This is a code file showing how to use Wavelet Transform in Python.

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The purpose of this code is to show how to use wavelet transform to denoise data. I wanted to explore other ways to denoise stock data for analysis, and we aren't sure if we will be using this or not. However, I thought it was worth putting it out for others to see the code.

Wavelet Transform is a relatively new concept that was originally developed to analyze signals intelligence. Fourier transform, its grandfather, shows what signals are present but not when they occured. Wavelet transform will show you what happened and when, as long as you're willing to analyze the stock data as a wave.

In order to use this, you'll have to convert your stock data into a file that wavelet transform can read. I didn't do that for you in this code becuase this process will be different depending on where your stock data originated.

In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
import seaborn as sns
import pywt
print(pywt.families(short=False))
```

```
['Haar', 'Daubechies', 'Symlets', 'Coiflets', 'Biorthogonal', 'Reverse biorthogonal',
'Discrete Meyer (FIR Approximation)', 'Gaussian', 'Mexican hat wavelet', 'Morlet wave
let', 'Complex Gaussian wavelets', 'Shannon wavelets', 'Frequency B-Spline wavelets',
'Complex Morlet wavelets']
```

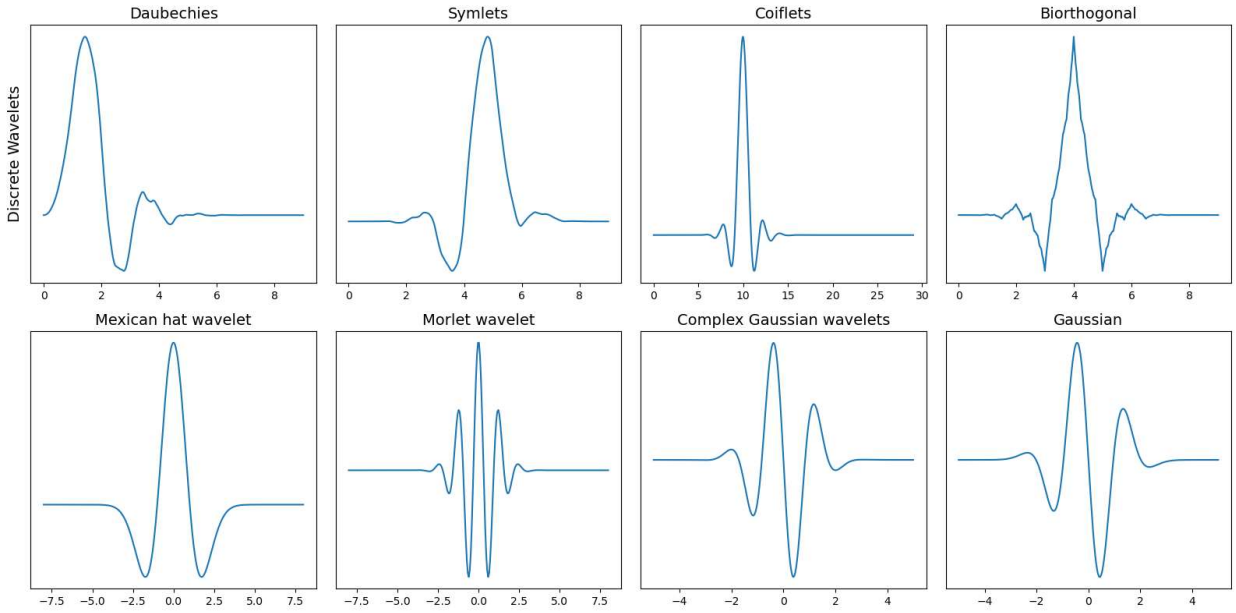
In [2]:
```
discrete_wavelets = ['db5', 'sym5', 'coif5', 'bior2.4']
continuous_wavelets = ['mexh', 'morl', 'cgau5', 'gaus5']

list_list_wavelets = [discrete_wavelets, continuous_wavelets]
list_funcs = [pywt.Wavelet, pywt.ContinuousWavelet]

fig, axarr = plt.subplots(nrows=2, ncols=4, figsize=(16,8))
for ii, list_wavelets in enumerate(list_list_wavelets):
    func = list_funcs[ii]
    row_no = ii
    for col_no, waveletname in enumerate(list_wavelets):
        wavelet = func(waveletname)
        family_name = wavelet.family_name
        biorthogonal = wavelet.biorthogonal
        orthogonal = wavelet.orthogonal
        symmetry = wavelet.symmetry
        if ii == 0:
            _ = wavelet.wavefun()
            wavelet_function = _[0]
            x_values = _[-1]
        else:
            wavelet_function, x_values = wavelet.wavefun()
```

```
        if col_no == 0 and ii == 0:
            axarr[row_no, col_no].set_ylabel("Discrete Wavelets", fontsize = 14)
        axarr[row_no, col_no].set_title("{}".format(family_name), fontsize = 14)
        axarr[row_no, col_no].plot(x_values, wavelet_function)
        axarr[row_no, col_no].set_yticks([])
        axarr[row_no, col_no].set_yticklabels([])
plt.tight_layout()
plt.show()
```

```
C:\Users\trade\anaconda3\lib\site-packages\matplotlib\cbook\__init__.py:1298: Complex
Warning: Casting complex values to real discards the imaginary part
  return np.asarray(x, float)
```



In [3]:
```
#it's okay that it omitted the complex data. For my use, I'm analyzing stock data whic
#people who are using this for signals analysis might want the complex data.
```

In [4]:
```
#choose a wavelet.
#for my use in denoising stock data, I need a discrete wavelet.
```

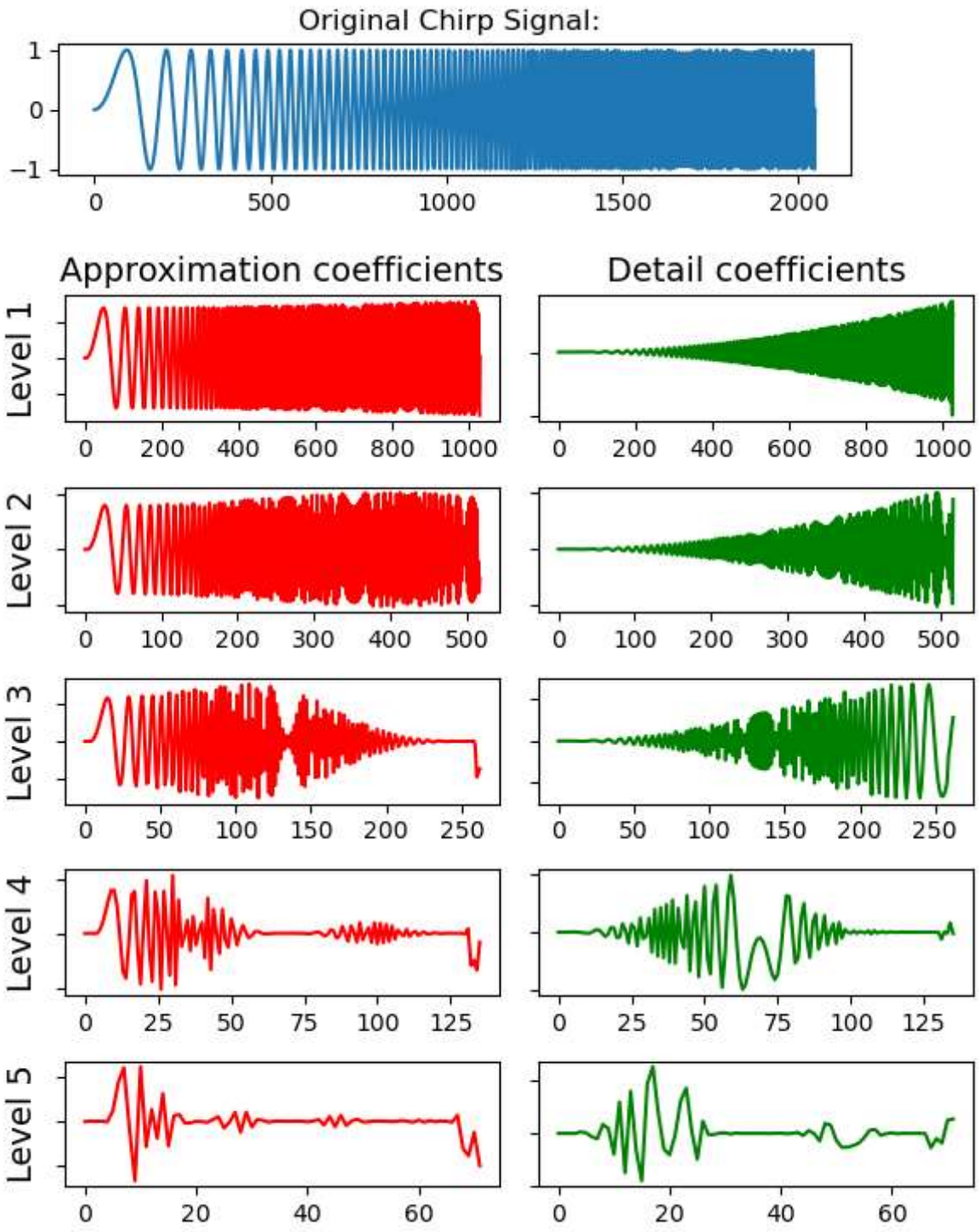
In [5]:
```
x = np.linspace(0,1,num=2048)
chirp_signal = np.sin(250*np.pi*x**2)

fig, ax = plt.subplots(figsize=(6,1))
ax.set_title("Original Chirp Signal: ")
ax.plot(chirp_signal)
plt.show()

data=chirp_signal
waveletname = 'bior2.4'

fig, axarr = plt.subplots(nrows=5, ncols=2, figsize=(6,6))
for ii in range(5):
    (data, coeff_d) = pywt.dwt(data, waveletname)
    axarr[ii, 0].plot(data, 'r')
    axarr[ii, 1].plot(coeff_d, 'g')
    axarr[ii, 0].set_ylabel("Level {}".format(ii + 1), fontsize=14, rotation=90)
    axarr[ii, 0].set_yticklabels([])
    if ii == 0:
        axarr[ii, 0].set_title("Approximation coefficients", fontsize=14)
        axarr[ii, 1].set_title("Detail coefficients", fontsize=14)
```

```
    axarr[ii, 1].set_yticklabels([])
plt.tight_layout()
plt.show()
```

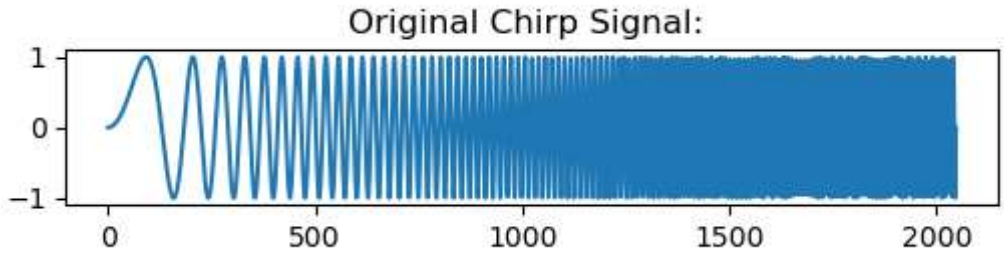


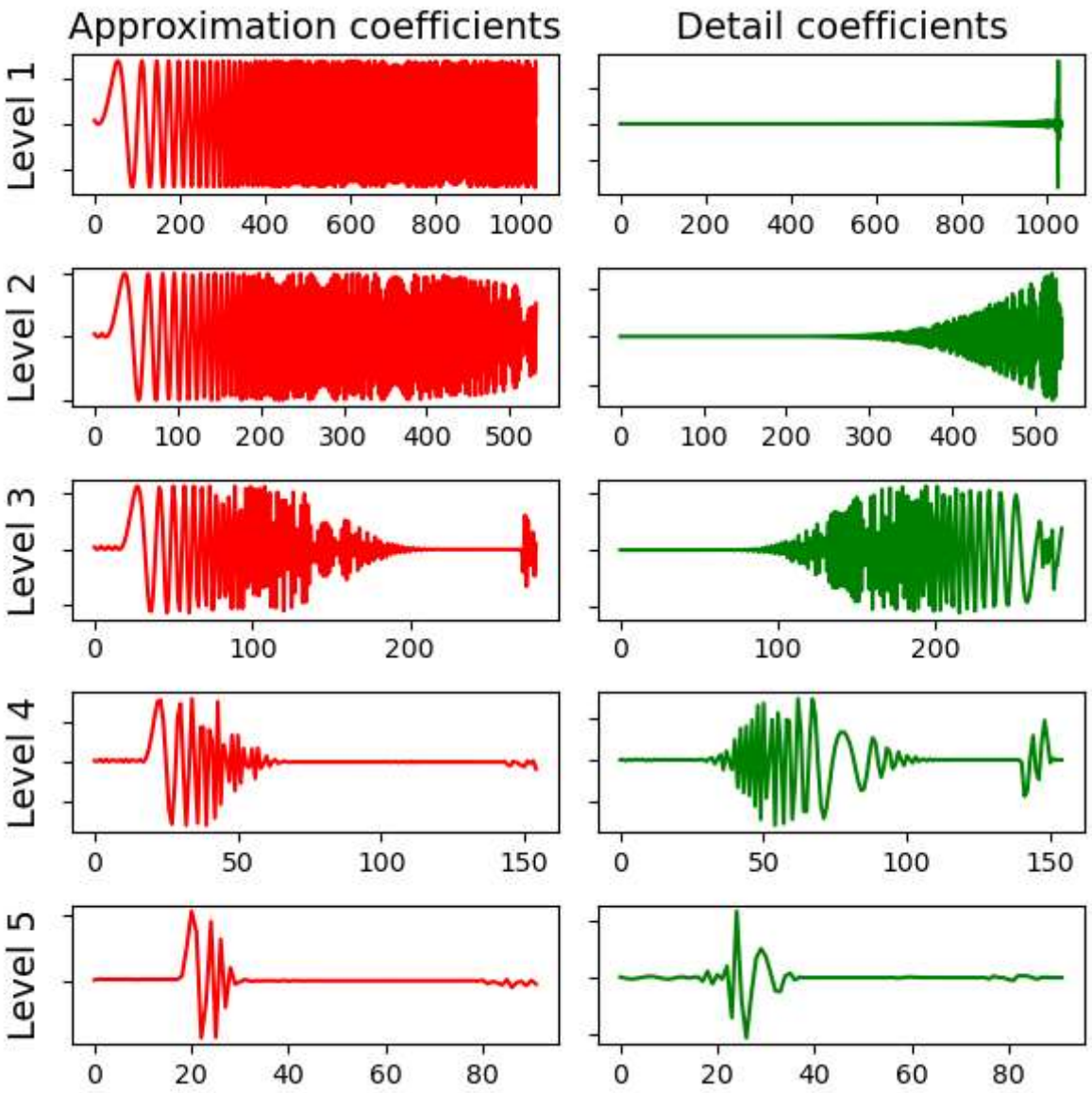
In [6]:
```
x = np.linspace(0,1,num=2048)
chirp_signal = np.sin(250*np.pi*x**2)

fig, ax = plt.subplots(figsize=(6,1))
ax.set_title("Original Chirp Signal: ")
ax.plot(chirp_signal)
plt.show()

data=chirp_signal
waveletname = 'coif5'
```

```
fig, axarr = plt.subplots(nrows=5, ncols=2, figsize=(6,6))
for ii in range(5):
    (data, coeff_d) = pywt.dwt(data, waveletname)
    axarr[ii, 0].plot(data, 'r')
    axarr[ii, 1].plot(coeff_d, 'g')
    axarr[ii, 0].set_ylabel("Level {}".format(ii + 1), fontsize=14, rotation=90)
    axarr[ii, 0].set_yticklabels([])
    if ii == 0:
        axarr[ii, 0].set_title("Approximation coefficients", fontsize=14)
        axarr[ii, 1].set_title("Detail coefficients", fontsize=14)
    axarr[ii, 1].set_yticklabels([])
plt.tight_layout()
plt.show()
```





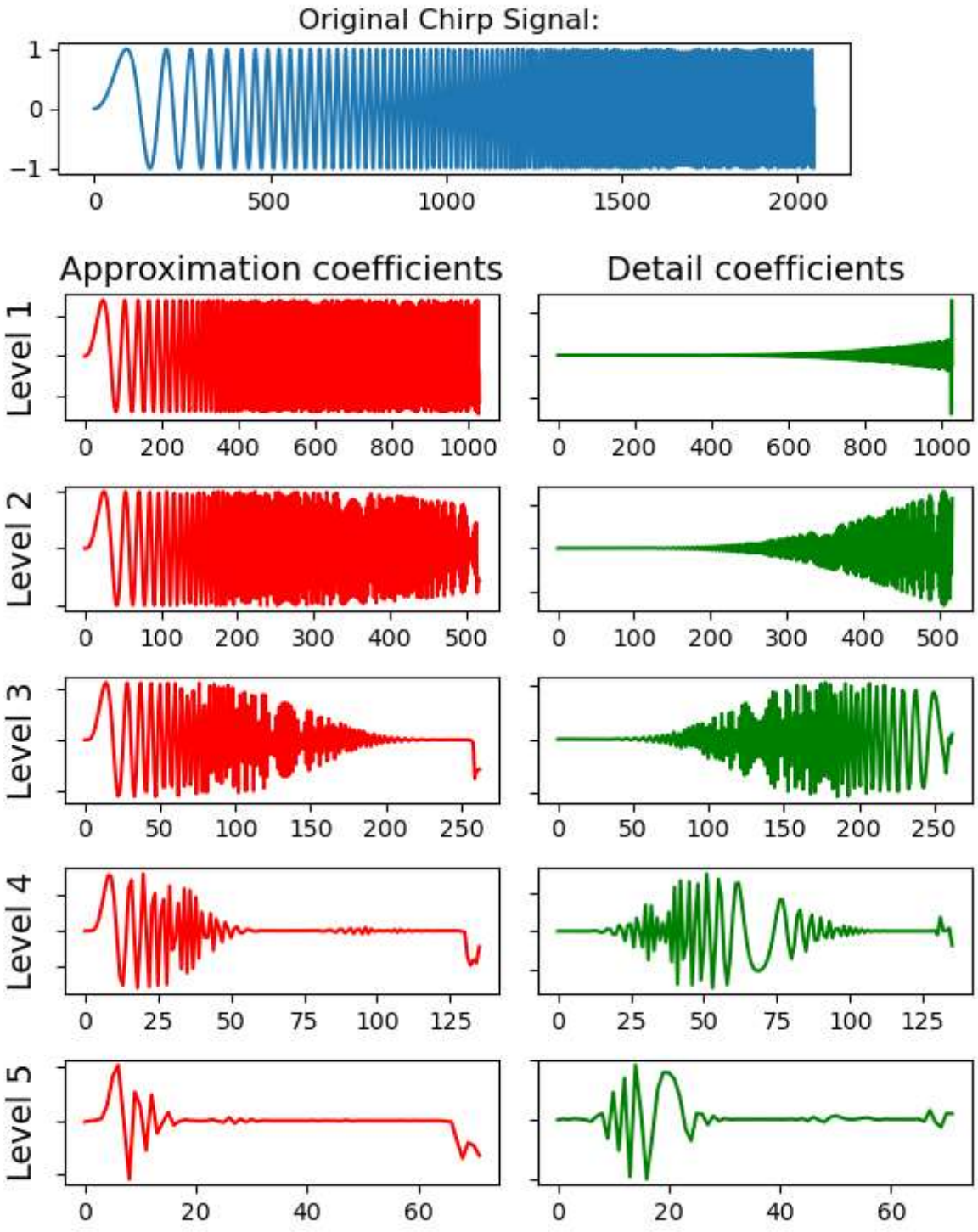
In [7]:
```
x = np.linspace(0,1,num=2048)
chirp_signal = np.sin(250*np.pi*x**2)

fig, ax = plt.subplots(figsize=(6,1))
ax.set_title("Original Chirp Signal: ")
ax.plot(chirp_signal)
plt.show()

data=chirp_signal
waveletname = 'sym5'

fig, axarr = plt.subplots(nrows=5, ncols=2, figsize=(6,6))
for ii in range(5):
    (data, coeff_d) = pywt.dwt(data, waveletname)
    axarr[ii, 0].plot(data, 'r')
    axarr[ii, 1].plot(coeff_d, 'g')
    axarr[ii, 0].set_ylabel("Level {}".format(ii + 1), fontsize=14, rotation=90)
    axarr[ii, 0].set_yticklabels([])
    if ii == 0:
        axarr[ii, 0].set_title("Approximation coefficients", fontsize=14)
        axarr[ii, 1].set_title("Detail coefficients", fontsize=14)
    axarr[ii, 1].set_yticklabels([])
```

```
plt.tight_layout()
plt.show()
```

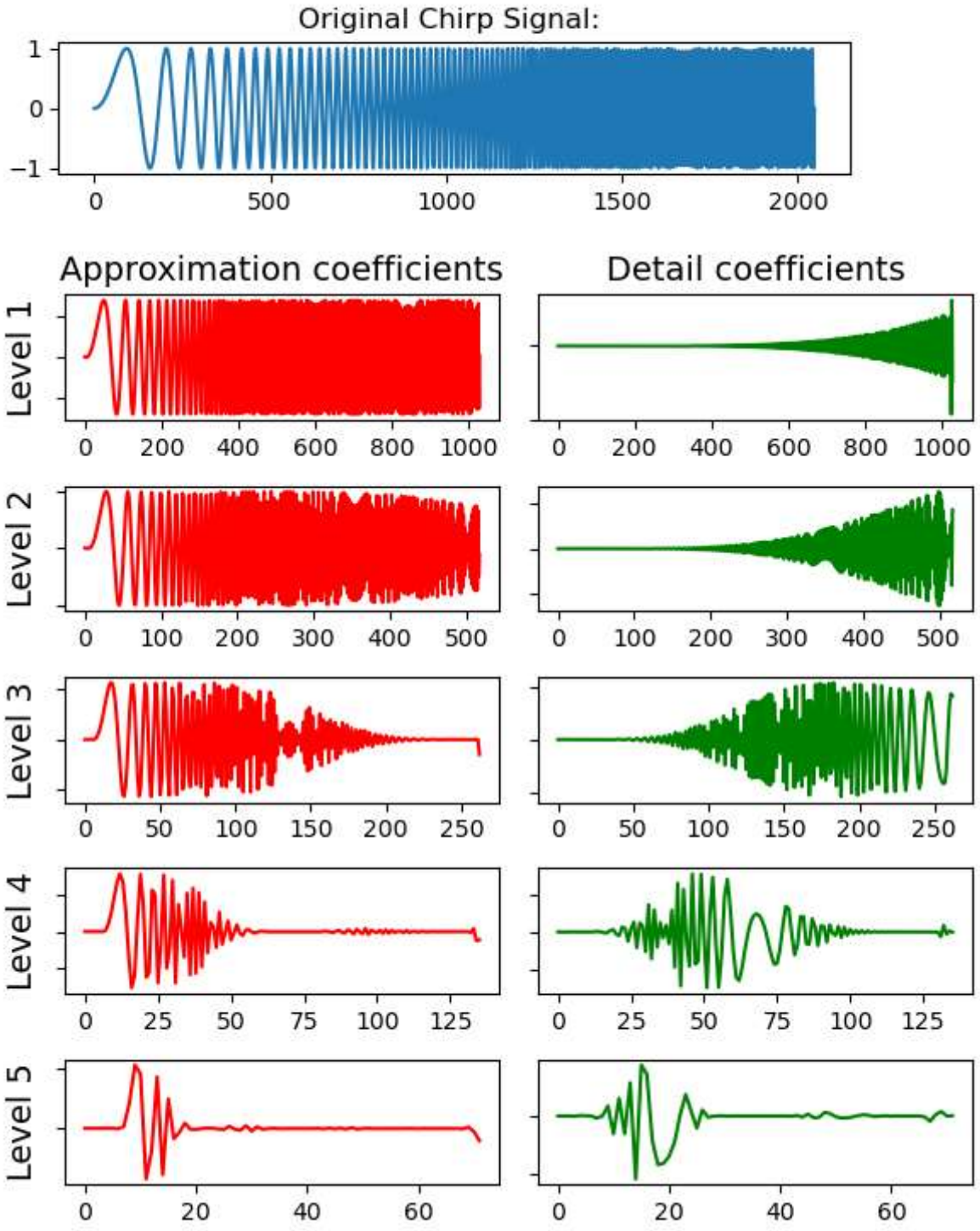


In [8]:
```
x = np.linspace(0,1,num=2048)
chirp_signal = np.sin(250*np.pi*x**2)

fig, ax = plt.subplots(figsize=(6,1))
ax.set_title("Original Chirp Signal: ")
ax.plot(chirp_signal)
plt.show()

data=chirp_signal
waveletname = 'db5'
```

```
fig, axarr = plt.subplots(nrows=5, ncols=2, figsize=(6,6))
for ii in range(5):
    (data, coeff_d) = pywt.dwt(data, waveletname)
    axarr[ii, 0].plot(data, 'r')
    axarr[ii, 1].plot(coeff_d, 'g')
    axarr[ii, 0].set_ylabel("Level {}".format(ii + 1), fontsize=14, rotation=90)
    axarr[ii, 0].set_yticklabels([])
    if ii == 0:
        axarr[ii, 0].set_title("Approximation coefficients", fontsize=14)
        axarr[ii, 1].set_title("Detail coefficients", fontsize=14)
    axarr[ii, 1].set_yticklabels([])
plt.tight_layout()
plt.show()
```



In [10]:
```
def plot_wavelet(time, signal, scales,
                 waveletname = 'cmor',
                 cmap = plt.cm.seismic,
                 title = 'Wavelet Transform (Power Spectrum) of signal',
                 ylabel = 'Period (years)',
                 xlabel = 'Time'):

    dt = time[1] - time[0]
    [coefficients, frequencies] = pywt.cwt(signal, scales, waveletname, dt)
    power = (abs(coefficients)) ** 2
    period = 1. / frequencies
    levels = [0.0625, 0.125, 0.25, 0.5, 1, 2, 4, 8]
    contourlevels = np.log2(levels)

    fig, ax = plt.subplots(figsize=(15, 10))
    im = ax.contourf(time, np.log2(period), np.log2(power), contourlevels, extend='bot

    ax.set_title(title, fontsize=20)
    ax.set_ylabel(ylabel, fontsize=18)
    ax.set_xlabel(xlabel, fontsize=18)

    yticks = 2**np.arange(np.ceil(np.log2(period.min())), np.ceil(np.log2(period.max()
    ax.set_yticks(np.log2(yticks))
    ax.set_yticklabels(yticks)
    ax.invert_yaxis()
    ylim = ax.get_ylim()
    ax.set_ylim(ylim[0], -1)

    cbar_ax = fig.add_axes([0.95, 0.5, 0.03, 0.25])
    fig.colorbar(im, cax=cbar_ax, orientation="vertical")
    plt.show()

def plot_signal_plus_average(time, signal, average_over = 5):
    fig, ax = plt.subplots(figsize=(15, 3))
    time_ave, signal_ave = get_ave_values(time, signal, average_over)
    ax.plot(time, signal, label='signal')
    ax.plot(time_ave, signal_ave, label = 'time average (n={})'.format(5))
    ax.set_xlim([time[0], time[-1]])
    ax.set_ylabel('Signal Amplitude', fontsize=18)
    ax.set_title('Signal + Time Average', fontsize=18)
    ax.set_xlabel('Time', fontsize=18)
    ax.legend()
    plt.show()

def get_fft_values(y_values, T, N, f_s):
    f_values = np.linspace(0.0, 1.0/(2.0*T), N//2)
    fft_values_ = fft(y_values)
    fft_values = 2.0/N * np.abs(fft_values_[0:N//2])
    return f_values, fft_values

def plot_fft_plus_power(time, signal):
    dt = time[1] - time[0]
    N = len(signal)
    fs = 1/dt

    fig, ax = plt.subplots(figsize=(15, 3))
    variance = np.std(signal)**2
    f_values, fft_values = get_fft_values(signal, dt, N, fs)
    fft_power = variance * abs(fft_values) ** 2     # FFT power spectrum
```

```
    ax.plot(f_values, fft_values, 'r-', label='Fourier Transform')
    ax.plot(f_values, fft_power, 'k--', linewidth=1, label='FFT Power Spectrum')
    ax.set_xlabel('Frequency [Hz / year]', fontsize=18)
    ax.set_ylabel('Amplitude', fontsize=18)
    ax.legend()
    plt.show()
```

In [ ]: