Homework 01: healpy

FERRAMENTAS DE ANÁLISE DE DADOS EM COSMOLOGIA

1. Consider the WMAP7 CMB maps downloaded during class - see healpy tutorial

a. Show all pixels of the map located at a 10° radius around the position $(l, b) = (150°, 27°)$, where (l, b) correspond to galactic coordinates. Note that you will have to do a coordinate conversion.

b. Same location in the sky, but for 5°, 20° e 30° radii.

c. Same as items [a] and [b], but around the $(l, b) = (208°, -53°)$ position. This is a region dubbed *CMB cold spot*, which is roughly $140\mu K$ colder than CMB average temperature of $T_0 = 2.73$K.

2. Consider the 21cm intensity mapping provided in FITS format in the supplementary data zipped file.

a. Make a Mollweide projection of this map

b. Same as item [a], but changing to Ecliptic and Celestial (Equatorial) coordinates.

c. What is the resolution of this map - in units of $n_{\rm side}$?

d. Degrade the resolution of this map for two immediate $n_{\rm side}$ values below the original resolution - for instance, if the map is in $n_{\rm side} = 128$, degrade it to $n_{\rm side} = 64$ and $n_{\rm side} = 32$ - and show their Mollweide projection. *Tip*: Use the UD GRADE healpy routine.

e. Compute the angular power spectrum of the original map using the healpy ANAFAST, as done in the tutorial.

f. Build a mask around $|b| \leq 20°$ and $|b| \leq 30°$ on the original map, and plot their respective Mollweide projections.

g. Same as item [f], but with a mask on $DEC < 30°$, where DEC denotes the declination in Celestial coordinates.

h. **(optional)**: Apply the mask given in the supplementary data on this map, and compute its power spectrum as in item [e]. Compare their results and discuss.

3. Consider the PANTHEON.DAT file given in the supplementary data, which comprises one of the most recent Type Ia Supernova distance compilation. The file columns correspond, respectively, to the SN redshift at the heliocentric rest frame, SN redshift at CMB rest frame, galactic longitude and latitude, distance modulus and distance modulus uncertainty.

a. Make a Mollweirde projection of the SN celestial positions. You can choose whatever resolution you like. *Tip*: Use the healpy PROJSCATTER and/or PROJPLOT routines

b. Show objects lying in $z < 0.2$, $0.2 < z < 0.5$ and $z > 0.5$ in different colours.