Finding Candidates for Potentially Gravitationally-Bound Galaxies

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Goal

- Create a process for confirming pairs of colliding galaxies using angular separation and intergalactic distances

Methodology

1) Calculate angular separation with spherical law of cosines

$$\cos(\gamma) = \cos(90^\circ - \delta_a)\cos(90^\circ - \delta_b) + \sin(90^\circ - \delta_a)\sin(90^\circ - \delta_b)\cos(\alpha_a - \alpha_b)$$

$$a = (\alpha_a, \delta_a)$$

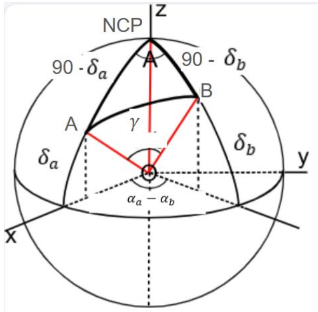
$$b = (\alpha_b, \delta_b)$$

$\alpha_a \rightarrow$ Galaxy 1 right ascension

$\delta_a \rightarrow$ Galaxy 2 declination

$\alpha_b \rightarrow$ Galaxy 1 right ascension

$\delta_b \rightarrow$ Galaxy 2 declination



2) Calculate intergalactic distance

$$c = \sqrt{a^2 + b^2 - 2ab(\cos\gamma)}$$

$c \rightarrow$ distance between two galaxies

$a \rightarrow$ distance to galaxy 1 from Earth

$b \rightarrow$ distance to galaxy 2 from Earth

3) Filter galactic distances < distance from Milky Way to Andromeda

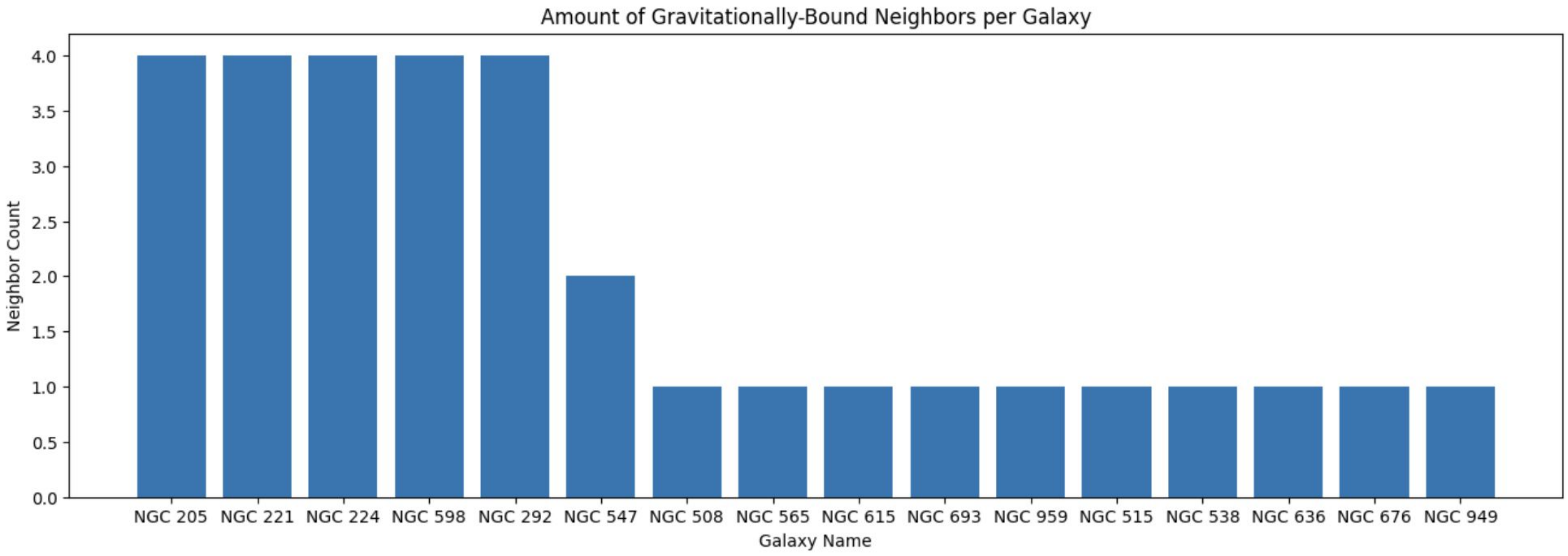
Data

- Used subset of NGC Catalog
- Gathered RA and Dec for each galaxy
- Used pandas to perform calculations between each galaxy and every other galaxy
- Checked resulting filtered pairs to see if they were gravitationally-bound in real life

```python
distances = {}
name_dists = []
distances1 = []
count = 0

for i in np.arange(394):
    g1name = galaxies.loc[i, "Name"]
    d1 = galaxies.loc[i, "Distance"]

    for j in np.arange(394):

        count += 1
        g2name = transposed.loc["Name", j]
        d2 = transposed.loc["Distance", j]
        gamma = gamma_vals[count - 1]

        one_distance_between = np.sqrt((d1**2) + (d2**2) - 2*d1*d2*np.cos(gamma))

        distances1.append(one_distance_between*3261.5637769443)
        name_dists.append((g1name, g2name))


distances = {distance_between: name for distance_between, name in zip(distances1, name_dists)}

distances
```

Results: The 15 pairs we generated

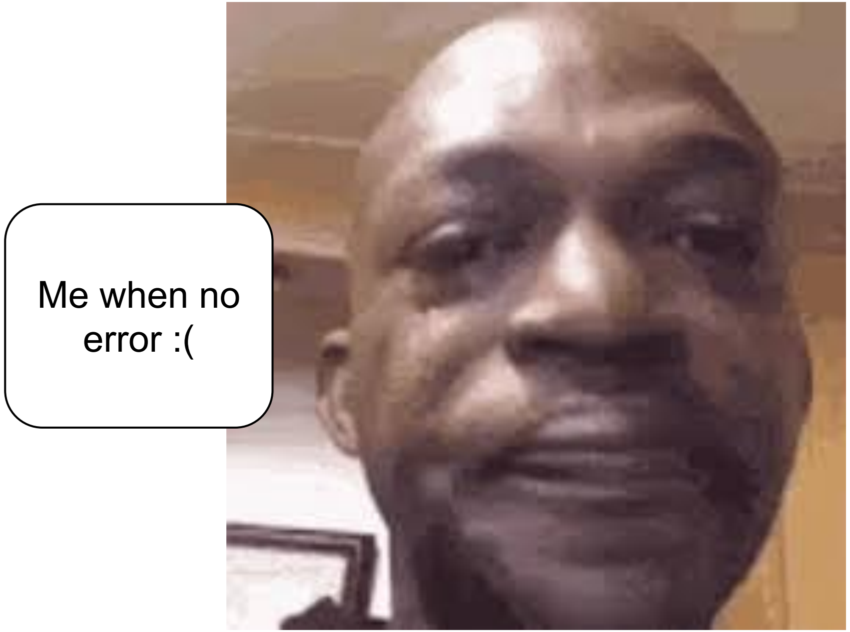
	Distance (ly)	G1	G2	Gamma
0	1.652946e+06	NGC 959	NGC 949	0.029644
1	1.432211e+06	NGC 693	NGC 676	0.009587
2	1.915582e+06	NGC 615	NGC 636	0.017550
3	2.289657e+06	NGC 205	NGC 292	1.998734
4	2.287100e+06	NGC 221	NGC 292	1.984090
5	2.288372e+06	NGC 224	NGC 292	1.991361
6	2.355140e+06	NGC 598	NGC 292	1.810007
7	1.163615e+06	NGC 547	NGC 538	0.005773
8	2.197333e+06	NGC 565	NGC 547	0.008744
9	3.509946e+04	NGC 221	NGC 205	0.015955
10	2.151365e+04	NGC 224	NGC 205	0.009779
11	6.084162e+05	NGC 598	NGC 205	0.267585
12	1.599827e+04	NGC 224	NGC 221	0.007272
13	5.764968e+05	NGC 598	NGC 221	0.253065
14	5.870424e+05	NGC 598	NGC 224	0.257863
15	1.839583e+06	NGC 508	NGC 515	0.005046



*Confirmed pairs with stellarium – many are within galaxy clusters

Problems

- No RA and Dec error in data set, so could not calculate error



Future

- Incorporate mass to find total system energy of two galaxies to support distance calculations
- Cross-reference other catalogues
- Use larger data set