coordinates_pt1

March 23, 2016

1 Imports

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

```
/usr/local/lib/python3.4/dist-packages/matplotlib/__init__.py:872: UserWarning: axes.color_cycle is depre
  warnings.warn(self.msg_depr % (key, alt_key))
```

For changing the style of the plot, we can also redefine default parameters. This can be done on the fly with the rcParams dictionary. This is one example were we change the default color cycle and various line properties. The line cycle definition is different depending on the Matplotlib version.

In [2]:
```
try:
    from cycler import cycler
except:
    pass
# example usage:
# cycler('color', ['r', 'g', 'b', 'y']) + cycler('lw', [1, 2, 3])

plt.rcParams['patch.linewidth'] = 0.5
#plt.rcParams['patch.facecolor'] = '348ABD'  # blue
#plt.rcParams['patch.edgecolor'] = 'EEEEEE'
plt.rcParams['patch.antialiased'] = True

plt.rcParams['font.size'] = 12.0

plt.rcParams['axes.facecolor'] = 'white'
plt.rcParams['axes.edgecolor'] = 'black'
plt.rcParams['axes.linewidth'] = 1
plt.rcParams['axes.grid'] = False
plt.rcParams['axes.titlesize'] = 'large'
plt.rcParams['axes.labelsize'] = 'large'
plt.rcParams['axes.labelcolor'] =  '555555'
#axes.axisbelow: True       # grid/ticks are below elements (eg lines, text)


# want to define these colors:
# E24A33 : red, 348ABD : blue, 988ED5 : purple, 777777 : gray
# FBC15E : yellow, 8EBA42 : green, FFB5B8 : pink

colorlist = ['#E24A33', '#348ABD', '#988ED5', '#777777', '#FBC15E', '#8EBA42', '#FFB5B8']
#colornames = ['red', 'blue', 'purple', 'gray', 'yellow', 'green', 'pink']
```

```
try:
    # newer Matplotlib

    plt.rcParams['axes.prop_cycle'] = cycler('color', colorlist)
except:
    # older Matplotlib (<1.5 I think)
    plt.rcParams['axes.color_cycle'] = colorlist

#xtick.color: 555555
#xtick.direction: in

#ytick.color: 555555
#ytick.direction: in

plt.rcParams['grid.color'] = 'grey'
plt.rcParams['grid.linestyle'] =  '-'

plt.rcParams['figure.facecolor'] = 'white'
plt.rcParams['figure.edgecolor'] = 'white'

plt.rcParams['text.usetex'] = False
plt.rcParams['mathtext.default'] = 'regular'
```

For interpreting the coordinates, we need some specific modules to parse them into Python objects etc.

```
In [3]: import astropy
        import astropy.coordinates as coordinates
        import astropy.units as u

        import astropy.constants as c
        from astropy.table import Table
```

2 2MASS Extended Source Catalog Redshift Survey

2.1 The data

The data is the 2MASS Extended Source Catalog Redshift
Available at: https://www.cfa.harvard.edu/~dfabricant/huchra/2mass/
Has 29 fixed width (Fortran format) columns. Columns defined in the header of the data file.
We use the Astropy.Tables fixed-width reader to read this data.

```
In [5]: from astropy.table import Table
        import astropy.constants as c
        import astropy.units as u
        colnames = ('id', 'RAdeg', 'DECdeg', 'l', 'b', 'k_c', 'h_c', 'j_c', 'k_tc',
            'h_tc', 'j_tc', 'e_k', 'e_h', 'e_j', 'e_kt', 'e_ht', 'e_jt', 'e_bv',
            'r_iso', 'r_ext', 'b/a', 'flgs', 'type', 'ts', 'v', 'ev', 'vc',
            'vsrc', 'CAT_ID')
        colstarts = (0, 16, 26, 36, 46, 56, 63, 70, 77, 84, 91, 98, 104, 110,
                     116, 122, 128, 134, 140, 146, 152, 158, 163, 169, 172,
                     179, 183, 185, 205)
        gals = Table.read('data/2mrs_v240/catalog/2mrs_1175_done.dat',
                    format='ascii.fixed_width_no_header',
                    names=colnames,
```

```
                    col_starts=colstarts,
                    )
```

With Astropy.Tables, just listing the columns gives an OK overview of what is there.

```
In [6]: gals
```

```
Out[6]: <Table length=43533>
               id          RAdeg   ...        vsrc                 CAT_ID
             str16        float64  ...        str19                str28
        ---------------- --------- ... ------------------- -----------------------
        00424433+4116074  10.68471 ... 1991RC3.9.C...0000d            MESSIER_031
        00473313-2517196  11.88806 ... 2004AJ...128...16K               NGC_0253
        09553318+6903549 148.88826 ... 1991RC3.9.C...0000d            MESSIER_081
        13252775-4301073 201.36565 ... 1978PASP...90..237G              NGC_5128
        13052727-4928044 196.36366 ... 2004AJ...128...16K               NGC_4945
        01335090+3039357   23.4621 ... 1991RC3.9.C...0000d            MESSIER_033
        09555243+6940469 148.96846 ... 1991RC3.9.C...0000d            MESSIER_082
        03464851+6805459  56.70214 ... 1999PASP..111..438F               IC_0342
        13370091-2951567 204.25383 ... 2004AJ...128...16K            MESSIER_083
        12395949-1137230 189.99789 ... 2000MNRAS.313..469S            MESSIER_104
                     ...       ... ...                 ...                     ...
        20381882-0406569 309.57846 ... 20096dF...C...0000J         g2038188-040657
        20473231+2229276 311.88461 ... 20112MRS.FLWO.0000H        20473231+2229276
        20530273+6624129 313.26117 ... 20112MRS.FLWO.0000H        20530273+6624129
        21002390+0927135 315.09958 ... 20112MRS.JPH..0000H            CGCG_400-018
        21104224-4855014 317.67612 ... 20096dF...C...0000J         g2110423-485502
        22064989+2501234 331.70792 ... 20112MRS.FLWO.0000H               A2204+2446
        22564201-4812368 344.17505 ... 20096dF...C...0000J         g2256420-481237
        23241975+0126293 351.08228 ... 20112MRS.FLWO.0000H        23241975+0126293
        23270825-4936242 351.78433 ... 1995AJ...110.1032M 2MASX_J23270825-4936242
        23520287+2102068 358.01202 ... 20112MRS.FLWO.0000H        23520287+2102068
```

Or you can display the table in a separate browser window.

```
In [7]: gals[:100].show_in_browser()
```

```
In [8]: gals.colnames
```

```
Out[8]: ['id',
         'RAdeg',
         'DECdeg',
         'l',
         'b',
         'k_c',
         'h_c',
         'j_c',
         'k_tc',
         'h_tc',
         'j_tc',
         'e_k',
         'e_h',
         'e_j',
         'e_kt',
         'e_ht',
         'e_jt',
```

```
'e_bv',
'r_iso',
'r_ext',
'b/a',
'flgs',
'type',
'ts',
'v',
'ev',
'vc',
'vsrc',
'CAT_ID']
```

One of the convenient things with Astropy Tables is that each column can have a unit. It is possible to give this at read-time, but we set it here.

```
In [9]: gals['RAdeg'].unit = u.deg
        gals['DECdeg'].unit = u.deg
        gals['l'].unit = u.deg
        gals['b'].unit = u.deg
        gals['v'].unit = u.km/u.s
```

```
In [10]: gals['RAdeg'].unit
```

```
Out[10]:
```

∘

Furthermore, we can load the coordinates into Astropy.coordinates SkyCoord object. With it we can access the coordinates in different systems etc.

```
In [11]: coordarr = coordinates.SkyCoord(gals['RAdeg'].quantity, gals['DECdeg'].quantity, frame='fk5', 
         gals['coord'] = coordarr
```

We can also define the distance to the galaxies, we just tell it that it is redshift distance that we have.

```
In [12]: zs = ((gals['v'] / c.c).decompose())
         dist = coordinates.Distance(z=zs, allow_negative=True)
         gals['dist'] = dist
```

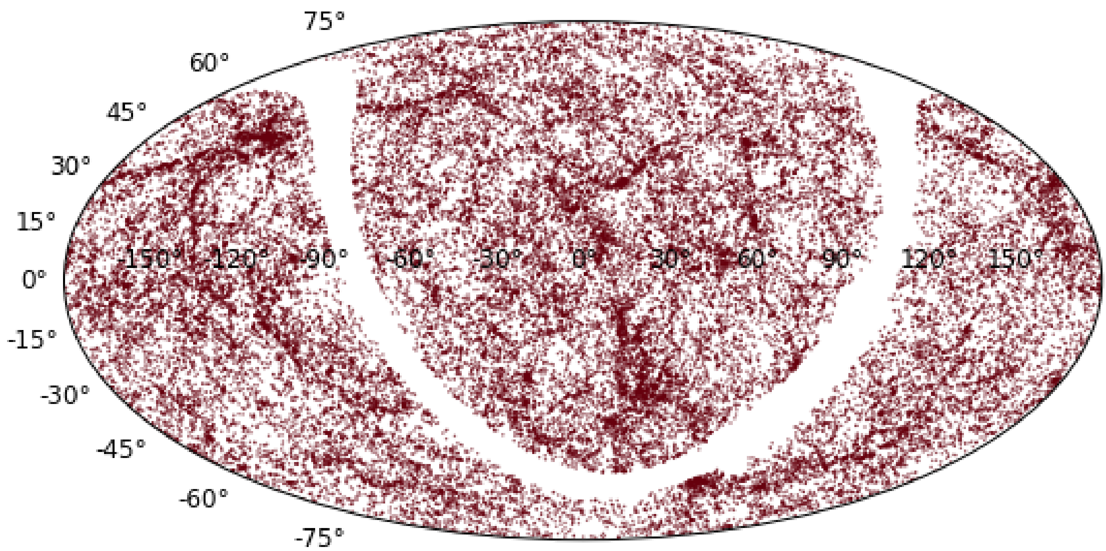
```
In [13]: print(gals.colnames)
```

```
['id', 'RAdeg', 'DECdeg', 'l', 'b', 'k_c', 'h_c', 'j_c', 'k_tc', 'h_tc', 'j_tc', 'e_k', 'e_h', 'e_j', 'e_k
```

2.2 Plot : All sky

With the catalog we can plot the all sky maps. Here we use the Mollweide projection.

```
In [18]: fig = plt.figure(figsize=(9,8))
         ax = fig.add_subplot(111, projection="mollweide")
         ax.scatter(gals['coord'].ra.radian-np.pi, gals['coord'].dec.radian,
                    color=plt.cm.Reds(gals['dist']),
                    s=1,
                    zorder=-1, alpha=0.5,
                   rasterized=True);

         #plt.savefig('allsky_rasterized.pdf', dpi=600)
         #plt.savefig('allsky_rasterized.svg', dpi=600)
```



2.2.1 Exercise

Improve the plot: - Change the color scheme and transparency (alpha) - Change the axis tick labels to be more readable - Add axis labels - Plot a different parameter

2.3 Cartesian coordinates

With the coordinates object and a distance, we can convert the RA, Dec and distance into cartesian coordinates in Mpc.

```
In [22]: coords_xyz = coordinates.SkyCoord(ra=gals['coord'].ra,
                                           dec=gals['coord'].dec,
                                           distance=gals['dist'].quantity, frame='fk5', equinox='J2000')
```

We can store the X,Y,Z coordinates now into the table

```
In [23]: gals['X'] = coords_xyz.cartesian.x
         gals['Y'] = coords_xyz.cartesian.y
         gals['Z'] = coords_xyz.cartesian.z
```

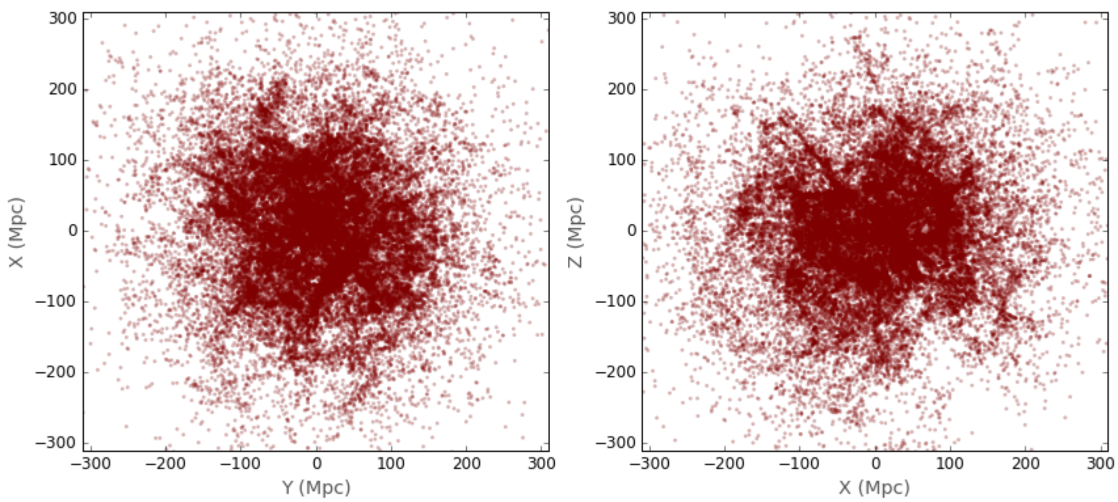
```
In [24]: gals['X'][:5]
```

```
Out[24]: <Column name='X' dtype='float64' unit='Mpc' length=5>
         -3.19393602411
          3.10353032104
         0.150029124455
         -5.38050269402
         -5.07177661034
```

2.4 Plot: 2D

The catalog can now easily be drawn, as a whole in X,Y and Z space.

```
In [27]: fig,ax = plt.subplots(1,2, figsize=(14,6))

         ax1= plt.subplot(121)
         ax1.scatter(gals['Y'], -1*gals['X'],
                     s=8, alpha=0.3,
                     color=plt.cm.OrRd(10**(gals['k_c'])),
                     edgecolor='None')
         ax1.set_xlabel('Y (Mpc)')
         ax1.set_ylabel('X (Mpc)')
         ax1.set_xlim(-310,310)
         ax1.set_ylim(-310,310)

         #plt.figure(figsize=(7,6))
         ax2 = plt.subplot(122)
         ax2.scatter(-1*gals['X'],gals['Z'],
                     s=8, alpha=0.3,
                     color=plt.cm.OrRd(10**(gals['k_c']) ),
                     edgecolor='None',
                    rasterized=True)
         ax2.set_xlabel('X (Mpc)')
         ax2.set_ylabel('Z (Mpc)')
         ax2.set_xlim(-310,310)
         ax2.set_ylim(-310,310);
```



This is very messy, so we need to think of how to display our data better, do wee need to plot a completely different plot, or can we do something with this?

2.4.1 Exercise

- Make a third suplot of Y vs. Z
- Have each subplot show points in different colors (e.g. depending on K magnitude?)
- Change the axis labels
- Rasterize the plot and save it (plt.savefig('filename.pdf', dpi=1200))

2.5 Plot: 2D - Filtering

Suppose we only want look at certain objects, or certain coordinates for example. Here we use the Boolean 'AND' operator '&'.

In [32]:
```
n = 2
n == True
```

Out[32]: False

In [34]:
```
decmin = 15
decmax = 30
ramin = 90
ramax = 295
czmin = 0
czmax = 12500
selection_dec = (gals['coord'].dec.deg>decmin) & (gals['coord'].dec.deg<decmax)
selection_ra = (gals['coord'].ra.deg>ramin) & (gals['coord'].ra.deg<ramax)
selection_czs = (gals['v']>czmin) & (gals['v']<=czmax)
selection_czs_pos = (gals['v']>czmin)
```

With this we can choose what to filter on. Creating a "master" filter which filters on all of the above.

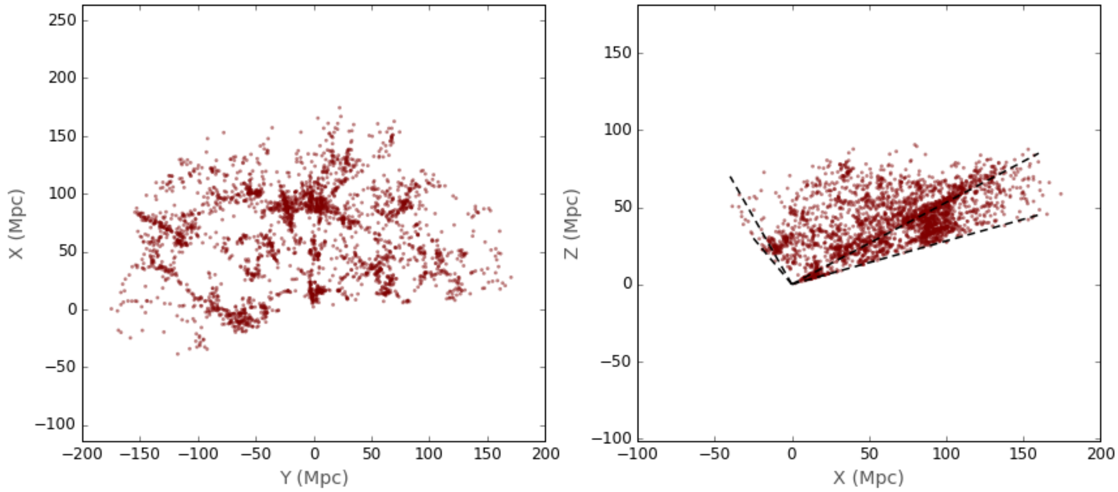
In [35]:
```
selection = selection_dec & selection_ra & selection_czs
```

In [36]:
```
selection
```

Out[36]: array([False, False, False, ..., False, False, False], dtype=bool)

Selection is a Boolean array, that will just pick out the values with True.

In [37]:
```
fig,ax = plt.subplots(1,2, figsize=(14,6))

ax1= plt.subplot(121)
ax1.scatter(gals['Y'][selection], -1*gals['X'][selection],
            s=8, alpha=0.5, color=plt.cm.OrRd(10**(gals['k_c'][selection])), edgecolor='None')
ax1.set_xlabel('Y (Mpc)'); ax1.set_ylabel('X (Mpc)')
ax1.axis('equal');

ax2 = plt.subplot(122)
ax2.scatter(-1*gals['X'][selection],gals['Z'][selection],
            s=8, alpha=0.5, color=plt.cm.OrRd(10**(gals['k_c'][selection]) ), edgecolor='None'
lstyle = dict(lw=1.5, color='k', dashes=(6,4))
ax2.plot([0,160], [0,85], **lstyle)
ax2.plot([0,160], [0,45], **lstyle)
ax2.plot([0,-40], [0,70], **lstyle)
ax2.plot([0,-25], [0,30], **lstyle)
ax2.set_xlabel('X (Mpc)'); ax2.set_ylabel('Z (Mpc)')
ax2.axis('equal');
```



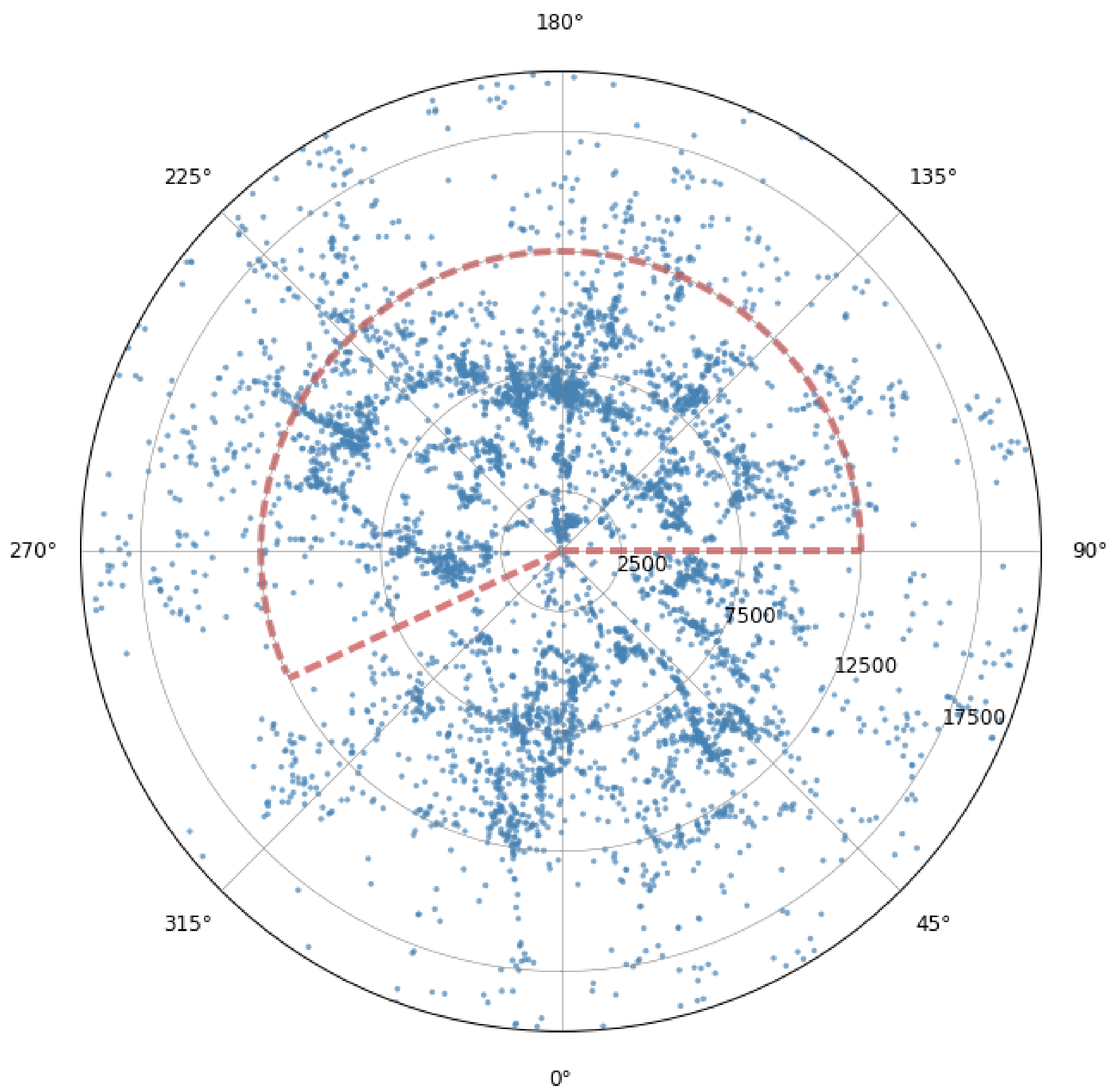
2.5.1 Exercise :

- Generate and plot another slice of the data
  - i.e. filter on other RA, Dec and redshift velocity (distance)
  - filter directly on the X, Y, Z coordinates instead and plot a square selection
- Just play around and try to improve it.

2.6 Polar plot

The natural coordinates here is polar coordinates of course, so lets plot them in a polar plot as well. Here we only use the Dec slicing.

```
In [38]: fig = plt.figure( figsize=(10,10))
         ax = fig.add_subplot(111, polar=True)
         sct = ax.scatter(gals['coord'].ra.radian[selection_dec], gals['v'][selection_dec],
                             color='SteelBlue',
                             #color=plt.cm.Blues_r((coords_uzc.dec.deg[selection_dec])/100.),
                             s=gals['k_c'][selection_dec],
                             edgecolors="none",
                             alpha=0.7,
                            zorder=0)
         ax.set_rlim(0,20000)
         ax.set_theta_offset(np.pi/-2)
         ax.set_rlabel_position(65)
         ax.set_rticks(range(2500,20001,5000));
         ax.plot([(ramin*u.deg).to(u.radian).value, (ramin*u.deg).to(u.radian).value], [0,12500],
                 color='IndianRed', alpha=0.8, dashes=(10,4), lw=4)
         ax.plot([ramax*np.pi/180., ramax*np.pi/180.], [0,12500],
                 color='IndianRed', alpha=0.8, dashes=(10,4), lw=4)
         theta = np.arange(ramin, ramax, 1)
         ax.plot(theta*np.pi/180., np.ones_like(theta)*12500,
                 color='IndianRed', alpha=0.8, dashes=(10,4), lw=4);
```



We here plot the selection that we did earlier as well. Polar plots are different from normal axes, therefore changing things are a bit different. The sizes of the scatter points are set by the k-magnitude.

2.6.1 Exercise:

- Plot your slice of the data on the polar plot
- Add axes labels
- Plot several Dec slices together, in different colors.
- Tweak how the points are displayed.
- Annotate the plot.

2.7 Plot: 3D

We have the whole data for the distribution of Galaxies from the 2MASS catalog. Can we plot something like this? I agree, this is not the best plot in the world, it is messy, what are they trying to say?

To do this we import the Axes3D object.

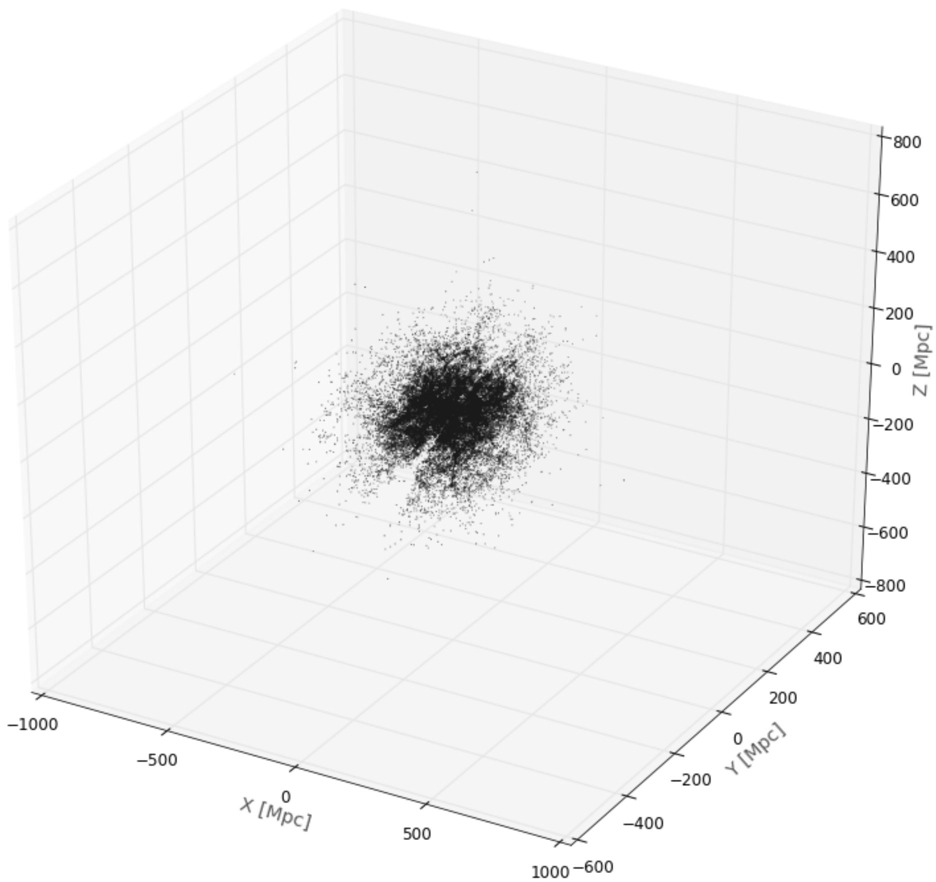
```
In [39]: from mpl_toolkits.mplot3d import Axes3D
```

```
In [1]: %%bash
        less /home/magnusp/Desktop/one_solution.txt
```

```
# set the axis line colors white to hide
ax.w_xaxis.line.set_color((1.0, 1.0, 1.0, 0.0))
ax.w_yaxis.line.set_color((1.0, 1.0, 1.0, 0.0))
ax.w_zaxis.line.set_color((1.0, 1.0, 1.0, 0.0))

ax.grid(False)
ax.xaxis.pane.set_edgecolor('white')
ax.yaxis.pane.set_edgecolor('white')
ax.zaxis.pane.set_edgecolor('white')
ax.xaxis.pane.fill = False
ax.yaxis.pane.fill = False
ax.zaxis.pane.fill = False

[t.set_va('center') for t in ax.get_yticklabels()]
[t.set_ha('right') for t in ax.get_yticklabels()]
[t.set_va('center') for t in ax.get_xticklabels()]
[t.set_ha('center') for t in ax.get_xticklabels()]
[t.set_va('bottom') for t in ax.get_zticklabels()]
[t.set_ha('right') for t in ax.get_zticklabels()]

ax.xaxis._axinfo['tick']['inward_factor'] = 0.1
ax.xaxis._axinfo['tick']['outward_factor'] = 0.4
ax.yaxis._axinfo['tick']['inward_factor'] = 0.1
ax.yaxis._axinfo['tick']['outward_factor'] = 0.3
ax.zaxis._axinfo['tick']['inward_factor'] = 0.1
ax.zaxis._axinfo['tick']['outward_factor'] = 0.3

#draw cube
r = [-310, 310]
from itertools import combinations, product
for s, e in combinations(np.array(list(product(r,r,r))), 2):
    if np.sum(np.abs(s-e)) == r[1]-r[0]:
        ax.plot3D(*zip(s,e), lw=0.5, color="0.5",dashes=(5,2))

/home/magnusp/dotfiles/.lessfilter: 18: /home/magnusp/dotfiles/.lessfilter: [[: not found
```

```
In [40]: fig = plt.figure(figsize=(15,13))
         ax = fig.add_subplot(111, projection='3d')

         ax.scatter3D(gals['X'], gals['Y'],
                      zs=gals['Z'], zdir='z', s=1, lw=0, c='0.1')

         # set the axis line colors white to hide
         ax.w_xaxis.line.set_color((1.0, 1.0, 1.0, 0.0))
         ax.w_yaxis.line.set_color((1.0, 1.0, 1.0, 0.0))
         ax.w_zaxis.line.set_color((1.0, 1.0, 1.0, 0.0))

         ax.grid(False)
         ax.xaxis.pane.set_edgecolor('white')
         ax.yaxis.pane.set_edgecolor('white')
```

```python
ax.zaxis.pane.set_edgecolor('white')
ax.xaxis.pane.fill = False
ax.yaxis.pane.fill = False
ax.zaxis.pane.fill = False

[t.set_va('center') for t in ax.get_yticklabels()]
[t.set_ha('right') for t in ax.get_yticklabels()]
[t.set_va('center') for t in ax.get_xticklabels()]
[t.set_ha('center') for t in ax.get_xticklabels()]
[t.set_va('bottom') for t in ax.get_zticklabels()]
[t.set_ha('right') for t in ax.get_zticklabels()]

ax.xaxis._axinfo['tick']['inward_factor'] = 0.1
ax.xaxis._axinfo['tick']['outward_factor'] = 0.4
ax.yaxis._axinfo['tick']['inward_factor'] = 0.1
ax.yaxis._axinfo['tick']['outward_factor'] = 0.3
ax.zaxis._axinfo['tick']['inward_factor'] = 0.1
ax.zaxis._axinfo['tick']['outward_factor'] = 0.3

#draw cube
r = [-310, 310]
from itertools import combinations, product
for s, e in combinations(np.array(list(product(r,r,r))), 2):
    if np.sum(np.abs(s-e)) == r[1]-r[0]:
        ax.plot3D(*zip(s,e), lw=0.5, color="0.5",dashes=(5,2))
ax.set_xlabel('X [Mpc]')
ax.set_ylabel('Y [Mpc]')
ax.set_zlabel('Z [Mpc]');
```



I managed to get it to something like this, pending fixing the tick line thickness...

The exercise is just for you to play around with this and make it look nicer.

2.7.1 Exercise:

- Change the viewing angle.
- Change the cube limits to highlight the structure better.
- Turn off the axis lines.
- Turn the grid off.
- Turn off the grey background.
- Perhaps change the ticks to be prettier?
- Draw a cube around the data.
- Is this a good way to represent this data set?

3 Map of the Milky Way

Bessel VLA survey - http://bessel.vlbi-astrometry.org/parallax

** Format of input file ** |name | l | b | Prlx | err | μ_α cos (δ) |err| μ_δ | err | v_LSR | err | Freq | Telescope | Ref | |–|–| – | – | – | – | – | – | –| –| –| – | – | | [str] | [deg] | [deg] | [mas] | +/- | [mas/yr] | +/- | [mas/yr] |

+/- | [km/s] | +/- | [GHz] | [str] | [str] | | G105.41+09.87 | 105.41 | 9.87 | 1.129 | 0.063 | -0.21 | 2.38 | -5.49 | 2.38 | -10.0 | 5.0 | 22.2 | VLBA | 2013ApJ. . . 769. . . 15X |

3.1 Read the data

In [41]:
```
bessel = pd.read_table('data/bessel.tab',
                       delim_whitespace=True,
                       names=['name', 'l', 'b', 'prlx', 'prlxerr', 'mua', 'muaerr',
                              'mud', 'muderr', 'vlsr', 'vlsrerr', 'freq', 'telescope', 'ref'],
                         )
```

In [43]:
```
bessel.head()
```

Out[43]:
```
             name      l     b   prlx  prlxerr   mua  muaerr   mud  muderr  \
0        Sgr-B2M   0.67 -0.04  0.130    0.012 -1.23    0.04 -3.84    0.11
1        Sgr-B2N   0.68 -0.03  0.128    0.015 -0.32    0.05 -4.69    0.11
2  G009.62+00.19   9.62  0.20  0.194    0.023 -0.58    0.05 -2.49    0.27
3  G010.47+00.02  10.47  0.02  0.117    0.008 -3.86    0.02 -6.40    0.08
4  G010.62-00.38  10.62 -0.38  0.202    0.019 -0.37    0.08 -0.60    0.06

   vlsr  vlsrerr  freq telescope                  ref
0  61.0      5.0  22.2      VLBA  2009ApJ...705.1548R
1  64.0      5.0  22.2      VLBA  2009ApJ...705.1548R
2   5.0      3.1  12.2      VLBA  2009ApJ...706..464S
3  68.9      4.5  22.2      VLBA  2014ApJ...781..108S
4  -3.0      2.7  22.2      VLBA  2014ApJ...781..108S
```

3.2 Convert to Astropy Table

In [44]:
```
bessel = Table(data=bessel.as_matrix(),
    names=['name', 'l', 'b', 'prlx', 'prlxerr', 'mua', 'muaerr',
                          'mud', 'muderr', 'vlsr', 'vlsrerr', 'freq', 'telescope', 'ref'],
    dtype=[str, float, float, float, float, float, float,
                          float, float,float, float, str, str, str],
     )
```

In [45]:
```
bessel[:5]
```

Out[45]:
```
<Table length=5>
     name        l       b       prlx   ... freq telescope         ref
    str15     float64 float64 float64 ... str7    str4            str19
------------- ------- ------- ------- ... ---- --------- -------------------
      Sgr-B2M    0.67   -0.04    0.13 ... 22.2      VLBA 2009ApJ...705.1548R
      Sgr-B2N    0.68   -0.03   0.128 ... 22.2      VLBA 2009ApJ...705.1548R
G009.62+00.19    9.62     0.2   0.194 ... 12.2      VLBA 2009ApJ...706..464S
G010.47+00.02   10.47    0.02   0.117 ... 22.2      VLBA 2014ApJ...781..108S
G010.62-00.38   10.62   -0.38   0.202 ... 22.2      VLBA 2014ApJ...781..108S
```

In [46]:
```
bessel['l'].unit = u.deg
bessel['b'].unit = u.deg
bessel['prlx'].unit = u.mas
bessel['prlxerr'].unit = u.mas
bessel['mua'].unit = u.mas/u.year
bessel['muaerr'].unit = u.mas/u.year
bessel['mud'].unit = u.mas/u.year
bessel['muderr'].unit = u.mas/u.year
```

```
bessel['vlsr'].unit = u.km/u.s
bessel['vlsrerr'].unit = u.km/u.s
bessel['freq'].unit = u.GHz
```

In [47]:
```
bessel['mud'].unit
```

Out[47]:

$\frac{\mathrm{mas}}{\mathrm{yr}}$

In [48]:
```
bessel['l'][:5]
```

Out[48]:
```
<Column name='l' dtype='float64' unit='deg' length=5>
 0.67
 0.68
 9.62
10.47
10.62
```

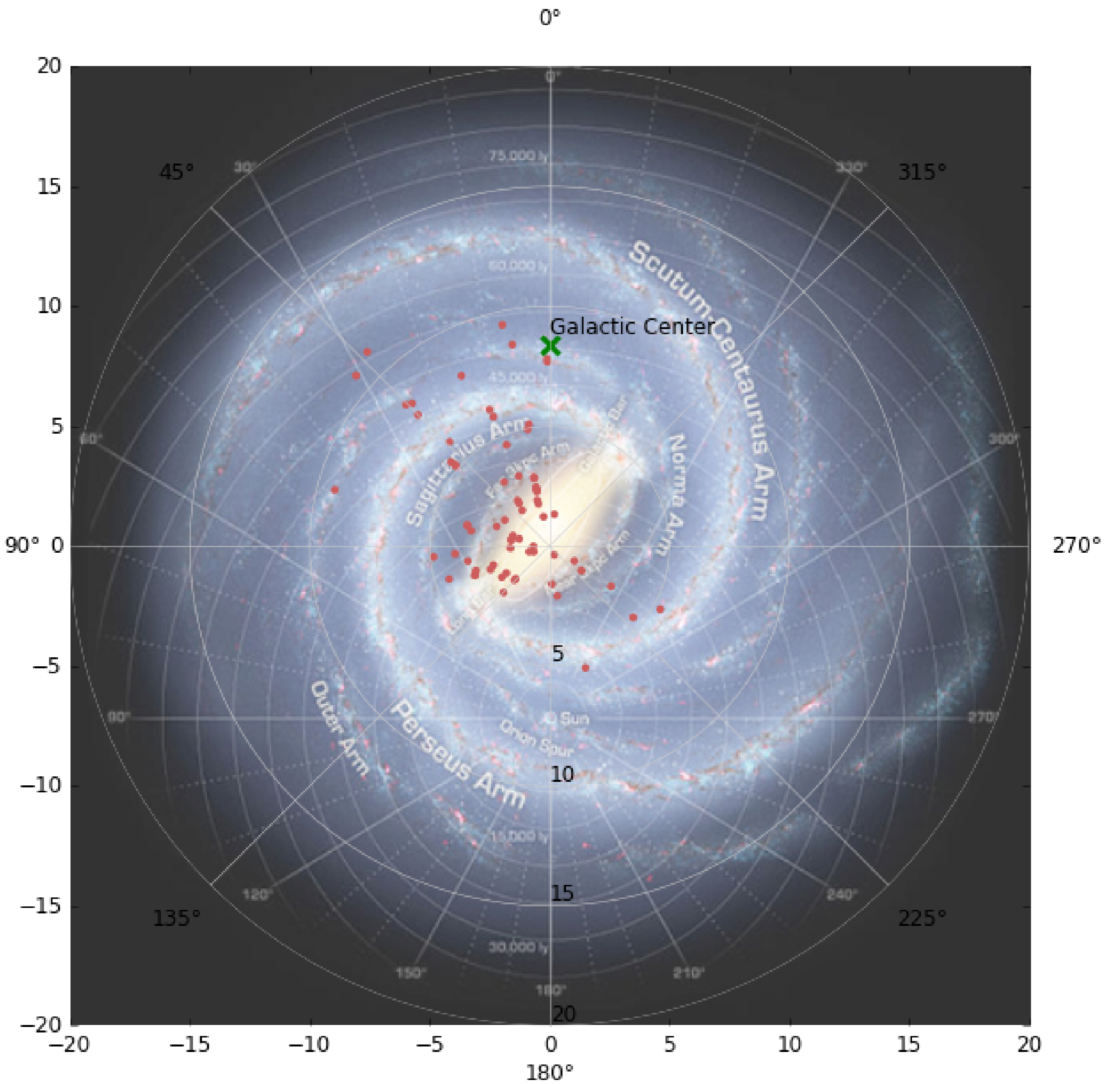
3.3 Plot the data

Since this dataset is a mapping of maser positions in our Galaxy, we have to plot them over a model image of the Galaxy. . .

In [49]:
```
distances = 1./bessel['prlx'].quantity.to(u.arcsec).value * 1e-3
```

In [50]:
```
from scipy.misc import imread
```

In [51]:
```
fig = plt.figure( figsize=(10,10))
rect1 = [0.15, 0.15, 0.75, 0.75]
ax_cartesian  = fig.add_axes(rect1, frameon=False)
#ax_cartesian.set_aspect('equal')
img = imread("images/MilkyWay.jpg")
ax_cartesian.imshow(img, zorder=0, extent=[-20, 20, -20, 20], alpha=0.8)

rect2 = [0.15, 0.15, 0.75, 0.75]
ax = fig.add_axes(rect2, polar=True, frameon=False)
sct = ax.scatter(bessel['l'].quantity.to(u.rad),
                 distances,
                 color='IndianRed',
                 #color=plt.cm.RdBu((coords_uzc.dec.deg[selection])/100.),
                 #s=uzcat['Zmag'][selection_dec*selection_czs],
                 edgecolors="none",
                 zorder=0)
gc = ax.plot(0,8.4, 'x', ms=10, mew=3, c='Green')
ax.text(0,8.9, 'Galactic Center')
ax.set_rlim(0,20)
ax.set_theta_offset(np.pi/2)

ax.set_rlabel_position(180)
ax.grid(color='0.8')
```




```
In [52]: astropy.__version__
```

```
Out[52]: '1.1.1'
```

As you can see this is not correct!!!

3.3.1 Exercise

This exercise is not perhaps super important, but I tried shifting the background or foreground to overlap so that we can plot in the figure.

Does anyone know how to do this?

- Play around a bit with the plotting, this is one way of overlaying polar and cartesian coordinates.

Bessel survey results...