import healpy as hp

import numpy as np

import matplotlib.pyplot as plt

from scipy.stats import pearsonr

# Load Q/U polarization maps from SMICA FITS file

# Index 1 = Q, Index 2 = U

q\_map = hp.read\_map("COM\_CMB\_IQU-smica\_2048\_R3.00\_oe2.fits", field=1)

u\_map = hp.read\_map("COM\_CMB\_IQU-smica\_2048\_R3.00\_oe2.fits", field=2)

nside = hp.get\_nside(q\_map)

npix = hp.nside2npix(nside)

# Define coordinate (e.g., cold spot)

theta\_cmb = np.radians(90 - 57)

phi\_cmb = np.radians(207)

# Ring profile function

def ring\_profile(field, theta, phi, nside, npix, num\_rings=10, max\_radius\_deg=50):

    vec = hp.ang2vec(theta, phi)

    vecs = np.array(hp.pix2vec(nside, np.arange(npix)))

    dots = np.sum(vecs \* np.array(vec)[:, None], axis=0)

    dots = np.clip(dots, -1.0, 1.0)

    angs\_deg = np.degrees(np.arccos(dots))

    edges = np.linspace(0, max\_radius\_deg, num\_rings + 1)

    profile = []

    for i in range(num\_rings):

        mask = (angs\_deg >= edges[i]) & (angs\_deg < edges[i+1])

        profile.append(np.mean(field[mask]))

    return profile

# Extract polarization profiles

q\_profile = ring\_profile(q\_map, theta\_cmb, phi\_cmb, nside, npix)

u\_profile = ring\_profile(u\_map, theta\_cmb, phi\_cmb, nside, npix)

# MBT curvature shell at the same spot

vec\_root = hp.ang2vec(theta\_cmb, phi\_cmb)

mbt\_field = np.zeros(npix)

mbt\_field[hp.query\_disc(nside, vec\_root, np.radians(10.0))] = 1.0

mbt\_profile\_q = ring\_profile(mbt\_field, theta\_cmb, phi\_cmb, nside, npix)

mbt\_profile\_u = ring\_profile(mbt\_field, theta\_cmb, phi\_cmb, nside, npix)

# Correlation

corr\_q, \_ = pearsonr(q\_profile, mbt\_profile\_q)

corr\_u, \_ = pearsonr(u\_profile, mbt\_profile\_u)

# Plot

plt.figure(figsize=(10, 5))

plt.subplot(1,2,1)

plt.plot(q\_profile, label='Polarization Q')

plt.plot(mbt\_profile\_q, label='MBT Field')

plt.title(f"Q Profile Correlation: r = {corr\_q:.2f}")

plt.grid(True); plt.legend()

plt.subplot(1,2,2)

plt.plot(u\_profile, label='Polarization U')

plt.plot(mbt\_profile\_u, label='MBT Field')

plt.title(f"U Profile Correlation: r = {corr\_u:.2f}")

plt.grid(True); plt.legend()

plt.tight\_layout()

plt.show()