Plotting Astronomical Data: Exercise with pywcsgrid2.

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Motivation:

Planetary nebulae (PN) can be used as kinematic tracers in galaxies, as well as to determine certain chemical properties of their interstellar medium.

In this exercise, we are going to show the spatial distribution of PNs in M31, together with information about their kinematics. In order to guide the reader through our wonderful figure, we need to show an actual image of M31 in the background. The traditional filter to morphologically catalog galaxies is U, or far blue[1]. Information from the infrared is also desirable. We will plot contours in order to show the infrared information. Lastly, we need to mark the position of M 110 in this figure.

Requirements:
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- M31 image must be 3 sigma clipped around its average (in counts).
- Contours over a Gaussian filtered (kernel = 15 pix) infrared image of M31. Draw 5 contours in total.
- We must plot all PNs in a radius of 0.8 deg from M31.
- The color range for PNs velocities must go from -600 to 100 m/s.
- A color bar, showing the the velocity range, 5% of the canvas in x, a separation of 0.1
- Use *tex* style.
- The figure must have a compass, and show the coordinates grid.
- Axes tick labels must be referred to the center of M31.

Resulting Figure:

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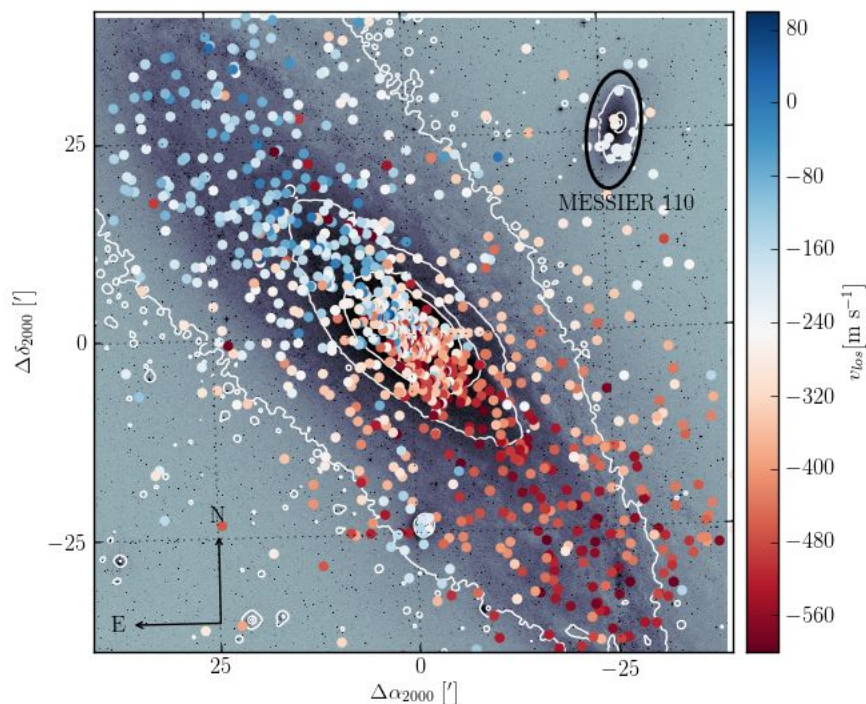
[1] In case you are curious, this is due to the higher sensibility of photographic plates to shorter wavelengths.

Starting point: Get the images!

Go to the ESO dss archive service:

http://archive.eso.org/dss/dss

Get two images (DSS-2-blue, DSS-2-infrared)
RA = 00:42:44.3, Dec = +41:16:07.5
Image size = 80'x80'
Download them as FITS

Required python modules:

```
# Import matplotlib modules

import matplotlib.pyplot as plt
from mpl_toolkits.axes_grid1.axes_divider import
make_axes_locatable
from matplotlib.axes import Axes
import matplotlib.cm as cm
from matplotlib.patches import Ellipse

# Import numpy and scipy for filtering
import scipy.ndimage as nd
import numpy as np

#Import astronomical libraries
import pyfits
import astropy.units as u
from astroquery.ned import Ned
import pywcsgrid2
```

Very simplified pseudo code (key steps):

- Load images using pyfits.
- Load all data available from NED[2] in a region of radius 0.8 degrees around M31.
- Select only PNs from this table ('Type' = 'PN').
- Load also from NED the position of M 110.
HINT: Loading large data tables from NED will take some time. You may want to save these results in a binary file to read it later.
- Define the plotting ranges for the images and PNs velocities.
- Initialize the figure, and the pywcsgrid2 axes using the U image.
- Use make_axes_locatable to create an auxiliary set of axes for the colorbar.
- Add compass and grid.
- Plot the M31 U image on the pywcsgrid2 axes.
- Over plot the infrared contours.
- Over plot the positions of the PNs. Color must shows line-of-sight velocities ('Velocity').
- Add markers and annotations for M 110. Offset of +10' in R.A. and -10' in Dec. for the name.
- Add colorbar, with its corresponding label.
- Save the Figure.

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2 NED: NASA/IPAC Extragalactic Database (https://ned.ipac.caltech.edu)