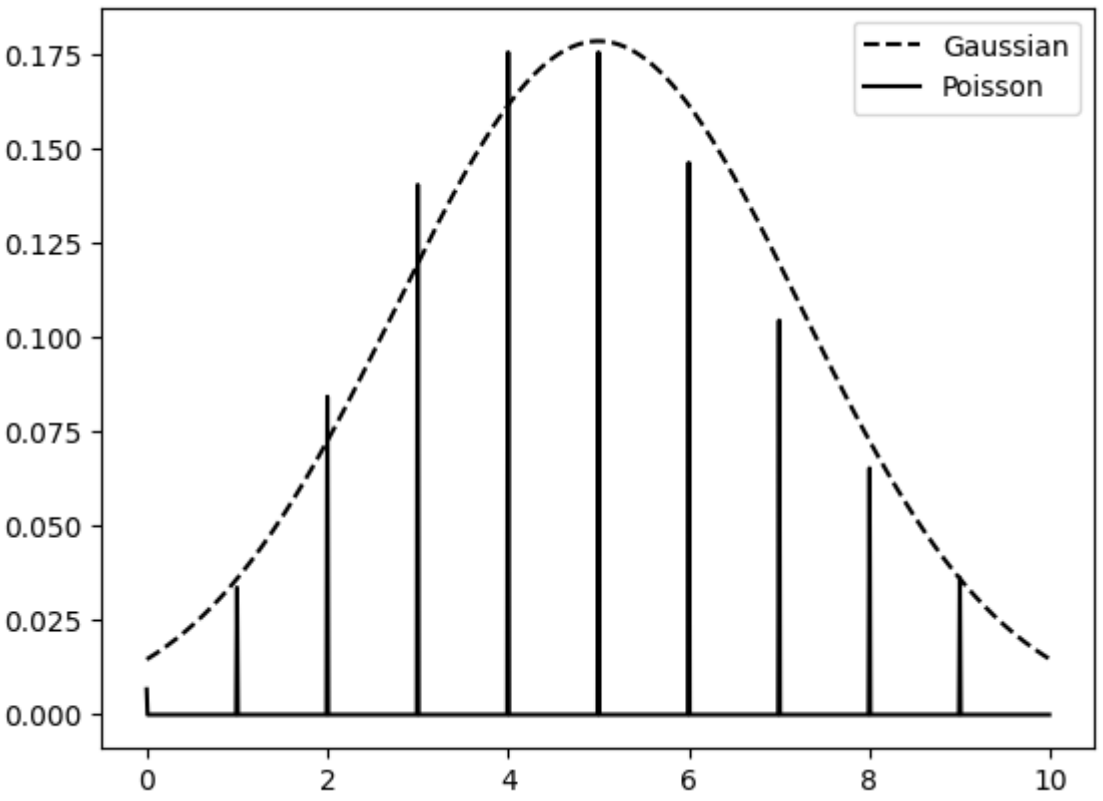
Out[8]:
```
<matplotlib.legend.Legend at 0x7fca05110f10>
```



Problem 4

In [9]:
```
x=np.arange(0,10,0.01)
gauss=stats.norm.pdf(x,5,np.sqrt(5))
poisson=stats.poisson.pmf(x,mu=5)
plt.figure()
plt.plot(x,gauss,'--',color='black',label='Gaussian')
plt.plot(x,poisson,color='black',label='Poisson')
plt.legend()
```

Out[9]:
```
<matplotlib.legend.Legend at 0x7fca0517c1f0>
```



Problem 5

The expressions for the weighted mean of a quantity and its uncertainty are given by:

$$\bar{x} = \frac{\sum_{i=1}^{N} x_i/\sigma_i^2}{\sum_{i=1}^{N} 1/\sigma_i^2} \quad \sigma_x^2 = \frac{1}{\sum_{i=1}^{N} 1/\sigma_i^2}$$

In [10]:
```
lt=1e-10*np.array([0.8920,0.881,0.8913,0.9837,0.8958])
delta=1e-10*np.array([0.00044,0.009,0.00032,0.00048,0.00045])
wm=np.sum(lt/delta**2)/np.sum(1/delta**2)
uc=np.sqrt(1/np.sum(1/delta**2))
print('Weighted mean=',wm)
print('Uncertainty=',uc)
```

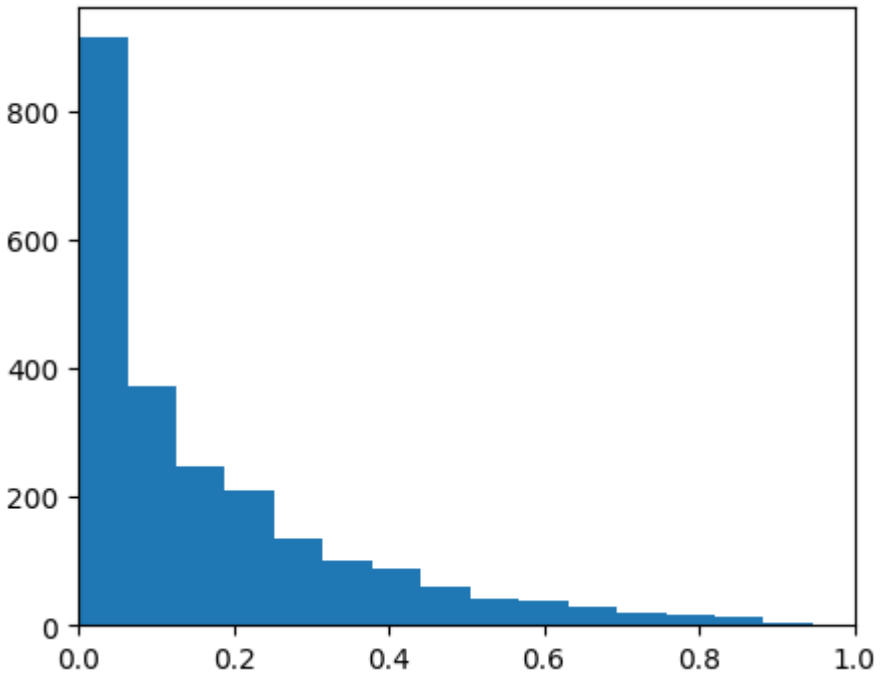
```
Weighted mean= 9.089185199574898e-11
Uncertainty= 2.0318737026848624e-14
```

Weighted mean lifetime= $(9.089 \pm 0.002) \times 10^{-11} s$

Problem 6

In [11]:
```
data=pd.read_csv('Downloads/eccen.csv')
e=data['eccentricity'].dropna().to_numpy()
plt.figure(figsize=(5,4))
plt.hist(e,bins=50)
plt.xlim(0,1)
```

Out[11]: (0.0, 1.0)



In [12]:
```
e_gauss,_=stats.boxcox(e[e>0])
fig,ax=plt.subplots(figsize=(5,4))
ax.hist(e_gauss, 50)
```

Out[12]:
```
(array([  1.,   1.,   0.,   3.,   2.,   3.,   5.,   7.,  10.,   7.,  33.,
         21.,  46.,  67.,  39.,  88.,  75., 112.,  98.,  98., 106.,  88.,
        125., 113.,  87.,  99.,  85.,  78.,  74.,  60.,  52.,  40.,  34.,
         38.,  22.,  13.,   4.,   0.,   1.,   0.,   0.,   0.,   0.,   0.,
          0.,   0.,   0.,   0.,   0.,   1.]),
 array([-3.75129237, -3.64964098, -3.54798959, -3.44633819, -3.3446868 ,
        -3.24303541, -3.14138401, -3.03973262, -2.93808123, -2.83642984,
        -2.73477844, -2.63312705, -2.53147566, -2.42982427, -2.32817287,
        -2.22652148, -2.12487009, -2.02321869, -1.9215673 , -1.81991591,
        -1.71826452, -1.61661312, -1.51496173, -1.41331034, -1.31165895,
        -1.21000755, -1.10835616, -1.00670477, -0.90505337, -0.80340198,
        -0.70175059, -0.6000992 , -0.4984478 , -0.39679641, -0.29514502,
        -0.19349363, -0.09184223,  0.00980916,  0.11146055,  0.21311195,
         0.31476334,  0.41641473,  0.51806612,  0.61971752,  0.72136891,
         0.8230203 ,  0.92467169,  1.02632309,  1.12797448,  1.22962587,
         1.33127726]),
 <BarContainer object of 50 artists>)
```