ASTRONOMY 300B

Homework No. 5

Due: Friday, 27, 2009

Power Spectrum of the Sunspot Number

For this exercise, we will find the period of the sunspot number using fourier transforms. Keep your code, which we will use in future assignments.

Please write your own code. The point of this problem set is to study the power spectrum of the historical sunspot number record, and the coding should be relatively "easy". If you are struggling to write the program required, please come see me.

1. **Get the data and plot the time series.** I've downloaded the monthly average sunspot number since 1953, from the National Solar Observatory homepage, and put it on our class homepage, in the password protected area. The file from the NSO homepage is **spots.list**. I've edited it so that it is easier to read into your code, see the file **spots.data**. Download these files and make a plot of the sunspot number as a function of time.

2. **Get the *Numerical Recipes* subroutine and associated files.**

Numerical Recipes by Press et al. is an invaluable compendium of useful code for statistical analysis of data. It was written by astronomers but is a best seller, and in widespread use in other fields. The books are on the reserve shelf in the Parker Room, and the code is available in F77 or C if you are on the Steward network.

For your code, I recommend that you use the subroutine "period.f" or "xperiod.c" which computes the power spectrum of *unevenly* spaced data. Even though the sunspot data is evenly spaced, data sets you may want to analyze in the future may not be.

You will see that these subroutines call other Numerical Recipes subroutines which must be linked together with your main program.

FOR C PROGRAMMERS: The Numerical Recipes subroutines are written assuming a fairly high level of C expertise. One tip: they have written the C subroutines assuming that array indices start with 1, not the default zero. I have an example book of programs calling C Numerical recipes subroutines; attached is the chapter on Fourier Transforms which shows a sample program that calls xperiod.c.

The subroutines are described in the Numerical Recipes section **13.8 Spectral Analysis of Unevenly Sampled Data**. This section can be downloaded for free from the Numerical Recipes web site; I've put a link on the class homepage. Or you can read it the old-fashioned way by going to the library. You will need to read the text in order to use the subroutine, since the code itself has no comments, but the is very well commented in the text.

I have have placed the files you will need from the Numerical Recipes subroutines on the password protected part of the class web site, so you will need to retrieve them from there.

Write a program to find the period of the sunspot numbers. The answer should be about 11 years. Attach your program, and a plot of the power spectrum you calculated.

If you prefer you may do this part of the problem set using IDL or Mathematica.

3. Nyquist sampling. The Nyquist theorem describes the minimum sampling necessary to recover information. In the case of the sunspot periodigram you just computed in part c, the data are VERY oversampled, that is, the period is 11 years and the data points were spaced one month apart. The minimum number of points per period necessary to recover the period is 4, whereas there were 132 points per cycle in the sunspot data.

Write a short program to resample the sunspot data set, averaging every 33 data points (12 months per year x a period of 11 years = 132 months divided by 4 is 33). Input this resampled data set into your power spectrum program, and see if you still recover the right period, 11 years.

Hand in a plot of your input data versus time, and your new power spectrum.