Sunspot Periodicity

Introduction

This application will find the periodicity of sunspots with two separate approaches:

- frequency domain transformation of the data
- autocorrelation

Both approaches should yield the same result.

Yearly sunspot data since 1700 is downloaded from a web-based source provided by the Royal Observatory of Belgium

```
> with(SignalProcessing) :
  with(plots) :
```

Import International Sunspot Number from Internet

Data source: WDC-SILSO, Royal Observatory of Belgium, Brussels

```
> data := ImportMatrix("http://www.sidc.be/silso/DATA/SN_y_tot_V2.0.txt", delimiter = " ")
```

$$data := \begin{bmatrix} 316\ x\ 5\ Matrix \\ Data\ Type:\ anything \\ Storage:\ rectangular \\ Order:\ Fortran\_order \end{bmatrix}$$

Plot the Data

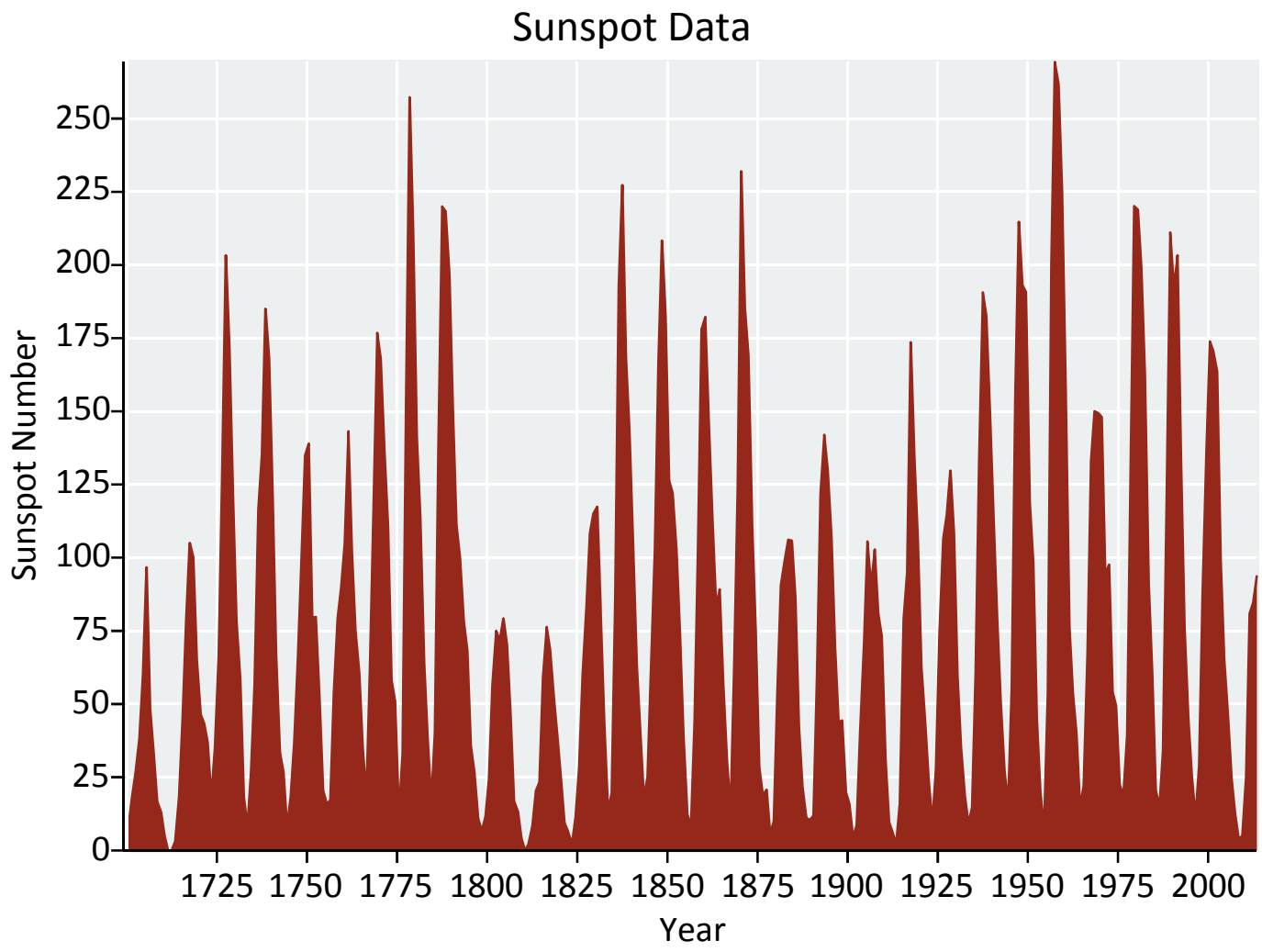
```
> SunspotNumber := data[ .., 2 ] :
> Year := data[ .., 1 ] :
> plot( [seq( [Year[i], SunspotNumber[i]], i = 1 ..314 ) ], labels = ["Year", "Sunspot Number"], labeldirections
```

$$= [\text{horizontal}, \text{vertical}], \text{title} = \text{"Sunspot Data"}, \text{titlefont} = [\text{Calibri}, 14], \text{thickness} = 0, \text{filled} = \text{true},$$

$$\text{size} = [800, 400], \textit{axesfont} = [\textit{Calibri}], \textit{labelfont} = [\textit{Calibri}], \textit{color} = \textit{RGB}\left(\frac{150}{255}, \frac{40}{255}, \frac{27}{255}\right),$$

$$\textit{transparency} = 0, \textit{background} = \textit{ColorTools}\text{:-}\textit{Color}\left(\text{"RGB"}, \left[\frac{236}{255}, \frac{240}{255}, \frac{241}{255}\right]\right), \textit{axis} = [\textit{gridlines}$$

$$= [10, \textit{color} = \textit{RGB}(1, 1, 1)]]\Bigg)$$



Periodicity via Fourier Transformation to the Frequency Domain

Now, calculate the period using a Fast Fourier Transform (FFT) of the first 2^8 data points:

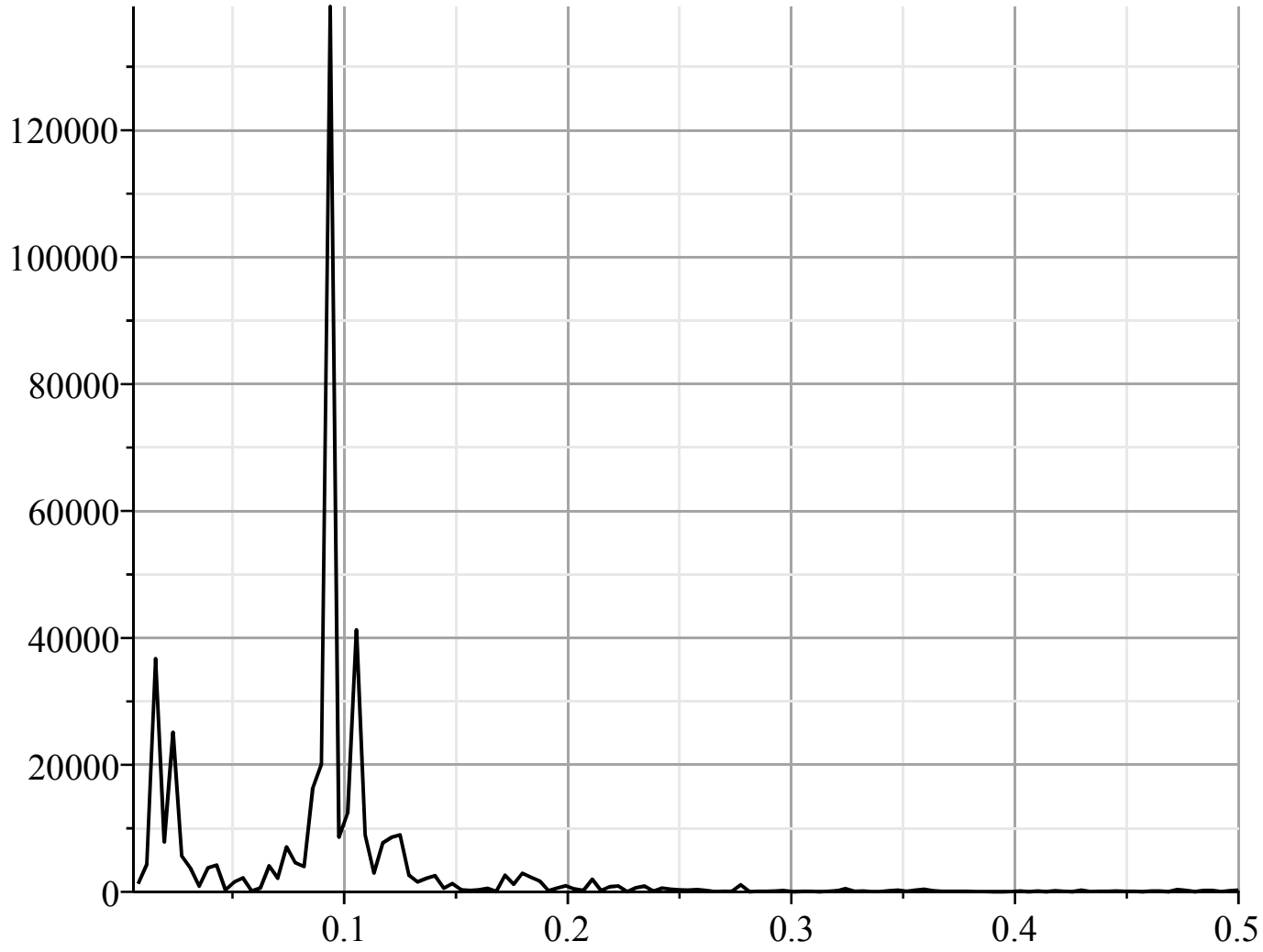
> fSunspots := FFT(SunspotNumber[1..2^8]) :

Plot the power spectrum:

> samplingRate := 1 :

> psSunspots := PowerSpectrum(fSunspots) :

> $plots:\text{-}pointplot\left(\left[seq\left(\left[\frac{i \cdot samplingRate}{2^8}, psSunspots[i]\right], i = 2 .. \frac{2^8}{2}\right)\right], connect = true, gridlines\right)$



Note the peak at a frequency of 0.09 years^{-1} . Try zooming in and using the point probe to confirm the value of this peak frequency.

The period is the reciprocal of the peak frequency.

> period := $\frac{1}{0.09}$

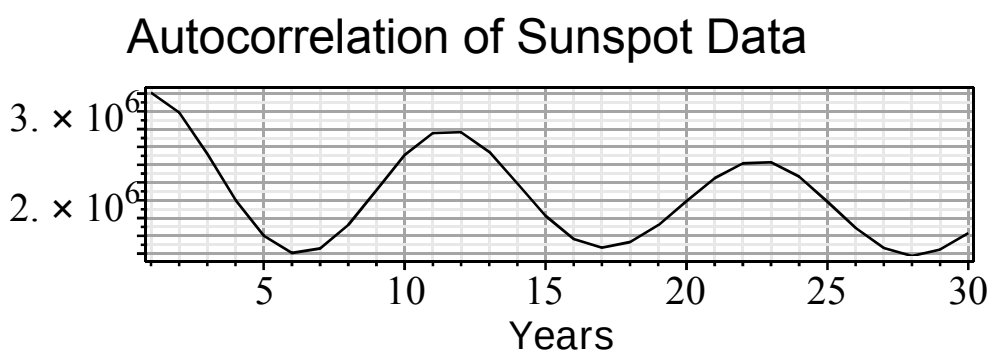
$$period := 11.11111111$$

Hence, the predicted periodicity is approximately 11 years.

Periodicity via Autocorrelation

> aSunspotNumber := AutoCorrelation(SunspotNumber) :

```
> SignalPlot( aSunspotNumber[1..30], labels = ["Years", ""], title = "Autocorrelation of Sunspot Data",
    titlefont = [Arial, 14]);
```



Here the first peak is at 11 years, indicating that the periodicity of sunspots is approximately 11 years. This confirms the period predicted by the Fourier Transform approach.