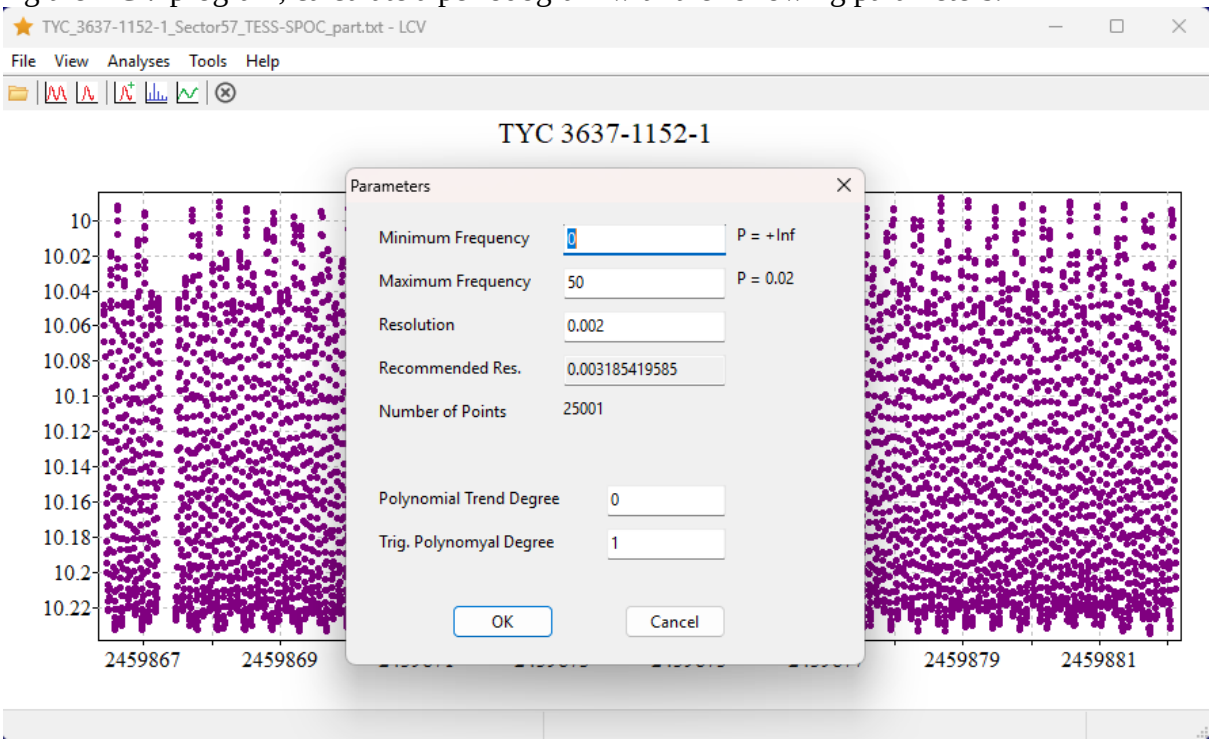
Multi-periodic star: an example of finding and refining periods

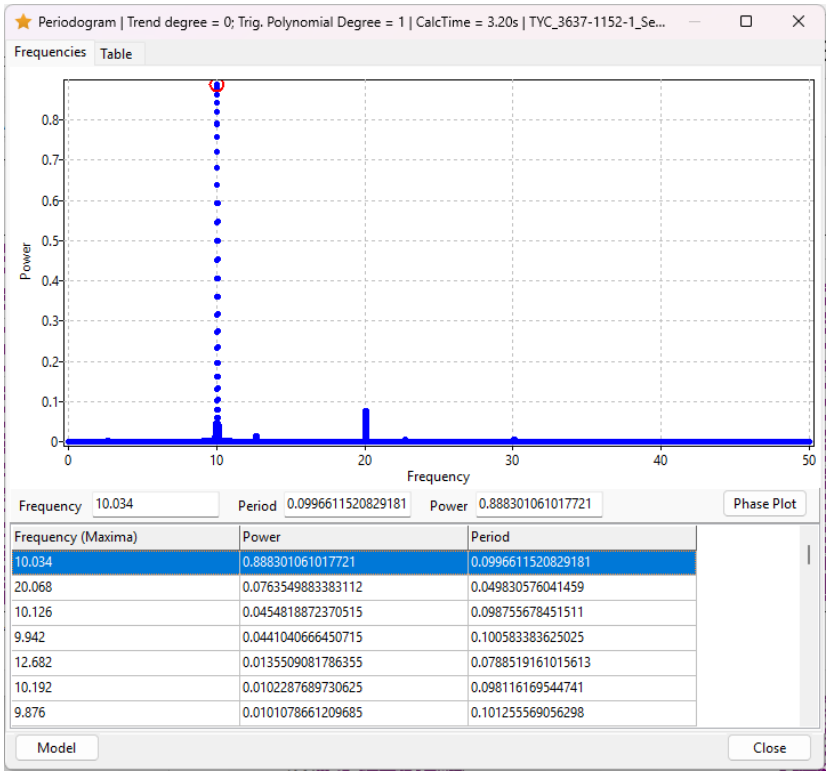
TYC 3637-1152-1 is a high-amplitude delta Scuti star with multiple periods (2019NewA...68...39P). Let's find its periods using TESS data and refine them.
Use the "TYC_3637-1152-1_Sector57_TESS-SPOC_part.txt" file from the 'data' folder.

To obtain preliminary period estimates, we will use the **LCV** program (https://github.com/mpyat2/LightCurveViewer).
Then we will refine the values of the periods with **V*-fit**.

Using the **LCV** program, calculate a periodogram with the following parameters:

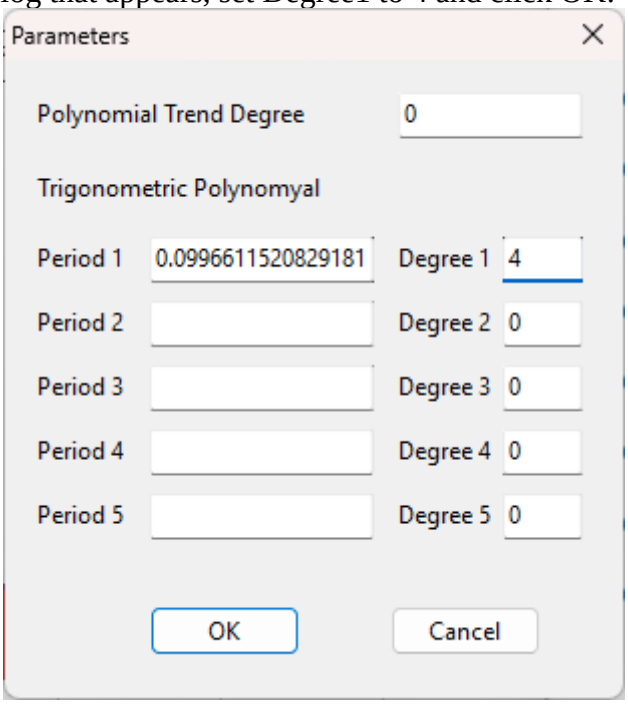


The periodogram displays a prominent peak at a period of 0.09966 days. The second harmonic is also visible at P=0.04983 days, and upon zooming in, the third and fourth harmonics become apparent.

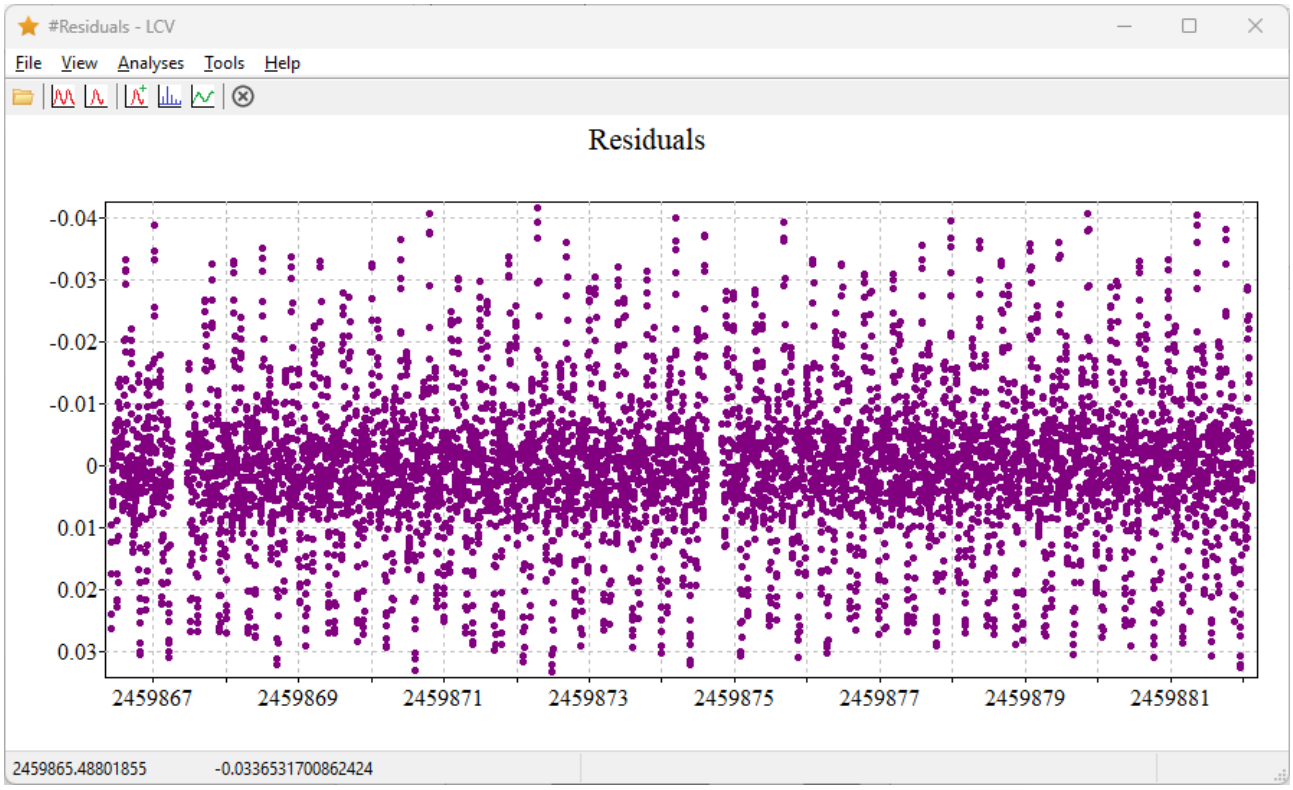


Frequency (Maxima)	Power	Period
10.034	0.888301061017721	0.0996611520829181
20.068	0.0763549883383112	0.049830576041459
10.126	0.0454818872370515	0.098755678451511
9.942	0.0441040666450715	0.100583383625025
12.682	0.0135509081786355	0.0788519161015613
10.192	0.0102287689730625	0.098116169544741
9.876	0.0101078661209685	0.101255569056298

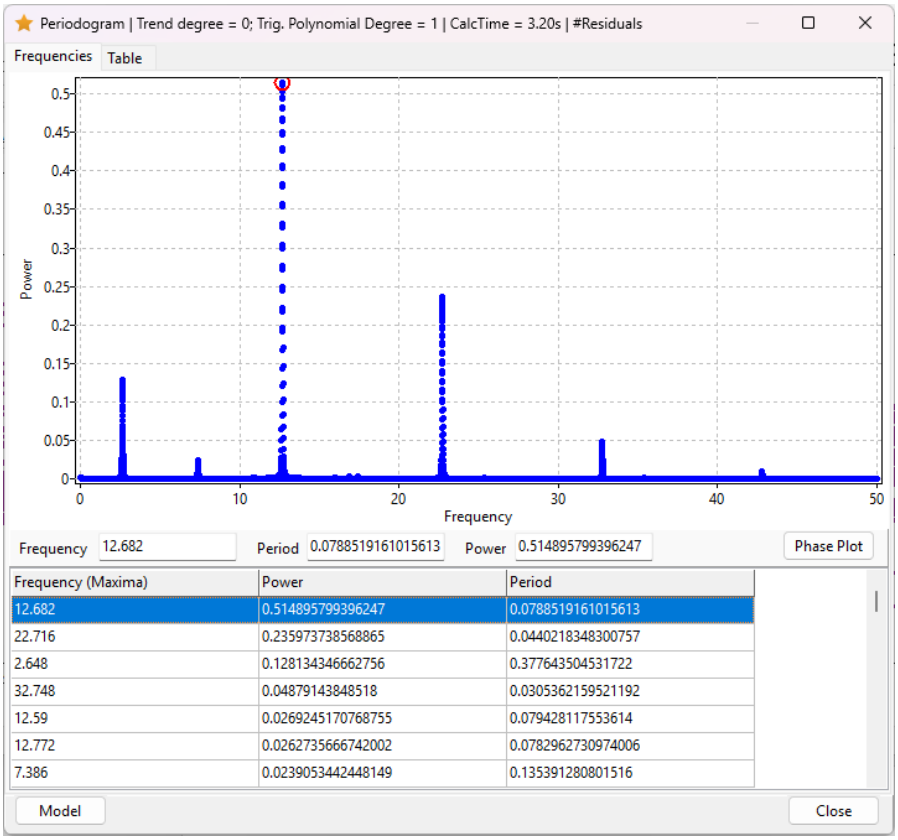
Let’s create a model. Select the most prominent period in the table (the first entry), then click the ‘Model’ button. In the dialog that appears, set Degree1 to 4 and click OK:



Now, select Analyses → Detrend from the menu. The residual light curve will then be displayed:



Rebuild the periodogram using the same parameters as before. You should now observe another prominent peak at a period of 0.07885 days.

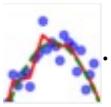


Create a model using this period with Degree1 set to 1, then recalculate the residuals.

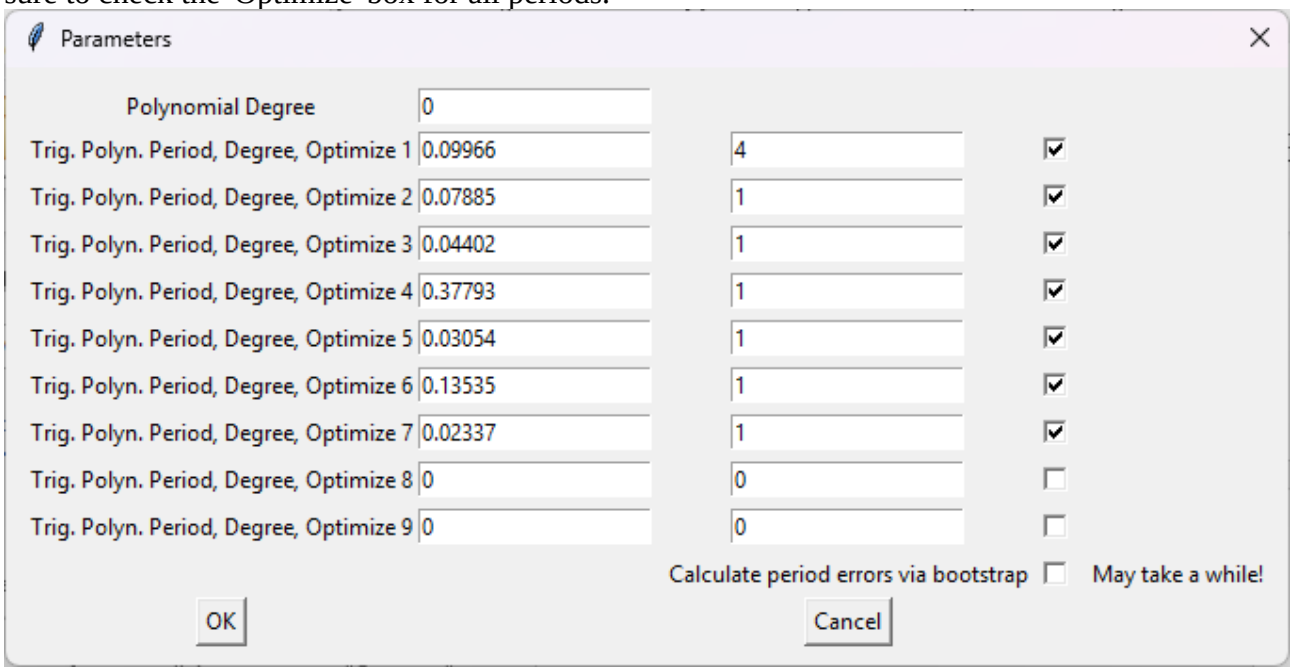
By repeating these steps several times, additional periods can be identified. The table below lists the first seven periods along with their corresponding frequencies:

N	Period	Frequency	Comment
1	0.09966	10.0341	
2	0.07885	12.6823	
3	0.04402	22.7160	f1+f2
4	0.37793	2.6460	f1-f2
5	0.03054	32.7439	2*f1+f2
6	0.13535	7.3883	2*f1-f2
7	0.02337	42.7899	3*f1+f2

To refine these periods, run the **V*-fit** program and open the file named “TYC_3637-1152-1_Sector57_TESS-SPOC_part.txt”.

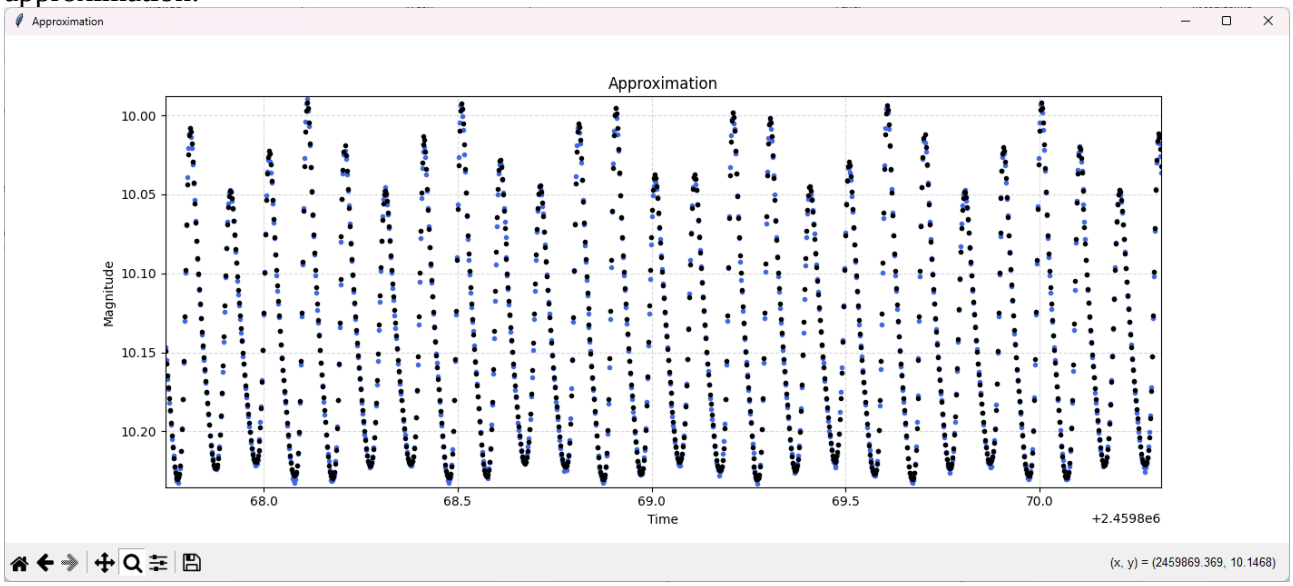
Then, click the Polynomial Fit button  .

Enter the periods, setting the degree to 4 for the first one and to 1 for each of the others. Also, make sure to check the 'Optimize' box for all periods.



Then click OK.

Within a few seconds, a plot showing the approximation will appear. Below is a zoomed-in section of the plot, where blue dots represent the original data and black dots indicate the model approximation:



In the Log window, you will find the refined periods, their estimated errors, and additional useful information, including the polynomial coefficients and their associated uncertainties.
The table below presents the initial period values, the refined period values, and their associated errors.

N	Period	Frequency	Comment	**Improved period**	**Error**
1	0.09966	10.0341		**0.09966148**	**0.00000012**
2	0.07885	12.6823		**0.07885759**	**0.00000074**
3	0.04402	22.7160	f1+f2	**0.04402356**	**0.00000034**
4	0.37793	2.6460	f1-f2	**0.377798**	**0.000034**
5	0.03054	32.7439	2*f1+f2	**0.03053551**	**0.00000036**
6	0.13535	7.3883	2*f1-f2	**0.135369**	**0.000010**
7	0.02337	42.7899	3*f1+f2	**0.02337424**	**0.00000049**

Note that only the first and second periods are independent. The remaining periods correspond to linear combinations of these fundamental frequencies and should therefore not be optimized independently. However, this constraint is not currently supported in **V*-fit**.

(End of the document)