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import numpy as np
from scipy.linalg import toeplitz as tp
from matplotlib import pyplot as plt

N_vec = np.array(range(2, 100 + 1, 2))
plt.figure(figsize=(16, 8))

for N in N_vec:
    h = 2 * np.pi / N
    x = - np.pi + np.matrix(range(1, N + 1)).T * h
    u_array = []
    for i in np.array(x.T):
        u_val = np.power(np.e, np.sin(i)**2)
        u_array.extend(u_val)

    u = np.matrix(u_array).T
    uprime = np.matrix(2*np.array(np.sin(x))*np.array(np.cos(x)) * np.array(u))

    column_sign = .5 * np.power((-1), range(1, N))
    column_cot = []

    for i in range(1, N):
        column_cot.append(1 / np.tan(i * h/2))

    column_cot = np.array(column_cot)
    column = np.array(0)
    column = np.append(column, column_sign*column_cot)

    column_1 = [0]

    for j in range(N - 1, 1 - 1, -1):
        column_1.append(column[j])

    D = tp(column, column_1)

    error_matrix = D * u - uprime
    error = error_matrix.sum(axis=1).max()

    plt.scatter(N, error, color='black')

#plt.ylim(10**(-15), 10**0)
#plt.xlim(10**0, 10**2)
plt.xscale('log')
plt.yscale('log')
plt.grid(which='both', linestyle=':')
plt.xlabel('N', fontsize=20)
plt.ylabel('Error', fontsize=20)
plt.title('Convergence of spectral differences', fontsize = 15)

plt.show()

```



