```
clearvars
format long
```

Research Techniques Project

Milestone 1 (6 October)

Data Exploration of BD+55_441

For this milestone, BD+55_441 is displayed and explored in detail. The other sources are briefly imported in upcoming sections.

```
opts = detectImportOptions("BD+55_441.txt");
opts.DataLines = 3;
opts.VariableNames = {'B_time','B_flux','R_time','R_flux','V_time','V_flux'};
```

"time" is in the units of days and "flux" is "rel_flux_T1" from AstroImageJ outputs.

```
opts.VariableTypes = {'double','double','double','double','double','double'};
preview("BD+55_441.txt",opts)
```

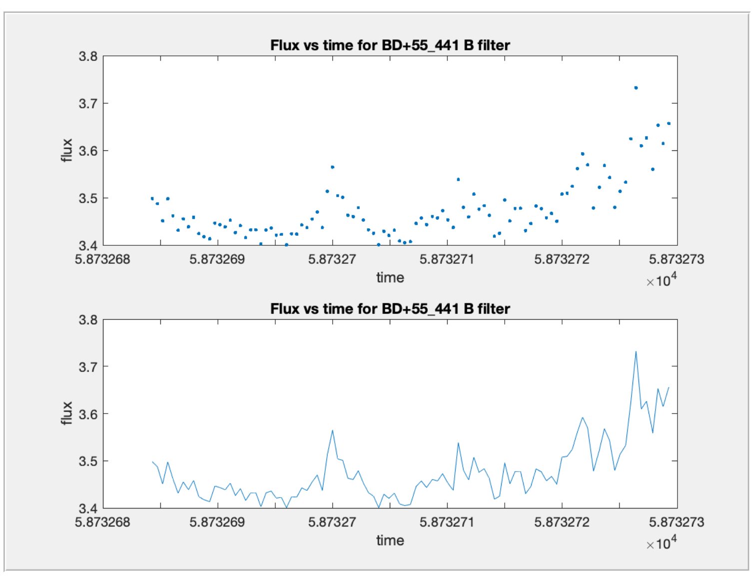
```
ans = 8×6 table
```

	B_time	B_flux	R_time	R_flux	V_time	V_flux
1	5.873268430…	3.497996000…	5.873268459…	1.961830000…	5.873268445…	2.352058000…
2	5.873268430…	3.497996000…	5.873268504…	1.942857000…	5.873268490…	2.360458000…
3	5.873268475…	3.487289000…	5.873268549…	1.947021000…	5.873268535…	2.329957000…
4	5.873268520…	3.450942000…	5.873268594…	1.930594000…	5.873268580…	2.344889000…
5	5.873268565…	3.497567000…	5.873268639…	1.942537000…	5.873268625…	2.361048000…
6	5.873268610…	3.461555000…	5.873268684…	1.935141000…	5.873268669…	2.333341000…
7	5.873268655…	3.431248000…	5.873268729…	1.931290000…	5.873268714…	2.331904000…
8	5.873268700…	3.455091000…	5.873268774…	1.928260000…	5.873268759…	2.323782000…

```
BD55_441 = readmatrix("BD+55_441.txt",opts);
whos BD55_441
```

```
  Name            Size             Bytes  Class     Attributes

  BD55_441      101x6               4848  double
```

```
hf_sub(1) = figure(1);
hp(1) = uipanel('Parent',hf_sub(1),'Position',[0 0 1 1]);
subplot(2,1,1,'Parent',hp(1));
plot(BD55_441(:,1),BD55_441(:,2),'.')
title('Flux vs time for BD+55\_441 B filter');
xlabel('time'),ylabel('flux');
subplot(2,1,2,'Parent',hp(1));
plot(BD55_441(:,1),BD55_441(:,2)),title('Flux vs time for BD+55\_441 B filter')
xlabel('time');
ylabel('flux');
```



Noting the graph above - displayed in discrete points and as a line graph - there is some periodicity. There are peaks at 58732.70, 58732.711 and 58732.722.

```
r = abs([0; BD55_441(:,1)] - [BD55_441(:,1);0]);
round(mean(r(3:end-1)),8) %average period between measurements
```

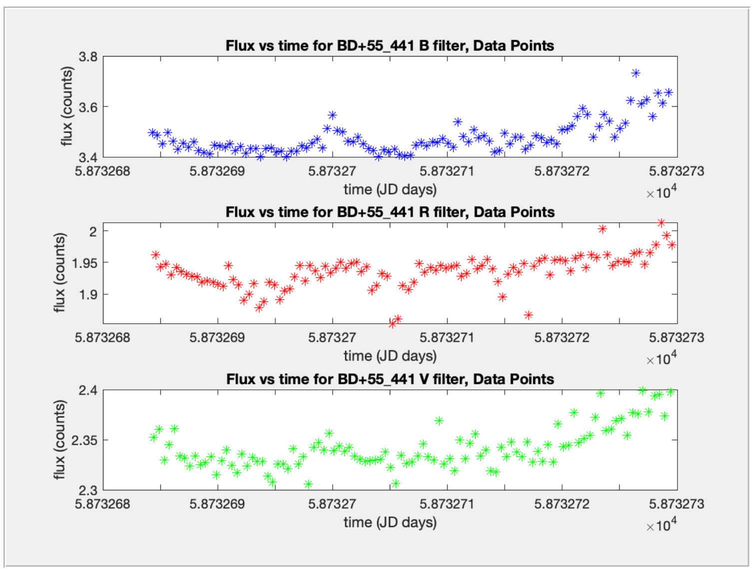
```
ans =
     4.543400000000000e-04
```

```
round(std(r(3:end-1)),8) %standard deviation - as a measurement of variation in period
```

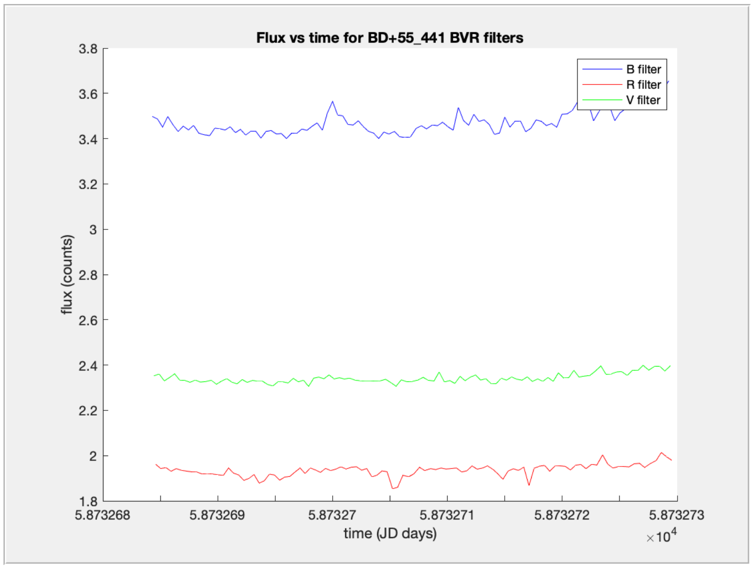
```
ans =
     1.885000000000000e-05
```

Periodicity between filters

```
hf_sub(2) = figure(2);
hp(2) = uipanel('Parent',hf_sub(2),'Position',[0 0 1 1]);
subplot(3,1,1,'Parent',hp(2));
% plotting in blue because B filter is blue light (~400-500 nm)
plot(BD55_441(:,1),BD55_441(:,2),'*b')
title('Flux vs time for BD+55\_441 B filter, Data Points');
xlabel('time (JD days)');
ylabel('flux (counts)');
subplot(3,1,2,'Parent',hp(2));
% plotting in red because R filter is red light (~550-800 nm)
plot(BD55_441(:,3),BD55_441(:,4),'*r');
title('Flux vs time for BD+55\_441 R filter, Data Points');
xlabel('time (JD days)');
ylabel('flux (counts)');
subplot(3,1,3,'Parent',hp(2));
% plotting green but V filter is visible light (~500-700 nm)
plot(BD55_441(:,5),BD55_441(:,6),'*g');
title('Flux vs time for BD+55\_441 V filter, Data Points');
xlabel('time (JD days)');
ylabel('flux (counts)');
```



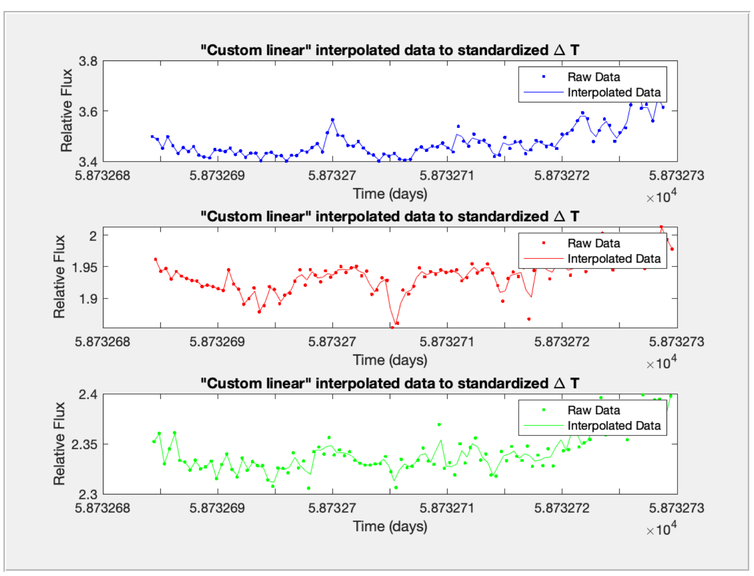

```
hf_sub(3) = figure(3);
hp(3) = uipanel('Parent',hf_sub(3),'Position',[0 0 1 1]);
subplot(1,1,1,'Parent',hp(3))
hold on
plot(BD55_441(:,1),BD55_441(:,2), 'b')
plot(BD55_441(:,3),BD55_441(:,4), 'r')
plot(BD55_441(:,5),BD55_441(:,6), 'g')
hold off
title('Flux vs time for BD+55\_441 BVR filters');
xlabel('time (JD days)');
legend('B filter', 'R filter', 'V filter');
ylabel('flux (counts)');
```



Interpolation investigation

custom linear

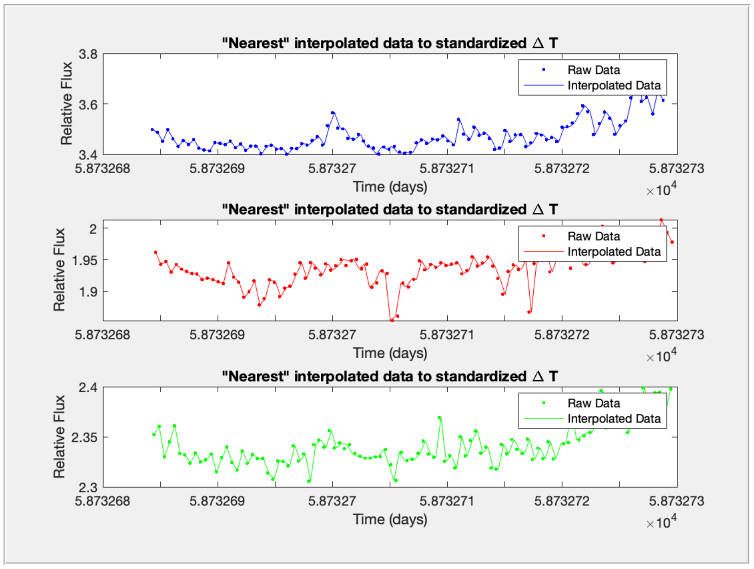
```
hf_sub(4) = figure(4);
hp(4) = uipanel('Parent',hf_sub(4),'Position',[0 0 1 1]);
subplot(3,1,1,'Parent',hp(4));
[Tnew,Mnew] = Interp_Lin(BD55_441(1:100,1),BD55_441(1:100,2));
plot(BD55_441(1:100,1),BD55_441(1:100,2),'.b',Tnew,Mnew,'b');
title('"Custom linear" interpolated data to standardized \Delta T');
legend('Raw Data','Interpolated Data');
xlabel('Time (days)');
ylabel('Relative Flux');
subplot(3,1,2,'Parent',hp(4));
[Tnew,Mnew] = Interp_Lin(BD55_441(1:100,3),BD55_441(1:100,4));
plot(BD55_441(1:100,3),BD55_441(1:100,4),'.r',Tnew,Mnew,'r');
title('"Custom linear" interpolated data to standardized \Delta T');
legend('Raw Data','Interpolated Data');
xlabel('Time (days)');
ylabel('Relative Flux');
subplot(3,1,3,'Parent',hp(4));
[Tnew,Mnew] = Interp_Lin(BD55_441(1:100,5),BD55_441(1:100,6));
plot(BD55_441(1:100,5),BD55_441(1:100,6),'.g',Tnew,Mnew,'g');
title('"Custom linear" interpolated data to standardized \Delta T');
legend('Raw Data','Interpolated Data');
xlabel('Time (days)');
ylabel('Relative Flux');
```



Nearest

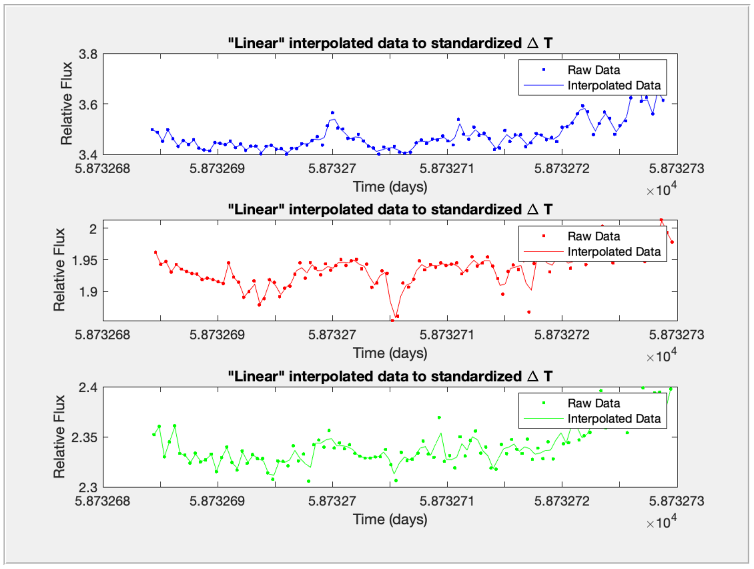
```
hf_sub(5) = figure(5);
hp(5) = uipanel('Parent',hf_sub(5),'Position',[0 0 1 1]);
```

```
subplot(3,1,1,'Parent',hp(5));
[Tnew,Mnew] = Interp_nearest(BD55_441(2:100,1),BD55_441(2:100,2));
plot(BD55_441(1:100,1),BD55_441(1:100,2),'.b',Tnew,Mnew,'b');
title('"Nearest" interpolated data to standardized \Delta T');
legend('Raw Data','Interpolated Data');
xlabel('Time (days)');
ylabel('Relative Flux');
subplot(3,1,2,'Parent',hp(5));
[Tnew,Mnew] = Interp_nearest(BD55_441(1:100,3),BD55_441(1:100,4));
plot(BD55_441(1:100,3),BD55_441(1:100,4),'.r',Tnew,Mnew,'r');
title('"Nearest" interpolated data to standardized \Delta T');
legend('Raw Data','Interpolated Data');
xlabel('Time (days)');
ylabel('Relative Flux');
subplot(3,1,3,'Parent',hp(5));
[Tnew,Mnew] = Interp_nearest(BD55_441(1:100,5),BD55_441(1:100,6));
plot(BD55_441(1:100,5),BD55_441(1:100,6),'.g',Tnew,Mnew,'g');
title('"Nearest" interpolated data to standardized \Delta T');
legend('Raw Data','Interpolated Data');
xlabel('Time (days)');
ylabel('Relative Flux');
```



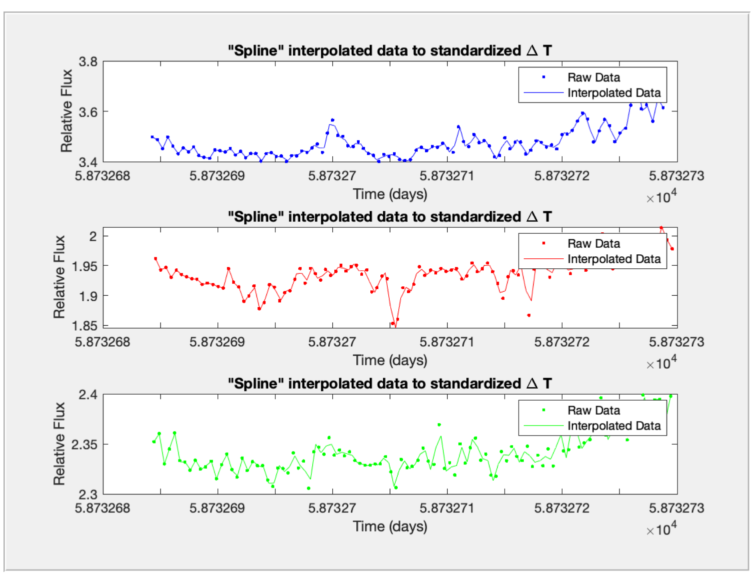
linear

```
hf_sub(6) = figure(6);
hp(6) = uipanel('Parent',hf_sub(6),'Position',[0 0 1 1]);
subplot(3,1,1,'Parent',hp(6));
[Tnew,Mnew] = Interp_linear(BD55_441(2:100,1),BD55_441(2:100,2));
plot(BD55_441(1:100,1),BD55_441(1:100,2),'.b',Tnew,Mnew,'b');
title('"Linear" interpolated data to standardized \Delta T');
legend('Raw Data','Interpolated Data');
xlabel('Time (days)');
ylabel('Relative Flux');
subplot(3,1,2,'Parent',hp(6));
[Tnew,Mnew] = Interp_linear(BD55_441(1:100,3),BD55_441(1:100,4));
plot(BD55_441(1:100,3),BD55_441(1:100,4),'.r',Tnew,Mnew,'r');
title('"Linear" interpolated data to standardized \Delta T');
legend('Raw Data','Interpolated Data');
xlabel('Time (days)');
ylabel('Relative Flux');
subplot(3,1,3,'Parent',hp(6));
[Tnew,Mnew] = Interp_linear(BD55_441(1:100,5),BD55_441(1:100,6));
plot(BD55_441(1:100,5),BD55_441(1:100,6),'.g',Tnew,Mnew,'g');
title('"Linear" interpolated data to standardized \Delta T');
legend('Raw Data','Interpolated Data');
xlabel('Time (days)');
ylabel('Relative Flux');
```



spline

```
hf_sub(7) = figure(7);
hp(7) = uipanel('Parent',hf_sub(7),'Position',[0 0 1 1]);
subplot(3,1,1,'Parent',hp(7));
[Tnew,Mnew] = Interp_spline(BD55_441(2:100,1),BD55_441(2:100,2));
plot(BD55_441(1:100,1),BD55_441(1:100,2),'.b',Tnew,Mnew,'b');
title('"Spline" interpolated data to standardized \Delta T');
legend('Raw Data','Interpolated Data');
xlabel('Time (days)');
ylabel('Relative Flux');
subplot(3,1,2,'Parent',hp(7));
[Tnew,Mnew] = Interp_spline(BD55_441(1:100,3),BD55_441(1:100,4));
plot(BD55_441(1:100,3),BD55_441(1:100,4),'.r',Tnew,Mnew,'r');
title('"Spline" interpolated data to standardized \Delta T');
legend('Raw Data','Interpolated Data');
xlabel('Time (days)');
ylabel('Relative Flux');
subplot(3,1,3,'Parent',hp(7));
[Tnew,Mnew] = Interp_spline(BD55_441(1:100,5),BD55_441(1:100,6));
plot(BD55_441(1:100,5),BD55_441(1:100,6),'.g',Tnew,Mnew,'g');
title('"Spline" interpolated data to standardized \Delta T');
legend('Raw Data','Interpolated Data');
xlabel('Time (days)');
ylabel('Relative Flux');
```



polyfit - needs to be conditioned appropriately.

```
hf_sub(8) = figure(8);
hp(8) = uipanel('Parent',hf_sub(8),'Position',[0 0 1 1]);
```

```
subplot(3,1,1,'Parent',hp(8));
[Tnew,Mnew] = Interp_polyfit(BD55_441(2:100,1),BD55_441(2:100,2));
```

```
Warning: Polynomial is badly conditioned. Add points with distinct X values, reduce the degree of the polynomial, or try centering and scalin
HELP POLYFIT.
```

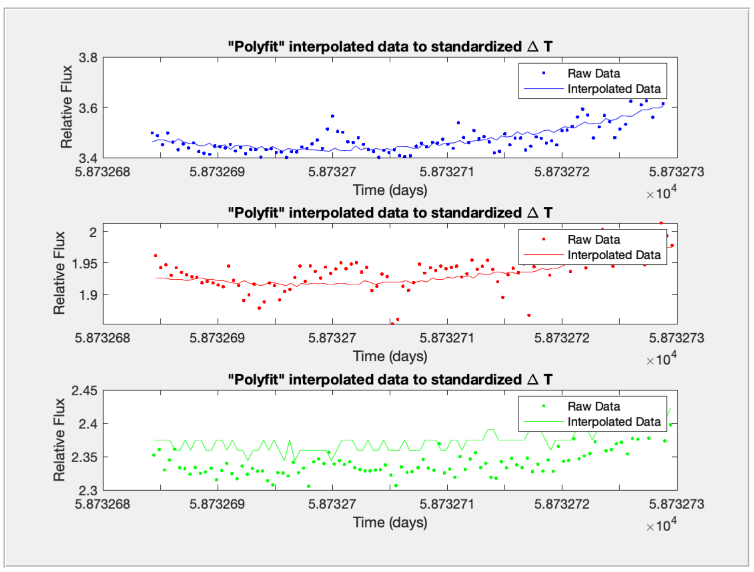
```
plot(BD55_441(1:100,1),BD55_441(1:100,2),'.b',Tnew,Mnew,'b');
title('"Polyfit" interpolated data to standardized \Delta T');
legend('Raw Data','Interpolated Data');
xlabel('Time (days)');
ylabel('Relative Flux');
subplot(3,1,2,'Parent',hp(8));
[Tnew,Mnew] = Interp_polyfit(BD55_441(1:100,3),BD55_441(1:100,4));
```

```
Warning: Polynomial is badly conditioned. Add points with distinct X values, reduce the degree of the polynomial, or try centering and scalin
HELP POLYFIT.
```

```
plot(BD55_441(1:100,3),BD55_441(1:100,4),'.r',Tnew,Mnew,'r');
title('"Polyfit" interpolated data to standardized \Delta T');
legend('Raw Data','Interpolated Data');
xlabel('Time (days)');
ylabel('Relative Flux');
subplot(3,1,3,'Parent',hp(8));
[Tnew,Mnew] = Interp_polyfit(BD55_441(1:100,5),BD55_441(1:100,6));
```

```
Warning: Polynomial is badly conditioned. Add points with distinct X values, reduce the degree of the polynomial, or try centering and scalin
HELP POLYFIT.
```

```
plot(BD55_441(1:100,5),BD55_441(1:100,6),'.g',Tnew,Mnew,'g');
title('"Polyfit" interpolated data to standardized \Delta T');
legend('Raw Data','Interpolated Data');
xlabel('Time (days)');
ylabel('Relative Flux');
```



Input all data

Text files:

```
%BD+48_1098
opts = detectImportOptions("BD+48_1098.txt");
opts.DataLines = 3;
opts.VariableNames = {'B_time','B_flux','R_time','R_flux','V_time','V_flux'};
opts.VariableTypes = {'double','double','double','double','double','double'};
BD48_1098 = rmmissing(readmatrix("BD+55_441.txt",opts)); %the matrix data of the text file
%preview("BD+48_1098.txt",opts)
whos BD48_1098
```

```
  Name             Size            Bytes  Class     Attributes

  BD48_1098      100x6              4800  double
```

```
%HD28497
opts = detectImportOptions("HD28497.txt");
opts.DataLines = 3;
opts.VariableNames = {'B_time','B_flux','R_time','R_flux','V_time','V_flux'};
opts.VariableTypes = {'double','double','double','double','double','double'};
```

```
HD28497 = rmmissing(readmatrix("HD28497.txt",opts)) %the matrix data of the text file
```

```
HD28497 = 600×6

10^4 ×
   5.844163256000000   0.151884039400000   5.844163279000000   0.047485834000000   5.844163267000000   0.069815062400000
   5.844163294000000   0.157713255000000   5.844163317000000   0.047850097100000   5.844163304999999   0.065578599100000
   5.844163332000000   0.147648080800000   5.844163355000000   0.050717498800000   5.844163344000000   0.074395448000000
   5.844163370000000   0.154105058200000   5.844163393000001   0.048745268800000   5.844163382000001   0.071764534300000
   5.844163409000000   0.154416998300000   5.844163431999999   0.046480291500000   5.844163420000000   0.070814725000000
   5.844163447000000   0.154034530100000   5.844163470000000   0.052878906200000   5.844163458000000   0.077323090500000
   5.844163485000000   0.158524561400000   5.844163508000000   0.050080829500000   5.844163497000000   0.071339644400000
   5.844163523000000   0.159731365000000   5.844163546000000   0.053844298900000   5.844163535000000   0.072074042600000
   5.844163560999999   0.140623476800000   5.844163584000000   0.050871022200000   5.844163573000000   0.070981291000000
   5.844163599000000   0.159835953000000   5.844163622000000   0.053311599500000   5.844163610000001   0.074646573400000
```

```
%preview("HD28497.txt",opts)
whos HD28497
```

```
  Name           Size             Bytes  Class     Attributes

  HD28497      600x6              28800  double
```

```
%HD46131
opts = detectImportOptions("HD46131.txt");
opts.DataLines = 3;
opts.VariableNames = {'B_time','B_flux','R_time','R_flux','V_time','V_flux'};
opts.VariableTypes = {'double','double','double','double','double','double'};
HD46131 = rmmissing(readmatrix("HD46131.txt",opts)); %the matrix data of the text file
%preview("HD46131.txt",opts)
whos HD46131
```

```
  Name           Size             Bytes  Class     Attributes

  HD46131      250x6              12000  double
```

```
%HD88661
opts = detectImportOptions("HD88661.txt");
opts.DataLines = 3;
opts.VariableNames = {'B_time','B_flux','R_time','R_flux','V_time','V_flux'};
opts.VariableTypes = {'double','double','double','double','double','double'};
HD88661 = rmmissing(readmatrix("HD88661.txt",opts)); %the matrix data of the text file
%preview("HD88661.txt",opts)
whos HD88661
```

```
  Name          Size             Bytes  Class     Attributes

  HD88661      35x6               1680  double
```

```
%HD105521
opts = detectImportOptions("HD105521.txt");
opts.DataLines = 3;
opts.VariableNames = {'B_time','B_flux','R_time','R_flux','V_time','V_flux'};
opts.VariableTypes = {'double','double','double','double','double','double'};
HD105521 = rmmissing(readmatrix("HD105521.txt",opts)); %the matrix data of the text file
%preview("HD105521.txt",opts)
whos HD105521
```

```
  Name            Size             Bytes  Class     Attributes

  HD105521      180x6               8640  double
```


```
%HD105521
opts = detectImportOptions("HD105521.txt");
opts.DataLines = 3;
opts.VariableNames = {'B_time','B_flux','R_time','R_flux','V_time','V_flux'};
opts.VariableTypes = {'double','double','double','double','double','double'};
HD105521 = rmmissing(readmatrix("HD105521.txt",opts)); %the matrix data of the text file
%preview("HD105521.txt",opts)
whos HD105521
```

```
  Name            Size             Bytes  Class     Attributes

  HD105521      180x6               8640  double
```


CSV files

```
%HD106306
%B_filter
opts = detectImportOptions('HD106306_B.csv');
opts.DataLines = [2 Inf];
All_fields_available = opts.VariableNames;
```

```
opts.SelectedVariableNames = {'J_D__2400000','rel_flux_T1'};
%preview("HD106306_B.csv",opts)
HD106306_B = readmatrix("HD106306_B.csv",opts);

%R_filter
opts = detectImportOptions('HD106306_R.csv');
opts.DataLines = [2 Inf];
All_fields_available = opts.VariableNames;
opts.SelectedVariableNames = {'J_D__2400000','rel_flux_T1'};
%preview("HD106306_R.csv",opts)
HD106306_R = readmatrix("HD106306_R.csv",opts);

%V_filter
opts = detectImportOptions('HD106306_V.csv');
opts.DataLines = [2 Inf];
All_fields_available = opts.VariableNames;
opts.SelectedVariableNames = {'J_D__2400000','rel_flux_T1'};
%preview("HD106306_V.csv",opts)
HD106306_V = readmatrix("HD106306_V.csv",opts);

HD106306 = rmmissing([HD106306_B HD106306_R HD106306_V]); %the matrix data of the text file
whos HD106306
```

```
  Name             Size              Bytes  Class     Attributes

  HD106306      100x6               4800  double
```

```
%HD147302
%B_filter
opts = detectImportOptions('HD147302_B.csv');
opts.DataLines = [2 Inf];
All_fields_available = opts.VariableNames;
opts.SelectedVariableNames = {'J_D__2400000','rel_flux_T1'};
%preview("HD147302_B.csv",opts)
HD147302_B = readmatrix("HD147302_B.csv",opts);

%R_filter
opts = detectImportOptions('HD147302_R.csv');
opts.DataLines = [2 Inf];
All_fields_available = opts.VariableNames;
opts.SelectedVariableNames = {'J_D__2400000','rel_flux_T1'};
%preview("HD147302_R.csv",opts)
HD147302_R = readmatrix("HD147302_R.csv",opts);

%V_filter
opts = detectImportOptions('HD147302_V.csv');
opts.DataLines = [2 Inf];
All_fields_available = opts.VariableNames;
opts.SelectedVariableNames = {'J_D__2400000','rel_flux_T1'};
%preview("HD147302_V.csv",opts)
HD147302_V = readmatrix("HD147302_V.csv",opts);

HD147302 = rmmissing([HD147302_B HD147302_R HD147302_V]); %the matrix data of the text file
whos HD147302
```

```
  Name             Size              Bytes  Class     Attributes

  HD147302      100x6               4800  double
```

HD152060 and HD209522 can't be described in the same form as the others. Will investigate

```
close all   %closes all previous figures from milestone 1 so that the plots in milestone 2 and 3 work correctly
```

Milestone 2 (13 October)

https://www.mathworks.com/help/matlab/ref/fft.html?searchHighlight=fft&s_tid=srchtitle

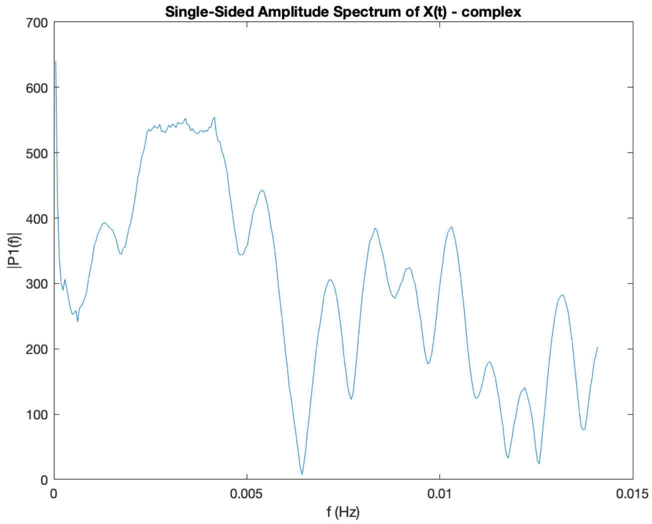
This is the source for implementing Fourier Transform for a Noisy Signal from the MathWorks documentation

Using fft for HD28497

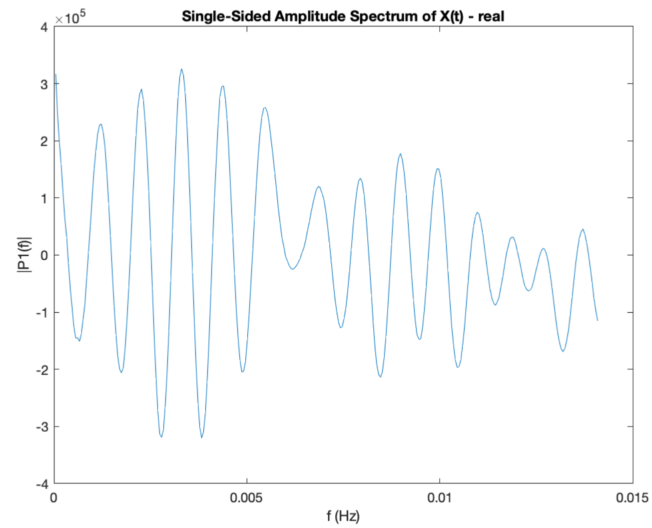
This star had the most data which made it ideal for performing a fourier transform. We chose linear interpolation for the purposes of this experiment at random. This is a feature to be explored later.

```
[Tnew,Mnew] = Interp_linear(HD28497(2:end,1),HD28497(2:end,2));
Tnew = Tnew*86400; %convert time from days to seconds
deltaT = Tnew(2)-Tnew(1);
Fs = 1/deltaT;            % Sampling frequency
T = deltaT;              % Sampling period
t = Tnew;                 % Time vector
L = numel(Tnew);          % Length of signal
X = Mnew;                %signal with noise
%Fourier transformation
```

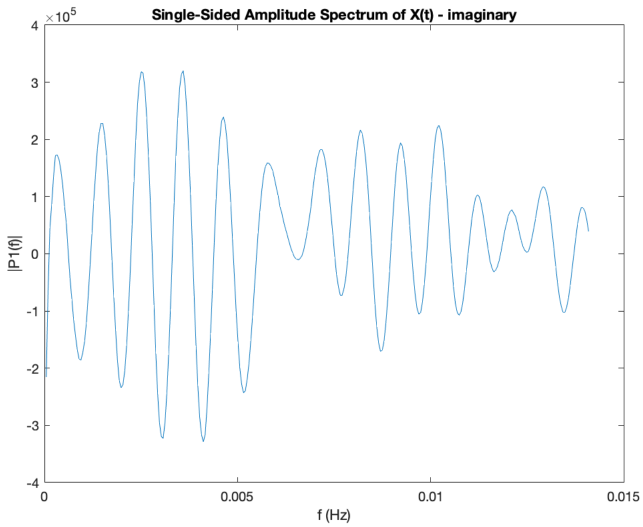
```
Y = fft(X);
P2complex = abs(Y/L); %real and imaginary parts together
P2real = real(Y);
P2imaginary = imag(Y);
P1complex = P2complex(1:floor(L/2)+1);
P1complex(2:end-1) = 2*P1complex(2:end-1);

%Plot

f = Fs*(0:(L/2))/L;
plot(f(2:end-1),P1complex(2:end-1))
title('Single-Sided Amplitude Spectrum of X(t) - complex')
xlabel('f (Hz)')
ylabel('|P1(f)|')
```




```
P1real = P2real(1:floor(L/2)+1);
P1real(2:end-1) = 2*P1real(2:end-1);
%plotting piece
f = Fs*(0:(L/2))/L;
plot(f(2:end-1),P1real(2:end-1))
title('Single-Sided Amplitude Spectrum of X(t) - real')
xlabel('f (Hz)')
ylabel('|P1(f)|')
```



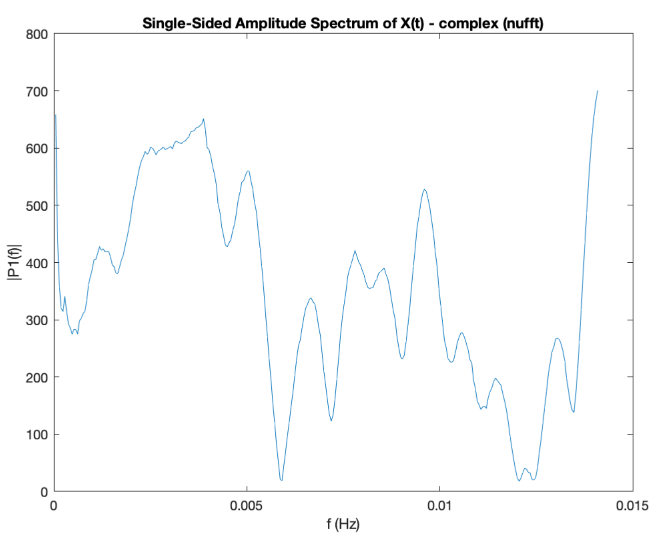

```
P1imaginary = P2imaginary(1:floor(L/2)+1);
P1imaginary(2:end-1) = 2*P1imaginary(2:end-1);
%plotting piece
f = Fs*(0:(L/2))/L;
plot(f(2:end-1),P1imaginary(2:end-1))
title('Single-Sided Amplitude Spectrum of X(t) - imaginary')
xlabel('f (Hz)')
ylabel('|P1(f)|')
```



Using NUFFT - used the data without interpolation

Results for this one star using the complex combination was very similar to fft.

```
Tnew = HD28497(2:end,1);
Mnew = HD28497(2:end,2);
Tnew = Tnew*86400;
% --Find averaged time scale--
n = numel(Tnew);
sum = 0;
for l = 1:n-1
    sum = sum + abs(Tnew(l+1) - Tnew(l));
end
deltaT = sum / (n-1); %average time between points
Fs = 1/deltaT;            % Sampling frequency
T = deltaT;              % Sampling period
t = Tnew;                 % Time vector
L = numel(Tnew);          % Length of signal
X = Mnew;                %signal with noise
%Fourier transformation
Y = nufft(X);
P2complex = abs(Y/L); %combination of real and imaginary
P2real = real(Y);
P2imaginary = imag(Y);
P1complex = P2complex(1:floor(L/2)+1);
P1complex(2:end-1) = 2*P1complex(2:end-1);
%plotting piece
f = Fs*(0:(L/2))/L;
plot(f(2:end-1),P1complex(2:end-1))
title('Single-Sided Amplitude Spectrum of X(t) - complex (nufft)')
xlabel('f (Hz)')
ylabel('|P1(f)|')
```



The investigation of the inverse fourier transform will be explored at a later date to complete milestone 2.

Milestone 3 (including previously unfinished parts of milestone 2)

Getting the Power Spectrum for HD28497

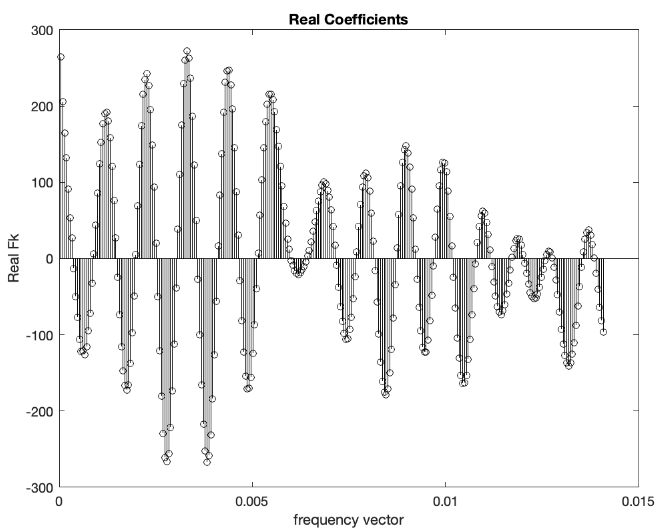
This star had the most data which made it ideal for performing a fourier transform. We chose linear interpolation for the purposes of this experiment at random. This is a feature to be explored late

Documentation: We used a combination of the following sources to develop this:

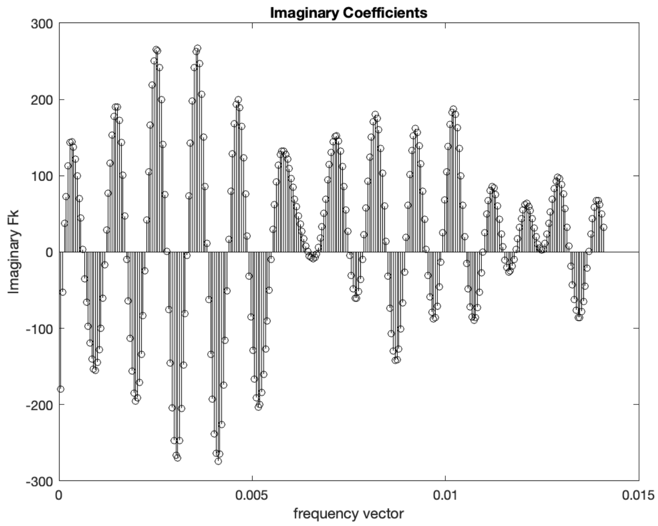
1. https://www.mathworks.com/help/matlab/ref/fft.html?searchHighlight=fft&s_tid=srchtitle (This is the source for implementing Fourier Transform for a Noisy Signal from the MathWorks documentation)
2. Gilat, Example 7-6 (pg. 281)
3. Gilat, Example 7-8 (pg 287)

Bd+55_441 and HD 28497 have documented periodicity - citation pending

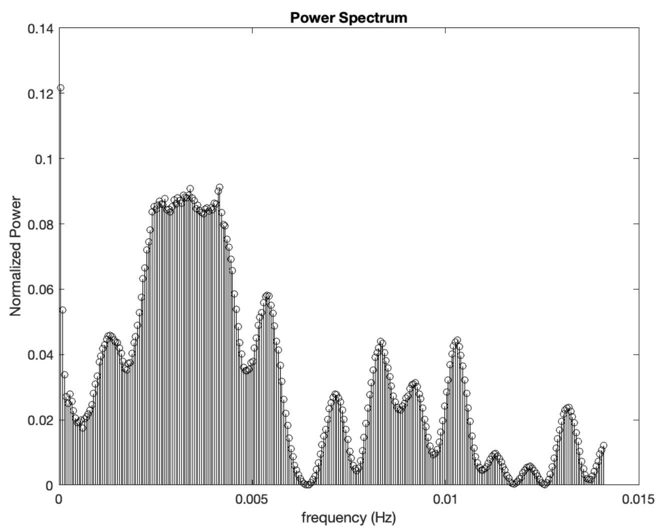
```
[Tnew,Mnew] = Interp_linear(HD28497(2:end,1),HD28497(2:end,2));
Tnew = Tnew*86400; %convert time from days to seconds
deltaT = Tnew(2)-Tnew(1);
Fs = 1/deltaT;            % Sampling frequency
T = deltaT;              % Sampling period
t = Tnew-Tnew(1);                 % Time vector
L = numel(Tnew);          % Length of signal
X = Mnew ;               %signal with noise



%Fourier transformation    %Based on Ex 7-6 Gilat
F = fft(X)/L  ;            %fourier transform devided by number of data points
power = F.*conj(F)/L;
powernorm = power/max(power);   %normalized power spectrum
fk = (0:L-1)*(Fs/L);      %frequency vector Gilat 7-6
stem(fk(2:floor(L/2)),real(F(2:floor(L/2))), 'ko','markersize',5)             %Threw out first number of F because seemingly s
xlabel('frequency vector')
ylabel('Real Fk')
title('Real Coefficients')
```



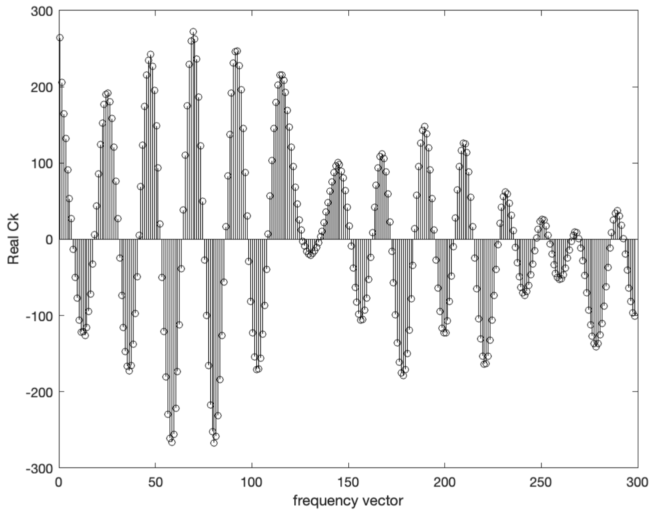

```
figure, stem(fk(2:floor(L/2)),imag(F(2:floor(L/2))),'ko','markersize',5)
xlabel('frequency vector')
ylabel('Imaginary Fk')
title('Imaginary Coefficients')
```



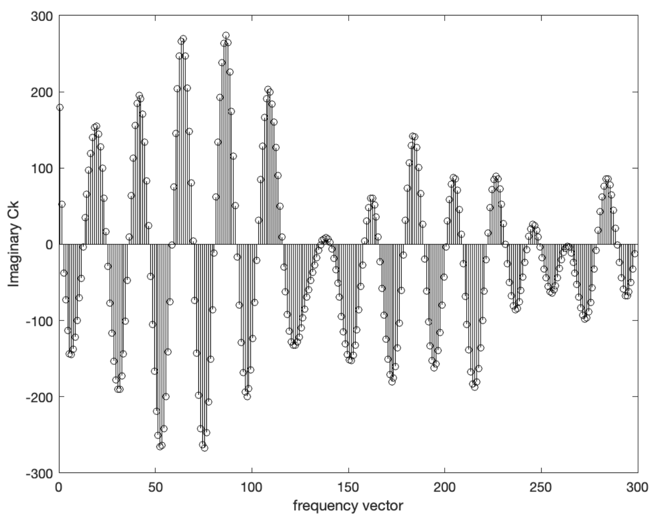

```
figure, stem(fk(2:floor(L/2)),powernorm(2:floor(L/2)),'ko','markersize',5)
xlabel('frequency (Hz)')
ylabel('Normalized Power')
title('Power Spectrum')
```



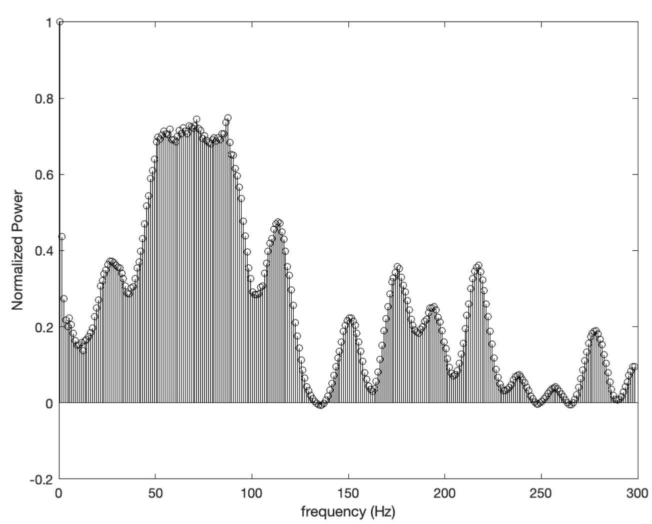

```
%Rearrange the spectrum using fftshift
C0 = fftshift(F(2:L));              %zero frequency in center (threw out first number of F as an outlier)
power0 = C0.*conj(C0)/L-1;
powernorm0 = power0/max(power0);   %normalized power spectrum
fk0 = (-L/2+1:L/2-1)*(Fs/L-1);      %frequency vector Gilat 7-6
stem(fk0(1:floor(L/2)),real(C0(1:floor(L/2))), 'ko','markersize',5)
xlabel('frequency vector')
ylabel('Real Ck')
```




```
figure, stem(fk0(1:floor(L/2)),imag(C0(1:floor(L/2))),'ko','markersize',5)
xlabel('frequency vector')
ylabel('Imaginary Ck')
```

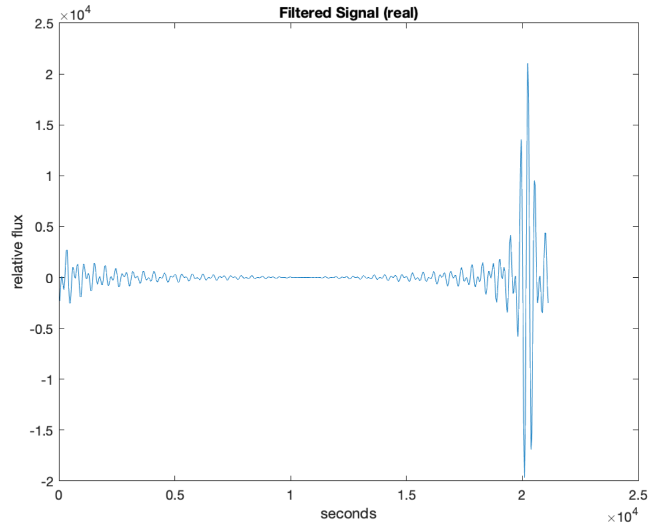



```
figure, stem(fk0(1:floor(L/2)),powernorm0(1:floor(L/2)),'ko','markersize',5)
xlabel('frequency (Hz)')
ylabel('Normalized Power')
```

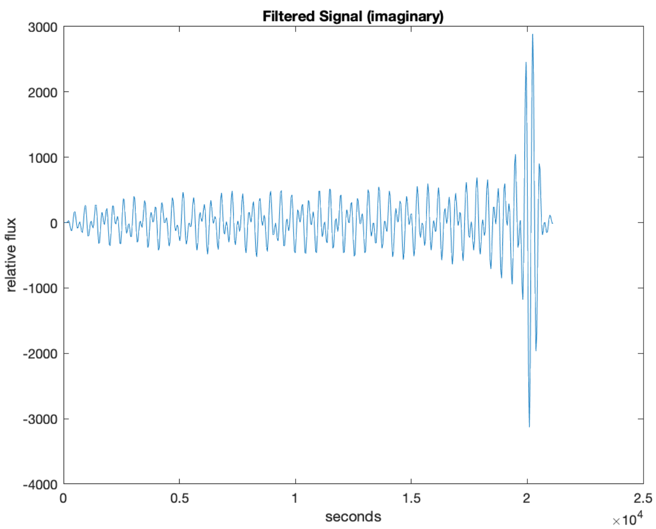



```
%Filtering out the noise            Based on Gilat Example 7-8
```

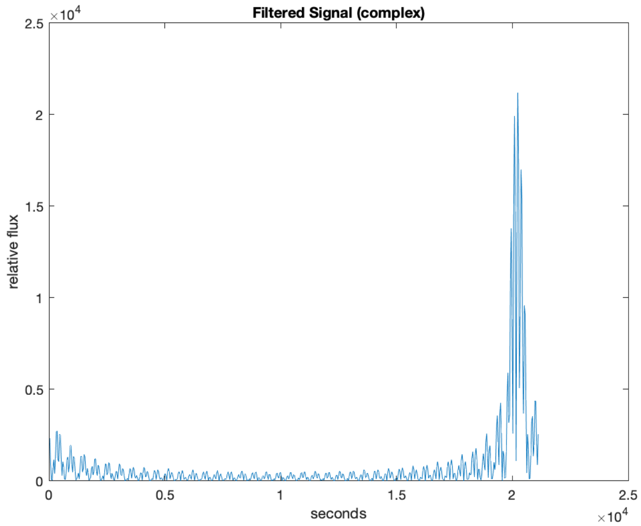
```
for k = 1:L-1
    if abs(fk0(k)) <= 50 || abs(fk0(k)) >= 90
        C0flter(k) = 0+0i;

    else
        C0flter(k) = C0(k);
    end
end


F0i = ifftshift(C0flter) * L-1;
finv = ifft(F0i);
figure, plot(t(2:L),real(finv))
title('Filtered Signal (real)')
xlabel('seconds')
ylabel('relative flux')
```



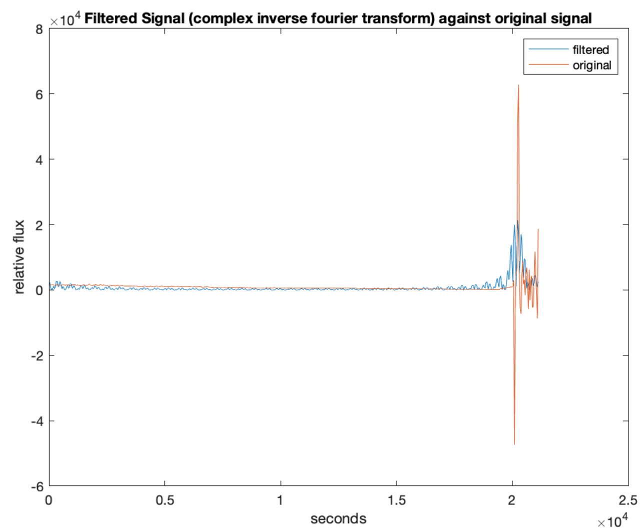

```
F0i = ifftshift(C0flter) * L-1;
finv = ifft(F0i);
figure, plot(t(2:L),imag(finv))
title('Filtered Signal (imaginary)')
xlabel('seconds')
ylabel('relative flux')
```



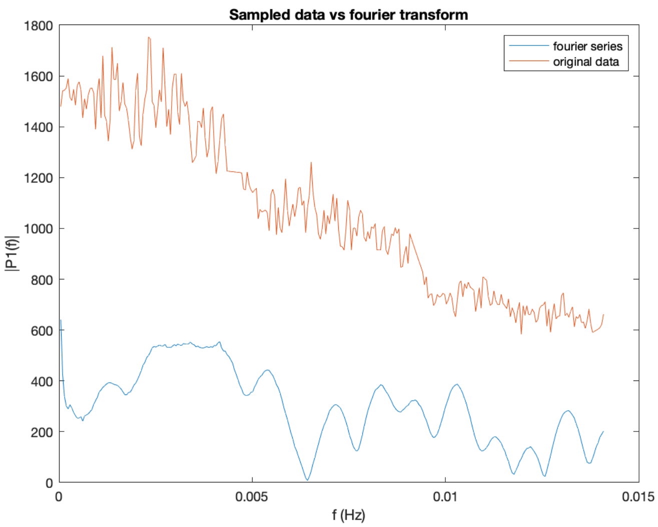

```
F0i = ifftshift(C0flter) * L-1;
finv = ifft(F0i);
figure, plot(t(2:L),abs(finv))
title('Filtered Signal (complex)')
xlabel('seconds')
ylabel('relative flux')
```




```
F0i = ifftshift(C0flter) * L-1;
finv = ifft(F0i);
figure, plot(t(2:L),abs(finv),t(2:L),X(2:L))
legend('filtered','original')
title('Filtered Signal (complex inverse fourier transform) against original signal')
xlabel('seconds')
ylabel('relative flux')
```




```
F =1./t(2:L);

%Fourier transformation
Y = fft(X);
P2complex = abs(Y/L); %real and imaginary parts together
P2real = real(Y);
P2imaginary = imag(Y);
P1complex = P2complex(1:floor(L/2)+1);
P1complex(2:end-1) = 2*P1complex(2:end-1);

%Plot

f = Fs*(0:(L/2))/L;
plot(f(2:end-1),P1complex(2:end-1),f(2:end-1),X(2:floor(l/2)))
title('Sampled data vs fourier transform')
xlabel('f (Hz)')
ylabel('|P1(f)|')
legend('fourier series','original data')
```



Important Interpolation Functions

There are two different linear interpolation functions - the first is without built-in functions and the other is built-in. The results from both funcitons are similar.

Other interpolation methods are displayed.

Custom functions

```
function [Tnew,Mnew] = Interp_Lin(T,M)
%This is Joe's custom linear interpolation:
%----

% --Sum all of the time differences between measurements--
n = numel(T);
sum = 0;
for l = 1:n-1
    sum = sum + abs(T(l+1) - T(l));
end

% --Find averaged time scale--
avg_dT = sum / (n-1);
Tnew = T(1):avg_dT:T(n);

% --Calculate Mnew values--
m = numel(Tnew);
Mnew = zeros(1,m);

Mnew(1) = M(1);
Mnew(m) = M(n);

for l = 2:m-1
    for k = 1:n
        if T(k) <= Tnew(l)
            if Tnew(l) <= T(k+1)
                Mnew(l) = (M(k+1) - M(k))./(T(k+1) - T(k)).*(Tnew(l)-T(k)) + M(k);
                %eq for a line. i.e. y = mx + b
            end
        end
    end
end

end
```

Various built-in Matlab Functions

```
function [Tnew,Mnew] = Interp_nearest(T,M)
%This uses the built-in function 'interp1' with method 'nearest'
%----

% --Sum all of the time differences between measurements--
n = numel(T);
sum = 0;
for l = 1:n-1
    sum = sum + abs(T(l+1) - T(l));
end

% --Find averaged time scale--
avg_dT = sum / (n-1);
```

```
Tnew = T(1):avg_dT:T(n);

% --Calculate Mnew values--
Mnew = interp1(T,M,Tnew,'nearest');
end
```

```
function [Tnew,Mnew] = Interp_linear(T,M)
%This uses the built-in function 'interp1' with method 'linear'
%----

% --Sum all of the time differences between measurements--
n = numel(T);
sum = 0;
for l = 1:n-1
    sum = sum + abs(T(l+1) - T(l));
end

% --Find averaged time scale--
avg_dT = sum / (n-1);
Tnew = T(1):avg_dT:T(n);

%--Calculate Mnew values--
Mnew = interp1(T,M,Tnew,'linear');
end
```

```
function [Tnew,Mnew] = Interp_spline(T,M)
%This uses the built-in function 'interp1' with method 'spline'
%----

% --Sum all of the time differences between measurements--
n = numel(T);
sum = 0;
for l = 1:n-1
    sum = sum + abs(T(l+1) - T(l));
end

% --Find averaged time scale--
avg_dT = sum / (n-1);
Tnew = T(1):avg_dT:T(n);

% --Calculate Mnew values--
Mnew = interp1(T,M,Tnew,'spline');
end
```

```
function [Tnew,Mnew] = Interp_polyfit(T,M)
%This uses the built-in function 'interp1' with method 'polyfit'
%----

% --Sum all of the time differences between measurements--
n = numel(T);
sum = 0;
for l = 1:n-1
    sum = sum + abs(T(l+1) - T(l));
end

% --Find averaged time scale--
avg_dT = sum / (n-1);
Tnew = T(1):avg_dT:T(n);

% --Calculate Mnew values--
n = numel(T);
p = polyfit(T,M,5);
Mnew = polyval(p,Tnew);
end
```