# Time Frequency Analysis and Wavelet Transform

# Final Project: Code Edition

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# 1. Function Description

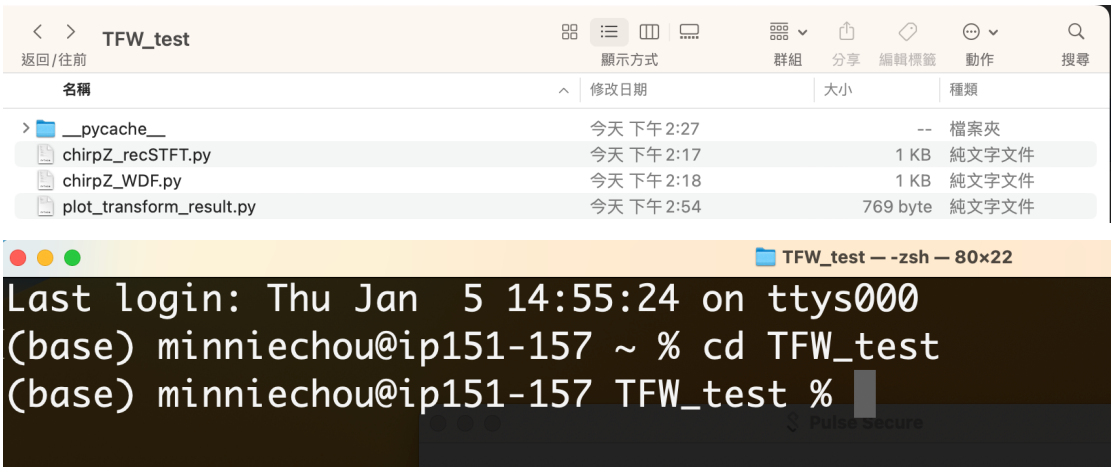
- Function ***chirpZ_recSTFT(x,t,f,B)*** in file chirpZ_recSTFT.py: Implement STFT by Chirp-Z Transform Method
  ***x: input***
  ***t: samples on time-axis***
  ***f: samples on frequency-axis***
  ***B: Bandwidth***

- Function ***chirpZ_WDF(x,t,f,B)*** in file chirpZ_WDF.py: Implement Wigner Distribution Function by Chirp-Z Transform
  ***x: input***
  ***t: samples on time-axis***
  ***f: samples on frequency-axis***
  ***B: Bandwidth***

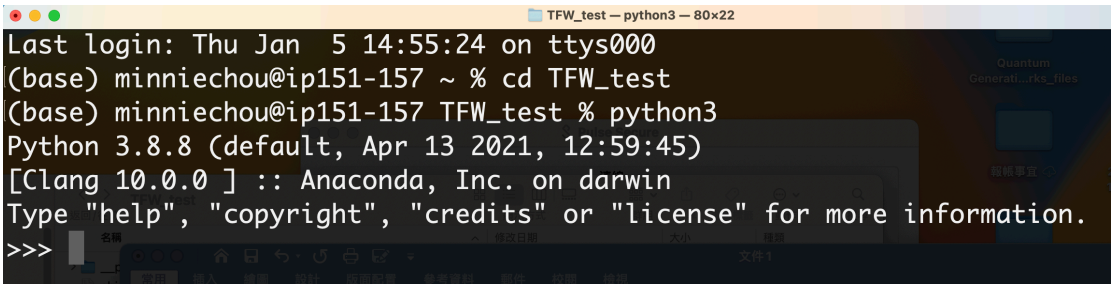
- Function ***plot_transform_result(y,t,f)*** in file plot_transform_result.py: Plot the Result of each transform
  ***y: output result of time-frequency analysis(STFT or WDF)***
  ***t: samples on time-axis***
  ***f: samples on frequency-axis***

# 2. Execute Method

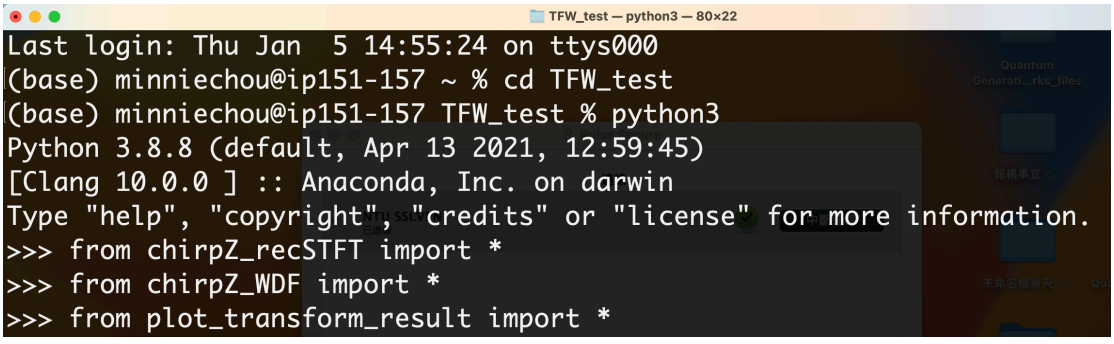
**STEP1**: 將所需的檔案 chirpZ_recSTFT.py / chirpZ_WDF.py / plot_transform_result.py 全部放在同一個資料夾，並於 cmd 內下指令切換至該資料夾:




**STEP2**: 輸入指令 python3 以執行 python 檔案




**STEP3**: import the functions we need



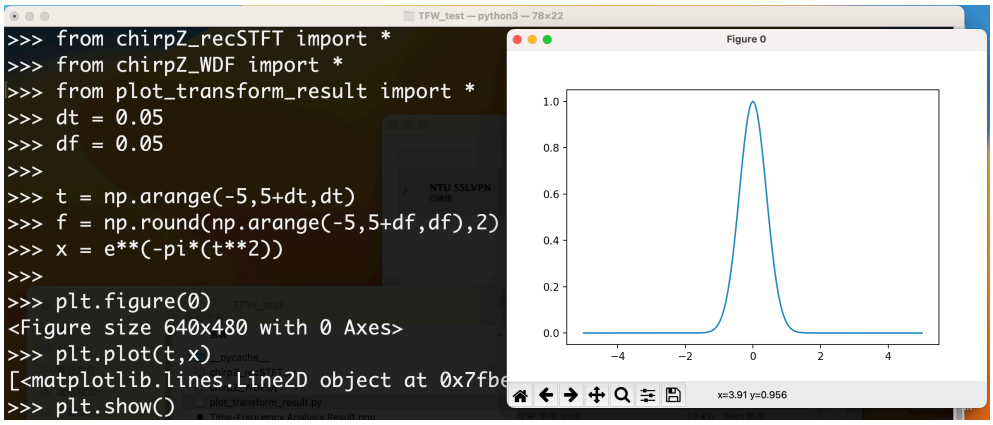

**STEP4**: input the signal and sample points on time/frequency to **chirpZ_recSTFT** and **chirpZ_WDF** function. (More details in next section)

# 3. Examples

## Case 1

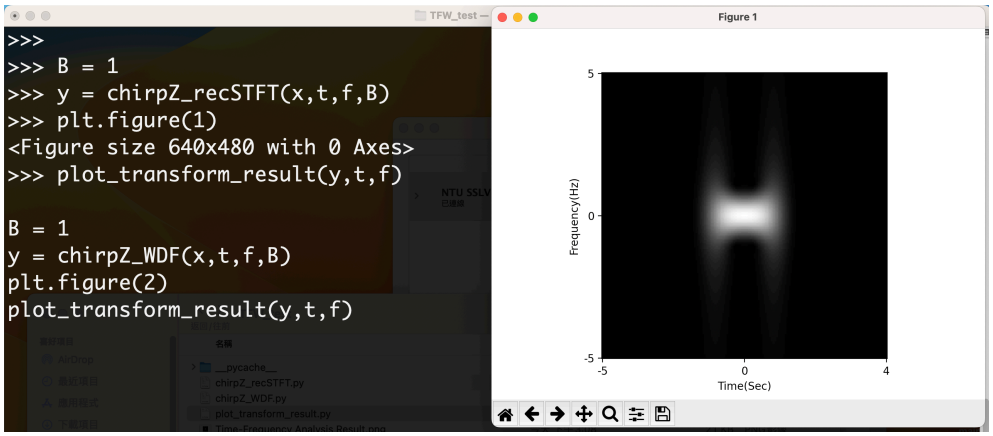
1-1 Original Signal on time domain (one component: Gaussian Function)

$$x(t) = e^{-\pi t^2}$$




1-2 Time-Frequency result after doing **recSTFT** by Chirp-Z Transform Method

☹ Low time/frequency resolution, 能量不集中/解析度低

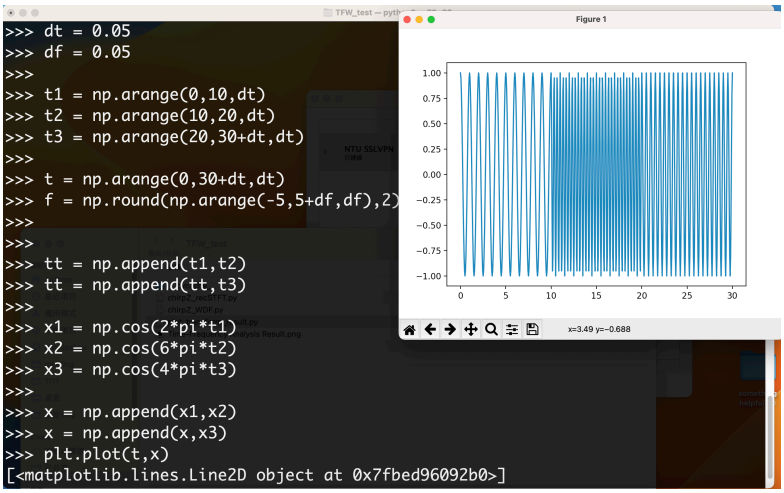



1-3 Time-Frequency result after doing **WDF** by Chirp-Z Transform Method

☺ High time/frequency resolution, 能量集中/解析度高

**Case 2:**

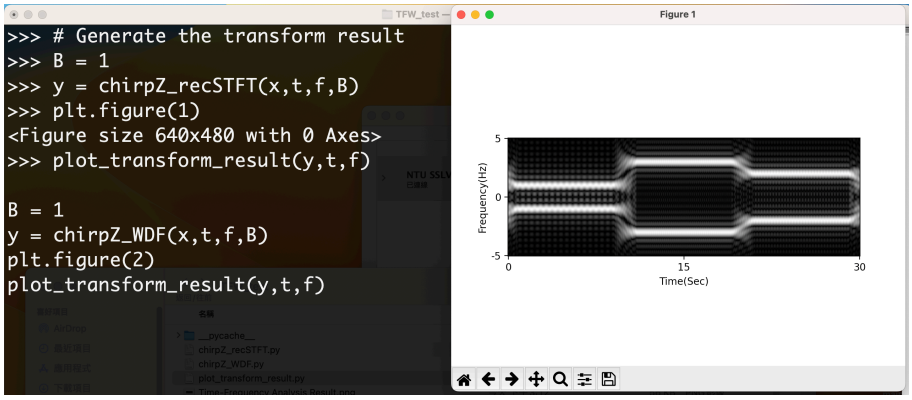
2-1 Original Signal on time domain (multiple components)




2-2 Time-Frequency result after doing **recSTFT** by Chirp-Z Transform Method

☹ Low time/frequency resolution

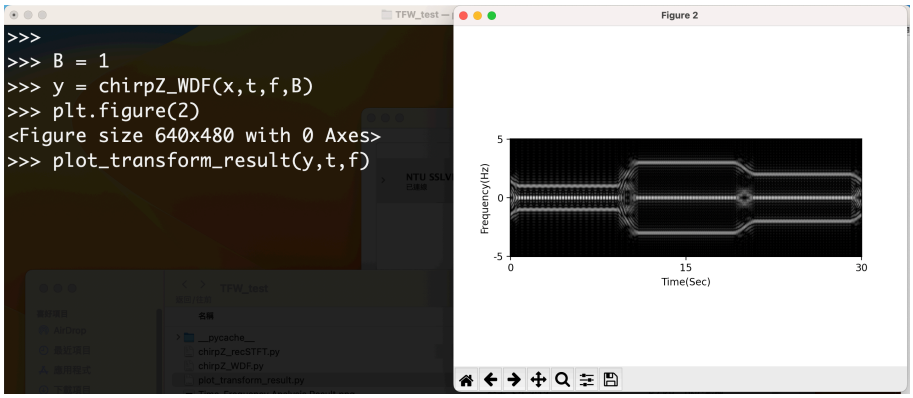
☺ but there's no cross term in this result




**2-3** Time-Frequency result after doing **WDF** by Chirp-Z Transform Method

☺ High time/frequency resolution

☹ but the cross term exists, caused by multiple components⟶WDF is not suitable for dealing multiple components' signal



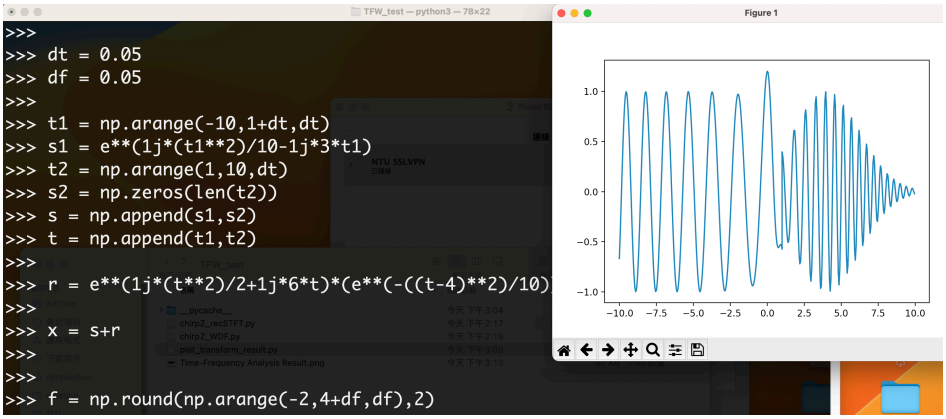
**Case 3**

3-1 Original Signal on time domain (multiple components)

$$s(t) = e^{\frac{jt^2}{10} - j3t} \quad for\ -9 \le t \le 1, \qquad s(t) = 0 \quad otherwise$$

$$r(t) = e^{\frac{jt^2}{2} + j6t} e^{\frac{-(t-4)^2}{10}}$$

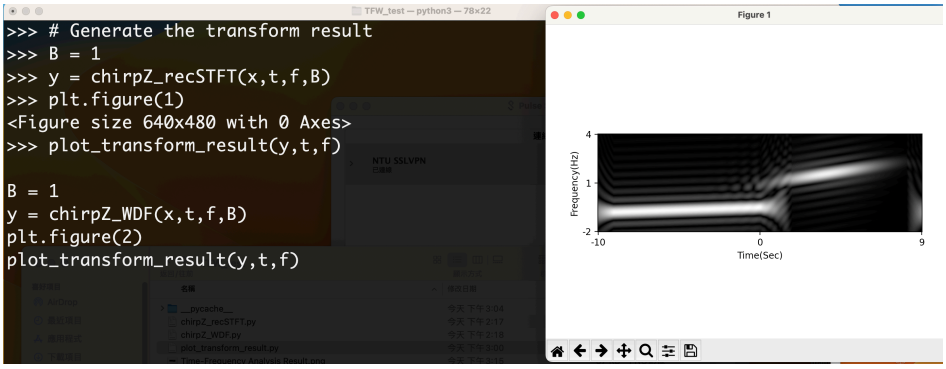
$$f(t) = s(t) + r(t)$$




3-2 Time-Frequency result after doing **recSTFT** by Chirp-Z Transform Method

☹ Low time/frequency resolution⟶add window might be better (Gabor Transform)

☺ but there's no cross term in this result




3-3 Time-Frequency result after doing **WDF** by Chirp-Z Transform Method

☺ Better time/frequency resolution

☹ but the cross term exists