MA666 Spectra Homework

1. Load the file:

   `EEG-a.mat`, available on the GitHub repository into Python.

   a. What is the sampling interval (Δ)?

      What is the total duration of the recording (T)?

      What is the frequency resolution (df)?

      What is the Nyquist frequency (f_{NQ})?

   b. **Plot the data** and visually inspect it. Describe briefly (in a sentence or two) what rhythms - if any - you see in the data.

   c. **Plot the spectrum** versus frequency. Choose to plot the spectrum on a decibel scale, or not, and with a logarithmic frequency axis, or not.

   d. **Plot the spectrogram** as a function of frequency and time. You will need to choose the interval size and the overlap between intervals. Do the rhythms in these data appear to change in time?

   e. **Interpret** (in a few sentences) the spectrum and spectrogram, and describe the rhythms present in the signal. Compare your visual inspection of the data to the spectrum results - do the analyses agree or disagree?

2. Repeat Question (1) for the data `EEG-b.mat`. Address each sub-question (a-e).
3. Repeat Question (1) for the data `EEG-c.mat`. Address each sub-question (a-e).
4. Repeat Question (1) for the **spike train** in `spikes-a.mat`. Address each sub-question (a-e).
5. Repeat Question (1) for the **spike train** in `spikes-b.mat`. Address each sub-question (a-e).

Challenging Bonus Questions

I. In Python, we used `np.correlate` to compute the covariance. Program “by hand” a function to compute the autocovariance using the equations we wrote in class (i.e., do not use `np.correlate` or ChatGPT). Show that your function and `np.correlate` produces the same result.

II. In class, we simulated a neural spike train with a refractory period and found a counterintuitive spectrum. Work out an (approximate) mathematical explanation for this spectrum. *HINT*: Approximate the impact of the refractory period on the autocovariance as a negative Gaussian.